CICM

Part II

Study notes

Christopher Andersen

2016

Contents

Airway managment

Respiratory and Ventilation

Cardiology and Cardiovascular surgery

Resuscitation and OOHCA

Trauma and Burns

Neurointensive care

Acid-Base, Electrolytes and Endocrine

Renal Medicine

Pharmacology and Toxicology

Sepsis and Infection

Haematology

Gastro and Nutrition

Paediatrics and Obstetrics

Statistics

Equipment and Procedures

Ethics and Administration

Clinical Examination

Airway managment

Airway assessment

2002/2 Outline how you would assess a patient for potential difficulty with endotracheal intubation

History

Review anaesthetic charts or ICU/ED documention of previous intubation attempts

> Pre-intubation assessment
> Airway grade or percent of glottic opening
> Complications encountered

Presenting features

> Indication for intubation
> Trauma, especially to chest, face, ENT, head and neck
> Pregnancy

Past medical history

> Obstructive sleep apnoea
> Dysmorphic syndromes
> Cervical spine inflammation/OA/previous surgery or trauma
> Dental procedures and implants
> ENT surgery, TMJ dysfunction
> Systems review

Medications

> Sedatives, opiates, steroids, hormones, anticoagulants

Allergies

Family history of anaesthetic complications (in particular malignant hypertension)

Examination

Current medical status of the patient

> Respiratory reserve - Sats, RR, PaO2:FiO2 ratio, CXR, bronchodilators
> Cardiovascular status - current CVS support (inotropes, pacing etc), ECG, chest pain
> Neurological status - risk of raised ICP, need for neuroassesment post intubation, compliance
> LIver and Renal function may influence choice of induction medicaitons

Perform the L-E-M-O-N assessment

> Look eternally for evidence of potential issues such as foreign bodies, patient positioning
> Evaluate the airway with the 3:3:2 rule (measurement less than this distance predicts diffuclt intubation)
  - 3 fingers would fit when the mouth is wide open
  - 3 fingers from the mentum to the hyoid bone
  - 2 fingers from the hyoid bone to the thyroid notch
> Perform the Mallampati evaluation (higher grade predicts more diffucult intubation)
> Look for obstruction - obesity, prominent breasts, soft tissue swelling, prominent or crowded teeth, overbite
> Check the neck mobility

Investigations and Planning

> Perform further investiations if warranted - neck imaging, CXR etc
> Have a clear plans A, B, C, D and communicate this plan to the team
> Ensure roles are allocated according to skill level
> Anticipate issues and call for help early

Complications of endotrachael intubation

Created Question List the complications of endotrachael intubation?

Statement

In a sequence of 3400 emergent intubations the rate of difficult intubation was roughly 10% and complications occurred in approximately 4%.

Airway

> Failure to intubate
> Dental damage
> Damage to airway
  - Soft tissue injuries (lips, tongue, soft/hard palate, uvula, pharynx)
  - Vocal cord paralysis
  - Laryngeal oedema
> Oesophageal intubation
> Tracheal stenosis, Tracheo-oesophageal Fistula

Respiratory

- Hypoxia - Prolonged intubation attempt/multiple failures and/or Poor lung recruitment
- Endobronchial intubation
- Aspiration
- Bronchospasm
- Laryngospasm
- Sputum retention + pneumonia
- Barotrauma
- Sinusitis
- VAP or VALI

Cardiovascular

- Hypotension
  - At induction secondary to medications and loss of sympathetic tone
  - Due to reduced preload from higher intra-thoracic pressures
- Hypertension and tachycardia
  - from laryngoscopy and tracheal stimulation
- Brady-arrhythmia from vagal maneuvers such as suctioning the oropharynx

Neurological

- Increased ICP
- Potential spinal cord injury during intubation in patients with an unstable cervical spine
- Critical illness polymyoneuropathy following prolonged intubation

Other

- Adverse drug reactions including anaphylaxis
- Gastroparresis and GI bleeding
- Requirement for close monitoring (one-one nursing care)

Fibre optic in ankylosing spondylitis

2011/1 A 40 year old man with a history of ankylosing spondylitis and known difficulty with intubation on previous elective surgery is admitted to your ICU for hypoxic respiratory failure. A decision to perform a semi-elective, awake fiberoptic intubation in the ICU has been made. Describe how you will prepare for this procedure.

Initially

> Identify the most senior airway specialist (anaesthetist) available and request help

Patient assessment

> Consent/explanation of procedure

> Obtain history of previous airway difficulty, technique used, complications, etc. (from patient, letter from anaesthetist).H/o allergies-esp. to local anaesthetics. Fasting status. Other co-morbidities, eg. coagulopathy.

> Clinical assessment- of airway itself, mouth opening, nasal cavity/septum, range of neck movement, mental status including ability to understand and cooperate with proposed procedure, degree of hypoxia and ability to pre-oxygenate

Equipment preparation

> Endoscope - focussed, white balanced and properly orientated, TV screen in good position.

> Check oxygen source and suction

> Check equipment for bronchoscopy- Intubating bronchoscope, light source, lubricant, suction for bronchoscope, (oxygen can be applied alternately through same port using 3-way tap) and injection port for local anaesthetic. Apply defogging solution, if available.

> Airway equipment- range of oral and nasal armoured tubes of appropriate size, oral intubating airways, soft nasopharyngeal airways, appropriate size laryngeal mask airway. Depending on choice of oral or nasal intubation, check, lubricate and load chosen tube onto bronchoscope.

> Equipment required for plan B.

Medications

> Anticholinergic agent to reduce secretions (glycopyrrolate 5mcg/kg)

> Sedation options

- Ketamine and midazolam (100mg and 10mg in 20ml with 2ml boluses)
- Remifentanil infusion (0.75mcg/kg/min)
- Dexmedetomidine (1mcg/kg q10mins then an infusion at 0.7mcg/kg/hr)

> Topicalisation

- Nebulizers—4% lignocaine (entire airway)
- Topical sprays and gels—upper airway
  - Cophenylcaine spray to nasal structures
  - 2% lignocaine gel
- "Spray as you go"—larynx and trachea

Environment preparation

> Monitoring - ECG, pulse oximetry, arterial line, capnography set up.

> Patient pre-oxygenated on 100% for several minutes

> Adequate and working IV access

> Endoscopist at the patient's side

> Patient generally in the sitting position or semi recumbent

> Ensure presence of adequate skilled assistants. Inform them in detail of steps of procedure and assign roles, as appropriate.(eg. observation of patient, administration of sedatives, optimisation of patient position, injection of LA, etc)

> Discuss a plan B, if technique were to fail.

> Keep resuscitation trolley easily available and ensure difficult airway equipment available.

Fibre optic intubation

Created questions Describe your method of performing fibre optic intubation

Fibre optic intubation

Involves the placement of an endotracheal tube under direct fibre optic visualisation. The major advantage is that a trachael tube may be placed prior to the induction of general anaesthesia. There are no set list of indications but it should be considered if there is an anticipated difficult airway based on pre operative assessment or previous experience, when ventilation is expected to be difficult and when risks of iatrogenic complications of intubation are increased (eg unstable c-spine).

Contraindications

It should be used with caution when there are significant blood and secretions in the airway, there is airway swelling preventing fibre optic insertion, when airway obstruction at the glottic level is likely to be exacerbated by topicalisation and when rapid airway management is required. Inadequate skill level of the intubating doctor. Base of skull fracture.

Preparation

Equipment

> Endoscope - focussed, white balanced and properly orientated, TV screen in good position.

Patient preparation

> Procedure clearly explained along with the rationale.
> Anticholinergic agent to reduce secretions (glycopyrrolate 5mcg/kg)
> Sedation options
  - Ketamine and midazolam (100mg and 10mg in 20ml with 2ml boluses)
> Topicalisation
  - Nebulizers—entire airway
  - Topical sprays and gels—upper airway
    - Cophenylcaine spray to nasal structures OR 2% lignocaine gel
  - Transtracheal injection—larynx and trachea
  - "Spray as you go"—larynx and trachea
  - Nerve blocks—distribution of the nerve supply
> Apply supplemental oxygen

Positioning

> Endoscopist at the patient's side
> Generally in the sitting position or semi recumbent

Endoscopy

Ensure that the ETT is lubricated and loaded

Nasal - Usually via the nasal cavity as this avoids the gag reflex

> Identify the septum, floor of nose and inferior turbinate - advance through the turbinate
> Pass between the soft palate and pharyngeal wall and proceed to the larynx insert the endoscope to the level of the carina

Oral - If oral ensure appropriate suppression of the gag reflex

ETT insertion

Push and twist the tube in a "drilling" fashion

Confirm the tube placement in relation to the carina before removing the endoscope

Post extubation stridor (PES)

2008/2 What are the risk factors for the development of post-extubation stridor? Briefly outline the treatment of post extubation-stridor

Definition

Post extubation stridor is characterised by high pitched audible inspiratory sounds and is usually due to laryngeal oedema. It is a frequent complication of intubation and in some case series occurs in up to 30% of patients. It is associated in a range of complications from transient discomfort through to airway comprimise and subsequent reintubation or respiratory arrest.

Risk factors

> High cuff pressures
> Larger ETT
> Traumatic or difficult intubation
> Previous self extubation
> Tracheostomy
> Trauma, infection or tumour to the upper airways
> Duration of endotracheal intubation
> Duration of critical illness
> Severity of illness (APACHE or SAPS II)
> Increased BMI
> Decreased GCS
> Older age
> Agitation
> Female gender

Prevention

> Systematic review have demonstrated that corticosteroids reduce the risk of laryngeal oedema and reintubation
  - This effect appears most beneficial if the C-S are commenced 12 hrs pre extubation
  - Steroid treatment is reasonable in all patients with increased risk of PES
> The lack of a reasonable cuff leak volume prior to extubation has been demonstrated to predict PES and reintubation
> Reduction and cuff pressures and tube size (acknowledging the issues with weaning) may be appropriate
> Ensuring appropriate neurological status prior to extubation

Treatment

> Close observation and prepare for potential reintubation
> Nebulised adrenaline (up to 5ml of 1:1000 adrenaline)
> Inhaled or IV corticosteroids may be a useful adjunctive treatment
  - Budesonide inhaled 1-2mg
  - Dexamethasome 4-8mg
> Non invasive ventilation
  - Has been shown to reduce reintubation rates in systematic reviews
> As helium is less dense than nitrogen there is physiological rationale for the use of heliox mixtures
> If patient appears to tire, the stridor becomes worse, or physiological parameters become deranged then reintubation is the most apprpriate course
  - It is likely that this will be a more complicated procedure and therefore difficult airway algorithms should be prepared

Airways in burns

2009/2 You are asked to review a 64 year old man who has been brought to the emergency department having been burned in a house fire. There is no coherent history available from the patient and you observe that he is drowsy and confused, an has a persistent cough. His heart rate is 120bpm, blood pressure 88/52mmHg, respiratory rate 28 and oxygen saturations 94% on high flow oxygen via a non-rebreather mask. List the initial priorities of management. What features on history and examination would suggest a significant airway injury? Give a differential diagnosis for his conscious level

Immediate assessment

> This patient has a likely inhalational injury (cough, drowsy)

> They have significantly elevated aA gradient which may be worse than expected as the saturations may be falsely elevated in CO poisioning and they are already receiving maximal oxygen via non invasive methods.

> They are haemodynamically unstable with a tachycardia and hypotension.

Management priorites

> This patient requires ugent intubation due to risk to airway from a possible airway burn, likely inhalational injury and type 1 respiratory failure

- I would continue assess the airway, take a focussed history and perform a focussed examination of the respiratory and cardiac systems
- I would request help from the most senior airway doctor in the hospital
- I would employ a check list to prepare such as SOAP-ME (Suction, Oxygen, Airways, Patient positioning, Monitoring (ETCO, Sats, BP, ECG), Emergency plan), allocate roles and discuss the plans
- Given the burns and hypotension I would use Ketamine 1mg/kg and Rocuronium 1mg/kg for induction and perform a modified RSI

> From a breathing perspective one the airway is secured I would continue 100% oxygen, monitor for chest wall compliance, check an ABG for CO levels and adequacy of ventialtion and perform a CXR to confirm tube placement

> From a cardio persepctive I would ensure that he has a large bore resuscitation IVC and commence a modified Parkland's protocol initially aiming for 2-3ml x kg x % burn, and use inotropes to support the blood pressure if required. I would titrate the fluids according to the urine output, aiming for 0.5ml/kg/hr. I would also place an arterial line and CVC

> I would use fentanyl and propofol for pain/sedation

> I would urgently consult the burns/plastics team if they are yet to be involved and assess the need for any urgent escharotomies (circumferential burns, evidence of compartment syndromes).

What features on history and examination would suggest a significant airway injury?

> Burns occuring in a closed space

> Cough, stridor, hoarseness of voice

> Burn to face, lips, mouth, pharynx or nasal mucosa

> Soot in sputum, nose or mouth

> Hypoxaemia or dyspnoea

> Carboxyhaemoglobin levels >2%

> Acute confusional state or depressed level of consciousness

Give a differential diagnosis for his conscious level

> Traumatic brain injury

> Carbon monoxide poisoning

> Cyanide poisoning

> Alcohol intoxication / overdose

> Other pathology precipitating acute loss of consciousness - stroke, ICH, seizure, hypoglycaemia

Respiratory and Ventilation

Thrombolysis in Pulmonary Embolism

2015/1 Critically evaluate the role of thrombolysis in pulmonary embolism

Rationale

Thrombolysis is usually provided by tissue plasminogen activator which markedly increases the rate of fibrin break-down. Other options include streptokinase and urokinase. This removes the clot blocking the pulmonary vasculature.

Drug delivery is usually systemic although it is also possible to give the drug locally via the assistance of interventional radiologists. Local delivery may increase the beneficial effects and reduce to risks as a lower overall dose is given.

Contraindications

Thrombolysis significantly increases the risk of bleeding (from 12 to 22%) and is contraindicated in patients with;

> Intracranial pathology: previous intracranial haemorrhage, CVA in past six months, intracranial mass, head trauma
> Recent major surgery: time frames dependent on surgery type
> Current bleeding, significant peptic ulcer disease
> Pre-existing bleeding diathesis
> Allergy to thrombolysis

Indications

> Thrombolysis is an accepted intervention in patients with confirmed PE and haemodynamic compromise (SBP <90) with evidence of a trend towards mortality benefit
> In cardiac arrest when the suspected cause is PE, thrombolysis is also not an unreasonable intervention option and some poor quality studies support this option. It is also on the ARC guidleines as an option to consider
> The role of thrombolysis in patients with "sub-massive" pulmonary embolism is contraversial (SBP >90)
  - There is some evidence to support its use in patients with RV strain although there was also a significant increase in major bleeding events (PEITHO and TOPCOAT Trials)
  - There is also some evidence to support its use in patients with a large clot burden especially at a reduced dose with reductions in pulmonary hypertension (MOPETT Trial)
> In patients without any compromise the use of thrombolysis is not supported

Discussion

> Thrombolysis should always be considered in a risk - benefit profile for each individual patient
> I would use this intervention in patients with haemodynamic comprimise unless contraindicated
> In a cardiac arrest I would thrombolyse if I had a strong suspicion that PE was the causative agent.
> I would consider thrombolysis in patients with submassive PE
> Pending research on long term outcomes especially with respect to pulmonary hypertension will potentially alter my practice.

Ventilator management of acute asthma

May 2015 Q1 (77%) You are called to review a 29-year-old male with confirmed asthma in the Emergency Department. He has been unwell for 2 days with increasing cough, wheeze and shortness of breath. He has just been intubated. a) Describe what ventilator settings you will initially set and give the reasons for your answer. (40% marks) Two hours later he has become increasing difficult to ventilate. You quickly assess and exclude all other causes except severe bronchospasm. b) Briefly outline your management of this situation. (60% marks)

Initial ventilator settings

FiO2 = 1.0

Volume control mode

> A volume controlled mode is most appropriate as the patient is in a state of variable airway restriction and therefore as the bronchoconstriction changes over time (worsens or improves) then there will be large variations in the volumes delivered.

> Aim for tidal volumes 6-8 ml/kg/min to protect against VALI

Respiratory rate at 8-10 and I:E ratio of 1:4 or 5

> Reduced respiratory rate and a prolonged I:E ratio to ensure adequate expiratory times, tolerating hypercapnoea initially

PEEP 0-3

> Asthma is characterised by high intrinsic PEEP and therefore high extrinsic PEEP may worsen gas trapping. As the patient improves I would consider adding a small amount of PEEP to ensure alveolar patency

Inspiratory flow rate

> I would use a VC mode which delivered the volume quickly initially

Pressure limits

> In terms of pressure limits, peak pressures may be high however this represents the pressure in the bronchus required to overcome bronchoconstriction. The p-plateau pressure is the more important figure to be cognisant of given this represents the pressure at the alveolus.

Severe bronchospasm (answer from CICM)

Ensure adequate sedation:

> Ketamine +/- propofol +/- analgesia

> Preferentially use non histamine releasing analgesia – fentanyl

Muscle relaxation: Non steroid/non histamine releasing agents – ideally cisatracurium

Bronchodilator therapy

> Regular inhaled salbutamol – MDI, nebuliser

> IV infusion salbutamol +/- IV adrenaline infusion

> Anticholinergic therapy: Ipratropium bromide inhaled regularly

> Magnesium infusion – aiming for Mg 1.5-2.5 mmol/L

> Methylxanthine therapy: Aminophylline infusion

Steroid therapy: 100 mg 6 hrly hydrocortisone

Ventilation

> Tidal volume 6-8 mL/kg, Reduce respiratory rate if possible, Minimise PEEP

> Check plateau (rather than peak) inspiratory pressure with inspiratory pause in volume control mode and paralysed patient

> Check for evidence of dynamic hyperinflation with expiratory hold in paralysed patient

> Permissive hypercapnia

Other strategies

Ventilator waveforms

Pressure-time curve

Volume controlled ventilation

> This is the most common curve for analysis and provides a lot of information about system resistance.

> Pressure max - Pressure plateau represents the resistance of the respiratory system. This can further be broken down into the airways resistance (Pmax-P1) and the tissue resistance P1-P2).

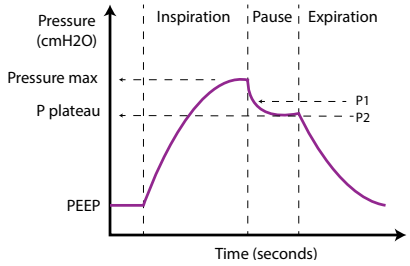
> The Pplat - PEEP represents the actual driving pressure of the lungs and if the change in volume is known then the static compliance of the lungs can be calculated. Dynamic compliance is the delta volume/Pmax-PEEP.

Pressure controlled ventilation

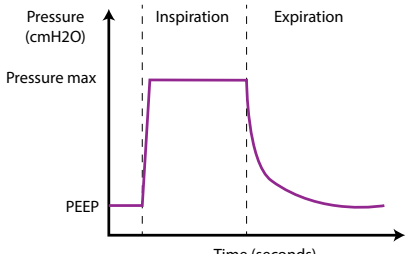
> In this setting the pressure rapidly rises to the set level and maintains at this level throughout the cycle. The expiratory curve is similar to VCV curve as it is also a passive process.

> Changes in compliance and resistance are difficult to detect in this mode as the pressure is regulated.

Pressure-time curve with VCV



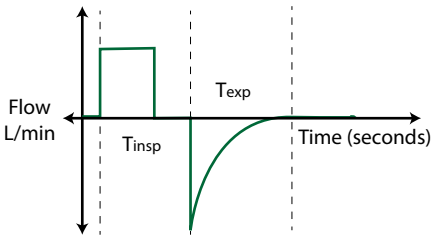
Pressure-time curve with PCV



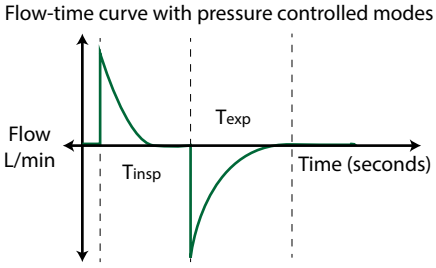
Flow-time curve

These curves are similar however with PCV modes there is a decelerating flow curve during inspiration. In VCV modes the ventilator achieves the flow rate and then maintains this rate until the target volume is achieved. The volume is the integration of the flow-time curve (area under the curve).

Flow-time curve with volume controlled modes



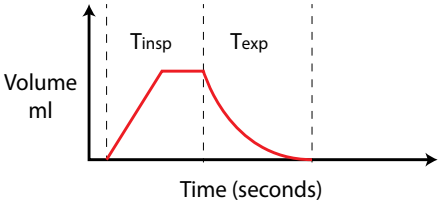
Flow-time curve with pressure controlled modes



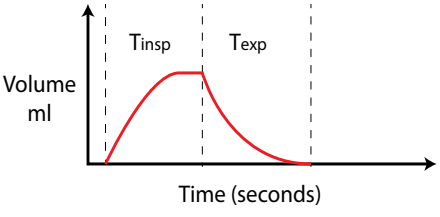
Volume-time curve

This is a representation of the change during a tidal volume breath with the baseline the FRC.

Volume-time curve with VCV



Volume-time curve with PCV

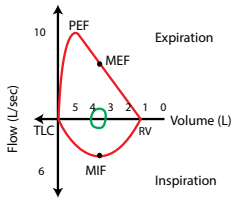


Flow volume loops

Created Question Describe the flow-volume loops for various pathologies

Normal flow volume loop

Flow volume loops provide an alternative method for evaluating airways resistance. Flow is plotted against either absolute lung volume or change in volume. This may be obtained for both inspiration and expiration. The normal expiratory curve is roughly triangular and inspiration is a semi-circle.



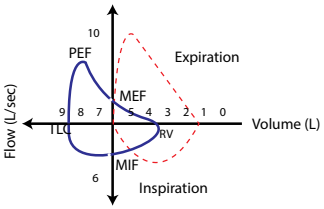
The highest flow is at the beginning of expiration when elastic recoil is at its highest and the airways are at the widest diameter. The inspiratory part of the loop is is dependent on the inspiratory muscles and in normally more even.

0 Normal tidal breath

PEF = Peak Expiratory Flow
TLC = Total Lung Capacity
RV = Residual Volume
MEF = Mean Expiratory Flow (at 50% FVC)
MIF = Mean Inspiratory Flow (at 50% FVC)

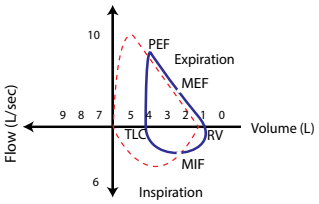
Obstructive lung disease

The PEF is reduced as well as the FVC There is increased residual volume as the patient breathes at a higher FRC to improve airway calibre which reduces obstruction (and thereby reduce the work of breathing). MEF will be less than MIF due to the non effort dependent scalloping of the expiratory curve.



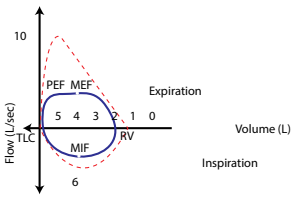
Restrictive lung disease

The loop is narrowed because of diminished lung volumes. Airflow is greater than normal at comparable lung volumes because the increased elastic recoil of lungs holds the airways open. MEF will be generally greater than MIF.

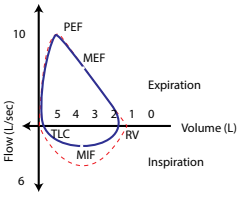


Other pathologies

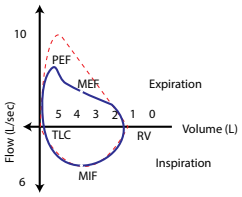
Fixed upper airway obstruction



Variable extrathoracic obstruction



Variable intrathoracic obstruction

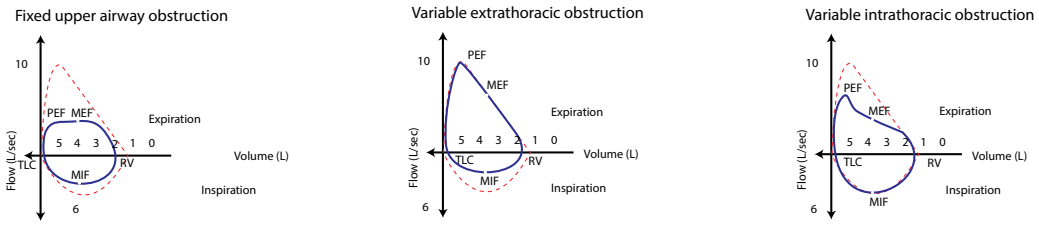


Fixed upper airway obstruction (tracheal stenosis, goitre) the expiratory and inspiratory loops are flattened reducing the PEF but resulting in a similar TLC and RV. MIF is often close to MEF.

Variable extrathoracic obstruction (vocal cord dysfunction or unilateral paralysis) When a single vocal cord is paralyzed, it moves passively with pressure gradients across the glottis. During forced inspiration, it is drawn inward,

resulting in a plateau of decreased inspiratory flow. During forced expiration, it is passively blown aside, and expiratory flow is unimpaired. Therefore, MIF 50% FVC < MEF 50% FVC. PEF, RV and TLC and unchanged.

Variable intrathoracic obstruction (tracheomalacia) During a forced inspiration, negative pleural pressure holds the floppy trachea open. With forced expiration, loss of structural support results in tracheal narrowing and a plateau of diminished flow. Airflow is maintained briefly before airway compression occurs. MEF is generally less than MIF. PEF is reduced and TLC and RV are unchanged.



Ventilator triggering and cycling

List and briefly describe the different mechanisms by which an ICU ventilator may detect (and thus is triggered by) a spontaneous inspiratory effort. Include in your answer the utility and potential disadvantages of each mechanism. (60% marks) b) Outline the mechanisms by which an ICU ventilator may cycle from inspiration to expiration. (40% marks)

Pressure Triggering

Pressure triggering: the ventilator triggers in response to a fall in pressure by a user defined value below set PEEP or CPAP. Requires a respiratory muscle contraction against a static load (closed inspiratory limb) to generate a negative pressure below the threshold set value before fresh gas flow can occur. The imposed work of triggering is high, and may exceed the patient's reserve, resulting in missed triggers. Working against a static load may cause patient distress. There is significant delay between the initiation of respiratory effort and the onset of any fresh gas flow.

Flow Triggering

Flow triggering: the ventilator triggers in response to a user defined change in flow during the expiratory phase. The exact mechanism is ventilator specific and differs between ventilator types. Obviates some of the disadvantages of pressure triggering. A constant fresh gas flow is available for any inspiratory effort, eliminating patient effort against a static load. However there still remains a delay between inspiratory effort and the onset of support. Auto triggering and cardiac triggering can occur if the flow is too sensitive.

Diaphragm Triggering

Uses a NG tube with electrodes to sense diaphragm effot. May improve synchrony and reduce wasted efforts.

Time cycled.

Once the time programmed for inspiration (inspiratory flow time plus inspiratory pause time) is completed, the ventilator automatically cycles to expiration. This occurs independent of any patient effort or other variables.

Flow cycled.

Once flow has decreased to a pre-determined minimum value, (eg 25% maximum flow rate), the ventilator cycles to expiration. In lungs with poor compliance, the cycling threshold will be reached more quickly, resulting in a shorter time for inspiration and a smaller tidal volume. Used more in spontaneous modes

Pressure cycled.

Once a set pressure is reached, the ventilator will cycle to expiration. Non-compliant lungs will have smaller tidal volumes than compliant lungs. The most common application for this mode is as an alarm setting as a safety feature to prevent sustained or excessive high pressures.

Volume cycled

Once a set volume is reached, the ventilator will cycle to expiration (or inspiratory pause).

NIV exam answer

2013/1 Outline your approach to the use of non-invasive ventilation in the critically ill patient

Introduction

Non invasive ventilation is defined as respiratory support without establishing a tracheal airway

- Rationale
- Closed circuit therefore the fraction of inspired O2 may be controlled and accurately increased to 1.0
- Increased mean airway pressure improves oxygenation
- Improves V/Q matching via recruitment and reducing de-recruitment (increasing the FRC above the closing capacity)
- Improved CO2 clearance (via improved ventilation) increases alveolar oxygenation and therefore paO2
- Decreases work of breathing
- Reduces the after-load of the left and right ventricles (although in normal cardiac function NIV reduces CO and DO2)

Strong indications

- Pulmonary oedema
- Asthma (although should not delay intubation if required)
- COPD
- Lung infection in the neutropenic patient

Weak indications

- weaning from invasive ventilation
- prevention/avoidance of intubation
- should not be used in community acquired pneumonia

Contraindications

- Respiratory arrest
- Unprotected airway
- Upper airway obstruction
- Inability to clear secretions
- Untreated pneumothorax
- Marked haemodynamic compromise

Adjustment of NIV

- Titrate IPAP and EPAP to work of breathing and tidal volume targets
- Adjust inspiratory flow rate and expiratory cycle-off to increase or decrease the expiratory phase
- Adjust delivery mechanism to suit patient needs (eg. nasal mask, full face mask or half face mask, or full helmet)

High flow nasal oxygen therapy

2013/1 With regards to the use of high-flow nasal oxygen therapy in adults: Describe the mechanisms by which high flow nasal oxygen therapy is believed to exert its beneficial effects. List two potential adverse effects associated with the use of high-flow nasal oxygen therapy. List two relative contraindications to the use of high-flow nasal oxygen therapy.

Benefits of HFHP

PEEP effect

> 3cm H2O with 60L/min flow, when the mouth is open
  - recruitment of atelectatic lungs, decreased work of breathing, and so forth.
  - overcome the "nasopharyngeal resistance" of obese OSA patients
  - increase in end-expiratory lung volume, which suggests that there is a real alveolar recruitment effect.

Increased FiO2

> The upper airways are washed out with O2 and this reduces dead space
> It is more effective than the venturi system

Increased comfort

> Humidification reduces insensible losses
> Patients tolerate it well as they can breath with mouth open

List two potential adverse effects associated with the use of high-flow nasal oxygen therapy.

> Overdistension of the alveoli, and barotrauma
> Nasal mucosal damage dure to high flow
> Pressure areas due to the device

List two relative contraindications to the use of high-flow nasal oxygen therapy.

> Nasal fracture, or any other sort of nasal injury
> Recent nasal surgery
> Base of skull fracture

Bronchopleural Fistulas

Exam Date: 1/2014 Outline the principles of, and strategies for management of a persisting bronchopleural fistula (BPF) in a mechanically ventilated patient.

Definition

Bronchopleural fistulas (BPF) are communications between the pleural space and the bronchial tree and most commonly occur after pulmonary resection but may also occur in a range of other settings, including post cardiothoracic surgery or procedures, following trauma, as a complication of mechanical ventilation and in primary lung diseases such as infection, malignancy and spontaneous pneumothorax.

Management Principles

Initial Management drainage of the pneumothorax (and empyema if present) with insertion of an intercostal catheter of adequate calibre. This also reduces the risk of haemodynamic comprimise from a tension pneumothorax. Some recommendations also suggest placing the patient in a position which makes the affect lung dependent to reduce the risk of bronchial spoiling and pulmonary flooding. Suction should be the minimum amount to ensure that the lung is reinflated and pleural apposition achieved as this may cause the BPF to persist.

Investigations include a chest x-ray, septic screen and consideration of a CT scan and bronchoscopy. An attempt should be made to estimate the size of the of the air leak by assessing the degree of bubble from the chest drain as this may guide management decisions.

Ventilation strategies are targeted at reducing the transpulmonary pressure gradient which is associated with a persistent BPF. Higher lung volumes and increased mean airway pressures are associated with an increased transpulmonary gradient. Ventilation strategies generally aim for lower tidal volumes and at times with permissive hypercapnoea. Low PEEP and the reducing the risk of intrinsic PEEP (by using PSV or SIMV with a reduced mandatory rate as well as decreasing the I/E ratio) result in reduced airway pressures. Early extubation should be a priority if possible.

Use of PEEP via an intercostal catheter may be effective in reducing the transpulmonary gradient whilst ventilating the lung effectively however it is may result in persistent pleural collections of air and fluid and carries the risk of a tension developing. It is also too complicated with multiple intercostal catheters.

Independent lung ventilation has been advocated and requires the use of a dual lumen ETT. The rationale for this approach is that it isolates the damaged lung whilst the normal lung is conventionally ventilated however it is complex, requiring two ventilators

Supportive management of the ventilated ICU patient should be reviewed or instigated especially nutrition with EN or PN, appropriate analgesia and sedation, thromboprophylaxis and ulcer prevention as well as glycaemic control. Broad spectrum antibiotics are recommended in many guidelines.

Definitive management may be required if conservative methods fail to result in closure of the BPF. Surgery is a good option if there is a large air leak and if the patient is post operative although has all the risks associated with cardiothoracic surgery. Endobronchial occlusion is the other option which is performed during bronchoscopy. The occlusion is via a balloon such as those found on the end of a swan-ganz catheter or by the injection of glue to the affected area.

Bronchoscopy in critical care

Created Question Discuss the role of bronchoscopy in critical care

Introduction

Bronchoscopy (Bs) refers to visualisation up to the third generation of the bronchial tree. In the ICU bronchoscopy is a common procedure and is almost exclusively performed via a flexible bronchoscope. Rigid bronchoscopy is rarely performed.

Bs may be for diagnostic and/or therapeutic indications.

Diagnostic indications

Bronchial washings or bronchial alveolar lavage are useful in evaluation of pneumonia or infiltrate of unclear aetiology

Assessment of

- Bronchial obstruction
- bronchopleural fistulas and bronchial stumps post lung section
- inhalational injuries
- airway trama
- evaluation of haemoptysis

Transbronchial lung biopsy in interstitual lung disease

Therapeutic indications

Treatment of mucous plugging

Toileting of the airway following aspiration

Removal of foreign bodies

Placement of a percutaneous tracheostomy is facilitated by Bs

Bs is very useful in placing an ETT in a difficult airway or positioning a double lumen tube

Haemoptysis may be treated by injecting a vasocontrictor at the bleeding point or placing a tamponade device.

Complications and issues

May cause difficulties in ventilating the patient with an increased aA gradient

Can cause trauma and bleeding and should be used in caution in a patient with a bleeding diathesis

Requires an appropriately large lumen ETT to ensure effective ventilation whilst visualising the bronchial tree

May induce bronchospasm in patients with reactive airways

Chest physio in ICU

2001/2 List the chest physiotherapy manoeuvres that you prescribe in ICU and provide a rationale for each

Manual lung hyperinflation

> Improves recruitment of atelectatic lung
> Mobilises bronchial secretions
> Improves lung compliance

Recruitment manoeuvres:

> Transiently improve oxygenation

Suctioning:

> Improves clearance of secretions

Inspiratory muscle training

> May improve the chances of successful ventilator weaning

Chest shaking and vibration

> Aid mucociliary clearance

Chest wall compression

> Enhances expiratory manoeuvres and aids secretion clearance

Percussion

> May mobilise secretions

Neurophysiological facilitation of respiration

> Stimulates increased VT and cough

Positioning

> May reduce the work of breathing

Gravity-assisted positioning

> May enhance secretion clearance

Active cycle of breathing techniques (ACBT)

> Breathing exercises to remove excess secretions

Dyspnoea in tracheostomy patient

2012/2 A 65-year-old man had an out of hospital cardiac arrest secondary to a large anterior ST elevation myocardial infarction. His ICU stay has been complicated by aspiration pneumonia. He is now day 14 from admission, with a tracheostomy in situ, and has started weaning from ventilation. You have been asked to review him as he is communicating that he 'can't get enough air' despite ongoing mechanical ventilatory support. How would you manage this patient who reports being breathless on a ventilator?

Immediate management

> Increase the FiO2 to 100%

> consider disconnecting the patient from the ventilator, and manually bag-ventilating them

> Simultaneously assess and manage threates to life in a systematic manner:

Airway

> machine factors
  - check for condensation in the ventilator tubing
  - change HME and ventilator filter

> patient factors:
  - check tracheostomy diameter (too narrow?)
  - check inner cannula (encrusted with inspissated secretions?)
  - check tracheostomy patency (blocked with secretions?)
  - Check tracheostomy position (dislodged during last turn?)
  - suction the patient, loking for fresh blood and clots (unrecognised pulmonary haemorrhage?)

Breathing

> machine factors
  - Check for ventilator malfunction
  - Look for patient-ventilator dyssynchrony and adjust the settings accordingly;
  - is the trigger insufficiently sensitive, or over-sensitive?
  - is the tidal volume and inspiratory flow sufficient to satisfy patient demand?

> patient factors
  - Assess lung compliance by observing ventilator peak pressures, or qualitatively by manually bag-ventilating the patient
  - Examine the patient and organise an ABG and chest Xray, looking for evidence of...
  - bronchospasm, pneumothorax, pulmonary oedema, impaired gas exchange
  - consider a CTPA if an unexplained A-a gradient has been discovered
  - metabolic acidosis, driving respiratory effort

Circulation

> cardiac dysfunction, eg. MI or new arrhythmia

> Organise an ECG and bedside TTE, looking for evidence of MI, Pulmonary oedema, arrhythmia new onset of heart failure evidence of right heart strain

Neurology

> look for muscle weakness or new neurological deficit

> Look for evidence of poorly controlled pain driving the respiratory effort

> Assess for delirium and agitation as the primary driver of increased respiratory effort

Resp assessment re extubation

2014/1 The following questions relate to separation from invasive mechanical ventilation: a) With reference to a spontaneous breathing trial (SBT): i. What is an SBT? ii. Over what duration should it occur? iii. Why would you perform an SBT in a mechanically ventilated patient? iv. List three methods of performing an SBT. b) What is the rapid shallow breathing index (RSBI) and how should it ideally be measured? c) Briefly outline the role of prophylactic (planned) non-invasive ventilation (NIV) immediately following extubation. Explain how this differs from therapeutically applied (rescue) NIV used in the same context.

Spontaneous breathing trial

> SBT is the simulation of extubated respiratory workload in a still-intubated patient

> Duration of the SBT: 30-120 minutes

> To assess a patient's suitability for extubation. It is also a form of respiratory training for a patient during prolonged ventilation as part of a weaning strategy.

> Support during the SBT: Low level Pressure Support (PSV < 7cm H2O), CPAP circuit, or unassisted via a simple T-piece- all of these seem to be equivalent.

> SBT failure is identified by the following features:

- Agitation and anxiety
- Diaphoresis
- Cyanosis
- Evidence of increasing respiratory effort
- Hypoxia (eg. SpO2 <90%)
- Hypercapnea (eg. PaCO2 >50mmHg)
- Unsatisfactory RSBI: an fR/VT more than 105 breaths.min-1L-1
- Resp rate over 35/min, or increased by more than 50%
- Hypotension, hypertension, or tachycardia
- Cardiac arrhythmia

Rapid Shallow Breathing Index

- The RSBI is the ratio of frequency of breathing to tidal volume (f/Vt).
- Rapid shallow breathing as reflected by f/Vt predicts weaning failure with a threshold of about 105 breaths per minute per litre (Yang and Tobin 1991).
- It is less predictive in those ventilated > 8d.
- It should be measured during the first minute of a T piece trial using a spirometer to measure Vt.
- It is of limited value when measured during trials of pressure support ventilation.

NIV post extubation

Prophylactic NIV:

> the use immediately after extubation in absence of respiratory failure-

> High risk patients may benefit (CHF, COPD, high severity scores).

- Ferrer et al , Am J Res and Crit Care Med, 2006 ~
  - Early NIV avoided respiratory failure and decreased ICU mortality - in this study NIV appeared useful mainly in a subset of hypercapnic patients with chronic respiratory disorders.
- However, of no benefit if applied indiscriminately in unselected patients, see Su et al, Resp. Care. 2012.

Therapeutic NIV:

> Used post extubation in the presence of established or evolving respiratory failure-

> It has no proven benefit in the overall population of patients in this context- it may even increase mortality by delaying re intubation, see Esteban, NEJM, 2004

Flow volume loops

Hiccups in ICU

Created Question List the causes and potential therapy for hiccups in the critically ill patient

Hiccups

A hiccup is an involuntary, intermittent, spasmodic contraction of the diaphragm and intercostal muscles. Muscle contraction results in a sudden inspiration and ends with abrupt closure of the glottis, causing the "hic" sound. They appear to be a primitive reflex with of uncertain function.

The major issue with hiccups in a critical care setting is the dysynchronisation that they cause with ventilators and the subsequent impaired ventilation. They may also be distressing for the patient and their families.

Causes

Irritation of vagus nerve

- Pharyngeal branches (Pharyngitis, Auricular branches, Hair or foreign body)
- Thoracic branches (Pneumonia, Pleuritis, Aortic aneurysm, Pericarditis, Chest tumours, Myocardial infarction)
- Abdominal branches (Distention, Gastritis, Ulcer disease, Abdominal abscess, Gallbladder disease, Tumors)

Diaphragmatic irritation

- Gastric distention, Hiatal hernia
- Splenomegaly/Hepatomegaly
- Subphrenic abscess

Central nervous system

- Structural lesions/Neoplasms/ Brain-stem tumors
- Multiple sclerosis
- Syringomyelia
- Trauma
- Vascular disease

Postoperative causes

- General anesthesia
- Suppression of normal inhibition
- Stimulation of oropharynx or glottis

Toxic-metabolic

- Alcohol, Drugs, Uremia
- Diabetes mellitus
- Electrolyte imbalance (sodium, potassium, carbon dioxide)

Psychogenic

Infectious causes (Meningitis, Encephalitis)

Management

Management should be focussed on treating the underlying cause if apparent (for example by gastric decompression with an NGT if due to gastric distension).

Non pharmacotherapies are focussed on stimulating CN X. Valsalva manourves, stimulating the occulur cardiac reflex, causing a gag reflex, or stimulating the nasopharynx and uvula may work. There are case reports of inducing hypercapnoea as an effective strategy.

Pharmacotherapy is based on small case series. Chlorperazine has traditionally been used. Metoclopramide 10mg has been reported to be effective and baclofen is an alternative option.

Management of hypoxic respiratory failure in AML

Created Question A 35 yo female is admitted to your ICU, she is Day 14 following an autologous bone marrow transplant for AML and has developed sudden acute hypoxic respiratory failure and shock.

Outline your management for the first 24 hours?

Care limitations I would first establish the current limitations of care involved with this patient by reviewing the medical record and having discussions with the patient, family and treating team. Once established I would operate carefully within these parameters.

With a five year survival of almost 50% in a patient of this age (at point of diagnosis) the expectation would be for full active treatment.

Intial assessment I would concurrently make an initial evaluation of the patient and would institute immediate management as required including non rebreather oxygen, peripheral vascular access, fluid resuscitation and peripheral vasoactives. I would conduct a septic screen and baseline bloods. I would conduct and appropriate focussed examination of the cardiorespiratory system and review recent investigations and medical history. I would institute broad spectrum antibiotics as part of my initial management in line with institutional guidelines for the management immunocomprised patients with shock.

Airway management There is evidence that a trial of NIV in patients with haematological malignancies and immunocomprimise may be advantageous when compared with intubation. In older patients with AML I would advocate NIV over intubation however in a younger patient cohort with fewer comorbidities such as our 35 year old I would recommend intubating earlier to achieve definitive control and increase management options.

I would identify to team members that this will be a time critical intubation given the respiratory failure and use my most experienced staff members for each of the roles to reduce risk of complications such as a significant desaturation. I would employ apnoeic ventilation and ensure appropriate preoxygenation. I would avoid cardio depressant drugs such as propofol given the shocked state and opt for fentanyl, midazolam and rocuronium. I would identify predictors of a difficult airway and enure all team members are aware of the different plans for intubation.

Respiratory management Following intubation I would review the CXR for focal areas of collapse, consolidation, pulmonary oedema or haemorrhage. I would institute an ARDS Net ventilation strategy in the first instance aiming for tidal volumes of 6-8 ml/kg predicted body weight, max p-plat of 30cm H2O, targeting RR to near normal CO2 if possible (but permitting hypercapnea if too difficult to achieve) and titrating the FiO2 and PEEP to achieve a PaO2 of 60-80.

I would use rescue therapies if my ventilation was difficult to achieve with these parameters in accordance with my institutitonal practices. My first option would be to consider continuing paralysis with cisatracurium. Other options would include prostacyclin and NO, prone positioning and possibly ECMO although this would depend on resource availablility.

In the first 24 hours I would aim for stabilisation of the respiratory status rather than a rapid de-escalation unless there is a clear reversible cause of comprimise such as transfusion associated cardiac overload.

Cardiovascular management I would establish appropriate central access preferably with an antibiotic coated multiple lumen CVC ideally via the internal jugular. I would avoid the subclavian in respiratory failure due to risk of pneumothorax. I would commence a noradrenaline infusion with a target MAP of >65, and consider using vasopressin if the noradrenaline requirements were high (1-2mg p'hr). I would perform a bedside ECHO and look for any evidence of gross pathology consistent with the history and presenting features such as massive PE and RV strain, myopathy secondary to chemo or a malignancy related pericardial effusion. If there were any suggestion I would request a formal ECHO and or investigate and manage as appropriate.

If the cardiovasular management was difficult I would consider instituting further monitoring with a transpulmonary or arterial wave analysis device and institute an appropriate inotrope.

Other Organs I would assess the renal function in terms of UO and creatinine and would institute renal replacement therapy in the event that there was a clear acute indication such as marked electrolyte disturbance or refractory acidosis. I would monitor the synthetic function of the liver and evidence of complications such as bleeding.

Haematological management I would ensure that the patient is placed in a positive pressure isolation room with appropriate contact precautions to reduce infection risk to the patient. I would remove all pre-exisitng catheters such as PICCs, IDC and cannula and replace if necessary. I would liase with the treating team regarding about the use of colony stimulating factors in this setting as their use is contraversial and get guidance regarding blood product replacement. I would discuss the recent infection profiles and attempt to fine tune the empirical antibiotic converage with ID. I would review all the previous micro results and assess the CMV status. I would attempt to establish evidence of GVHD and discuss this with haem.

Nitric Oxide and Prostacyclin in Respiratory Failure

Created Question Compare and contrast the advantages, disadvantages, indications and contraindications for the use of inhaled prostacyclin and nitric oxide for the treatment of severe hypoxaemic respiratory failure.

Inhaled Nitric Oxide (iNO)

Introduction

Inhaled nitric oxide (iNO) is a colorless, odourless gas and which freely crosses tissue membranes. It mediates cGMP production in smooth muscle to cause vasodilation.

iNO results in preferential pulmonary vasodilation and lowers pulmonary vascular resistance, augments hypoxic pulmonary vasoconstriction, and improves oxygenation.

Advantages

> Has been demonstrated to improve oxygenation in multiple clinical trials
> Reduces right heart strain

Disadvantages

> Despite improving oxygenation there is no compelling evidence that iNO improves outcomes
> Meta-analyses have demonstrated a significant increased risk in renal impairment (RR1.6)
> Accumulation may occur and result in methemoglobinaemia and acute lung injury
> Institutional costs for iNO are significant and there are ongoing costs
> Specific training is required to set the system up and the delivery machine and cylinders are large and cumbersome limiting space in the patient's room.

Indications

> Is indicated in neonates with pulmonary hypertension from either primary of secondary causes, has been described in the short term management of adults with pulmonary hypertension with right heart failure.
> May be indicated in adult severe hypoxaemic respiratory failure as a rescue therapy
> May be useful in patients with cardiorespiratory dysfunction secondary to an acute sickle cell crisis.

Contraindications

> Intra-cranial haemorrhage (relative)
> Bleeding diathesis (relative)
> Severe LV impairment (relative)

Prostacyclin (epoprostenol)

Introduction

It is presented as a powdered form for reconstitution with a sterile glycyine diluent.

Prostacyclin is a naturally occurring prostaglandin and, similarly, is a potent pulmonary vasodilator, which only reaches well-ventilated areas of the lung. It has similar actions to iNO but may also reduce platelet aggregation and inflammation.

Advantages

> Has similar effects on oxygenation and right heart strain to iNO
> Is significantly cheaper than iNO, with both reduced costs of set up and reduced ongoing costs.
> The physical size of the set up is greatly reduced compared to iNO (uses a nebuliser) and is therefore more convenient

Disadvantages

> Inhaled epoprostenol can cause systemic hypotension and tachycardia
> Inhaled prostacyclin is quite basic (pH ~10) and may cause coughing, bronchial irritation and rarely trachetitis
> Glycine may block the expiratory filter causing increased expiratory resistance
> There is very limited literature to support inhaled prostacyclin's use

Indications

> May assist as a rescue therapy in severe hypoxaemia
> May assist in acute RV dysfunction / pulmonary hypertension post cardiac surgeryas well as patients with severe pulmonary arterial hypertension

Contraindications

> Known allergy or sensitivity to epoprostenol Active pulmonary hemorrhage
> Secondary pulmonary artery hypertension (PAH) due to left ventricular systolic dysfunction
> Thrombocytopaenia (relative)
> Pregnancy (relative)

Non Invasive Ventilation (NIV)

Exam Date: 1/2004 Outline your approach to the use of NIV in the critically ill patient.

Statement

There is robust evidence to support the use of NIV in specific settings of hypoxic respiratory failure which reduces the need for endotracheal intubation and improves patient outcomes. Whilst often applied its use in other patient populations with hypoxic respiratory failure is more controversial.

Definition

Non invasive ventilation is defined as respiratory support without establishing a tracheal airway.

Physiological Rationale in Hypoxia

- Closed circuit therefore the fraction of inspired O2 may be controlled and accurately increased to 1.0
- Increased mean airway pressure improves oxygenation
- Improves V/Q matching via recruitment and reducing de-recruitment (increasing the FRC above the closing capacity)
- Improved CO2 clearance (via improved ventilation) increases alveolar oxygenation and therefore paO2
- Decreases work of breathing
- Reduces the after-load of the left and right ventricles (although in normal cardiac function NIV reduces CO and DO2)

Contraindications

- Respiratory arrest
- Unprotected airway
- Upper airway obstruction
- Inability to clear secretions
- Untreated pneumothorax
- Marked haemodynamic compromise

Evidence

There is strong evidence for NIV in COPD exacerbations with multiple RCTs and meta-analyses demonstrating reductions in need for intubation (RR 0.41), mortality (RR 0.52) reduced hospital length of stay and improved physiological values with NIV such as vital signs, pH and gas exchange. It is considered first line therapy for hypoxic respiratory failure caused by COPD exacerbations. NIV is also supported by RCTs for the extubation of patients with COPD, decreasing length of stay in hospital and ICU and improving 90 day survival.

Equally strong evidence exists for the use of NIV in acute cardiogenic pulmonary oedema. Meta-analyses have demonstrated that NIV significantly reduced hospital mortality (RR 0.66) when compared with standard care and intubation (RR 0.52) when compared with standard care.

There is also RCT evidence for the use of NIV in immunocomprimised patients where the infectious complications of intubation result in higher mortality when compared to immunocompetent patients.

The use of NIV in other patient populations with hypoxic respiratory failure is an ongoing source of debate. The use of NIV in immunocompetent patients with community acquired pneumonia is associated with a high failure rate and whilst many studies report improvements in physiological values there does not appear to be a change in mortality. Similarly the use of NIV in status asthmaticus is also not supported by the evidence however in appropriate settings with skilled staff (should the patient require intubation) a trial of NIV is not unreasonable.

Post pneumonectomy

Created Question A 65 year old male is admitted to the unit post right pneumonectomy. Outline the principles of initial management of this patient.

Introduction

Pneumonectomy, (especially right sided) is associated with increased morbidity and mortality when compared to other pulmonary resections. COPD, obesity and IHD are independent predictors of post pneumonectomy complications. The most common complications include atelectasis and pneumonia although rare complications such as the post pneumonectomy syndrome and bronchopleural fistula are a significant concern.

Management principles

> Ensure good handover from anaesthetic colleagues, review patient history and presentation

> General principles

- Patient should be seated in an upright position (up to 90 degrees)
- Do not roll the patient onto the left side

> Brief assessment of airway

> Respiratory

- Check respiratory rate, saturations, ABG and CXR
- If intubated review ventilator settings, minimise pressures, negative pressure ventilation is preferred to reduce risk of damage to surgical site and development of bronchopleural fistula, extubate when able
- Chest drain management
  - Should be off suction and underwater seal - as this will drain air from the empty chest cavity and shift the major chest structures causing tamponade
  - Double clamp but may be periodically unclamped under supervision
  - Should be monitored for blood loss
  - Aim to remove at around 24 hours post op
- Ensure good left sided chest expansion via inspection and auscultation
- Early chest physiotherapy as tolerated with antibiotics to prevent atelectasis and pneumonia (up to 25% of pts)

> Cardiac

- Check BP/HR identify risk of shock/SIRS response
  - May be masked when chest drain clamped - hence need to unclamp intermittantly
  - Avoid aggressive fluid resuscitation - aim to be very judicious - increased risk of pulmonary oedema
  - Use inotropes earlier if required
- ECG - correct electrolytes- note that theses patients have a ~ 20% risk of AF
- Check the JVP and the CVP
  - Right heart pressures will increase moderately and this may cause a shunt if PFO present, or RV impairment
  - Very high right sided pressures may represent cardiac herniation or tamponade
- Ischaemia occurs in up to 5% of patients - monitor troponins

> Neurological

- Assess for evidence of phrenic nerve damage (multiple procedures) or recurrent laryngeal nerve damage
- Pain management: will usually have pain buster or epidural in situ

> Other and supportive care

- Correct coagulation, monitor Hb, renal and liver function
- PO Feeding when swallow is OK, NG feeds otherwise,

Prone exam answer

2013/1 Critically evaluate the role of prone position in critically ill patients

Introduction

Prone position involvews placing patients in a ventral position and is one of several rescue therapies for patients with hypoxaemic respiratory failure

Rationale

> More homogenous distribution of ventilation without significant change in the perfusion distribution
> Possibly due to the changed position of the heart, the pressure of the abdominal contents on the diaphram, and the increased parenchyma in the dorsal regions of the lungs versus the ventral lung.
> There is a reduction in VQ mismatching and therefore improved oxygenation.
> Increased recruitment of the dorsal lung normally exceeds the derecruitment of the ventral lung
> More homogenous distribution of ventilation is believed to reduce the shearing stress to lung parenchyma
> Reduction in lung injury is the reason for the reported survival benefit in severe hypoxaemia

Technical issues

> Requires additional training for nursing and support staff
> More labour intensive
> Monitoring may be more difficult
> Increased risk of
  - ETT and line displacement
  - Pressure areas
> Contraindicated in raised ICP and intra-abdominal pressures

Evidence

> PROSEVA - severe ARDS (P:F <150) demonstrated improved oxygenation and mortality
> Meta-analysis 2014 incl PROSEVA with total of 2250 patients
  - mortality benefit (NNT 16) and a greater benefit in more severe patients
  - Increased risk of pressure areas and major adverse airway events (without fatality)

My practice

> I would support the introduction of prone positioning in my unit
> and/or would advocate for involvement in a well designed RCT in my ICU to replicate the results of PROSEVA
> I would not use proning in an institution unfamiliar with the technique unless backed by a comprehensive training program and rollout.

Ventilation and Perfusion Physiology

2/2014 Describe the effects of V/Q inequality on the partial pressure of oxygen (PaO2) and carbon dioxide (PaCO2) in arterial blood.

Normal values

The normal value of PaO2 in a patient beathing room air at sea level is 90-105 mmHg

PaCO2 is regulated within a tight range by the body to a value of 35-45 mmHg

Ventilation and Perfusion

Whilst the blood flow (Q) and ventilation (V) to the lungs is roughly equal each usually between 4-5 litres, in different parts of the lung they are not necessairly equally matched.

The effect of gravity which is the most important factor for both V and Q although is more signicant in terms of perfusion

Variable time constants in (primarily in the diseased lung) may also cause variability in ventilation

V/Q Scatter

The differences in V and Q due to gravity leads to a scatter of V/Q ratios which is exacerbated in older subjects even in the absence of lung disease. V/Q ratios at the apex of the lungs (where ventilation is relatively greater than perfusion) has values of 3.3, at the base (where perfusion dominates) is 0.6 in normal subjects.

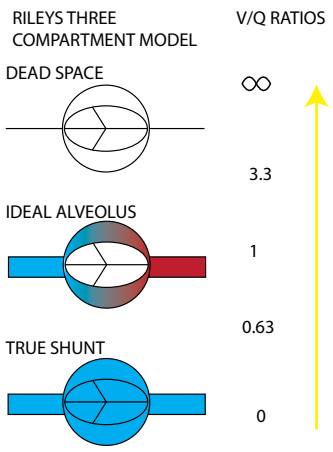
Dead Space

In pathologial states alveolus may receive no perfusion and thus forms part of the physiological dead space. Examples of this include a pulmonary embolism, or a sudden decrease in cardiac output resulting in decreased perfusion to the apicies. The V/Q ratio will approach infinity.

Shunt

If the alveolus receives no ventilation it represents a form of true shunt and the V/Q ratio will be 0.

Consequences and Management



CONSEQUENCE	TREATMENT
Decreased perfusion leads wasted ventilation therefore decreased minute alveolar ventilation & leads primarily to increased blood CO2	Increased tidal volumes will reduce the effect of dead space (note that Alveolar Vent = TV - PDS)
V/Q scatter leads to decreased PaO2 because a majority of mismatch flow is at ratios < 1 and a small drop is acentuated by the point on the Hb dissociation curve	Increased FiO2 will improve oxygenation unless the V/Q ratio is 0 (true shunt). High FiO2 will remove the V/Q scatter effect.
Shunt leads to both ↑CO2 and ↓O2 but the decrease in PO2 is more pronounced because it is on the flat of the dissociation curve and the CO2 dissociation is near linear	Improved recruitment may work unless the shunt is extra-pulmonary. ↑FiO2 is decreasingly effective in true shunts > 30%

Ventilator associated lung injury

2012/1 Outline the potential mechanisms of ventilator associated lung injury in patients with Acute Respiratory Distress Syndrome and the steps that can be taken to minimise them.

Definition

ARDS is defined by

> Acute onset of less than 1 week
> Bilateral opacities not fully explained by effusions, collapse or nodules
> Respiratory failure not fully explained by cardiac failure
> Impaired oxygenation with at least 5cmH2O of PEEP (characterised by PaO2 to FiO2 ratio)
  - Mild P:F < 300, Moderate <200, Severe <100

Mechanisms of injury

Gross barotrauma (high transpleural pressure)

> Pneumothorax, Pneumomediastinum, Subcutaenous emphysema

Volutrauma (absolute change in lung volumes)

> Leading to overdistention of the alveolar units
> Pulmonary oedema
> Shear stress between lung areas with different time constants

Atelectrauma

> Caused by the opening and closing of alveolar units leading to damage and stress

Oxygen toxicity

> Lorrain Smith effect where high FiO2 causes lung damage

Biological damage

> Release of inflammatory mediators
> Increased vascular permiability and distruption of basement membranes

Management strategies

> Gross barotrauma is reduced by limiting the overall pressures, it should be noted however that it is there transpleural pressure that is the most important and in some patients with poor pleural and chest wall compliance increased pressures may be required
> Volutrauma
  - reduced by ensuring low tidal volumes in keeping with the ARDSnet studies, generally aiming for 4-8ml/kg.
  - Increasing inspiratory time and using pressure control methods (with volume limiting) may ensure a more even distribution of ventilation in diseased lungs with different time constants
  - Permissive hypercapnoea accepts lower total ventilation to protect the lungs
> Atelectrauma
  - Reduced with maintaining a high level of PEEP usually around 10cm H2O but at times up to 15cm.
  - Recruitment manouvres using a ladders such as the PHARLAP protocol or 40cm for 40 seconds also ensure more alveolar remain open
  - Prone positioning has demonstrated mortality benefit
> Oxygen toxicity is reduced by targeting lower saturations and paO2 such as a PaO2 of 55-65 and sats of 90%.
> Options to reduce biological trauma remain experimental

Lists in Respiratory

Types of hypoxia

> Hypoxic hypoxia - inadequate oxygen delivery eg. altitude, lung pathology or big shunt
> Anaemic hypoxia - inadequate Hb to transport O2
> Stagnant hypoxia - poor perfusion states
> Histotoxic hypoxia - classically described in cyanide poisoning when the electron transport chain is damaged

Complications of tracheostomy

Immediate

> Procedural complications
  - Haemorrhage
  - Surgical emphysema, pneumothorax, air embolism
  - Cricoid cartilage damage
> Misplacement in pretracheal tissues or right main bronchus
> Compression of tube lumen by cuff herniation
> Occlusion of the tip against the carina or tracheal wall

Delayed

> Blockage with secretions
> Infection of the tracheostomy site, tracheobronchial tree, and
> larynx
> Pressure on tracheal wall from the tracheostomy tube or cuff
  - Mucosal ulceration and perforation
  - Deep erosion into the innominate artery
  - Tracheo-oesophageal fistula

Late

> Granulomata of the trachea
> Tracheal and laryngeal stenosis
> Persistent sinus at tracheostomy site
> Tracheomalacia and tracheal dilatation

Clinical conditions associated with acute upper airway obstruction

Functional causes

> Central nervous system depression
  - Head injury, cerebrovascular accident, cardiorespiratory arrest, shock, hypoxia, drug overdose, metabolic encephalopathies
> Peripheral nervous system and neuromuscular abnormalities
  - Recurrent laryngeal nerve palsy (postoperative, inflammatory or tumour infiltration), obstructive sleep apnoea, laryngospasm, myasthenia gravis, Guillain–Barré polyneuritis, hypocalcaemic vocal cord spasm

Mechanical causes

> Foreign body aspiration
  - Infections
  - Epiglottitis, retropharyngeal cellulitis or abscess, Ludwig's angina, diphtheria and tetanus, bacterial tracheitis,

laryngotracheobronchitis

> Laryngeal oedema
  - Allergic laryngeal oedema, angiotensin-converting enzyme inhibitor associated, hereditary angioedema, acquired C1 esterase deficiency
> Haemorrhage and haematoma
  - Postoperative, anticoagulation therapy, inherited or acquired coagulation factor deficiency
> Trauma
> Burns
  - Inhalational thermal injury, ingestion of toxic chemical and caustic agents
> Neoplasm
  - Pharyngeal, laryngeal and tracheobronchial carcinoma, vocal cord polyposis
> Congenital
  - Vascular rings, laryngeal webs, laryngocele
> Miscellaneous
  - Cricoarytenoid arthritis, achalasia of the oesophagus, hysterical stridor, myxoedema

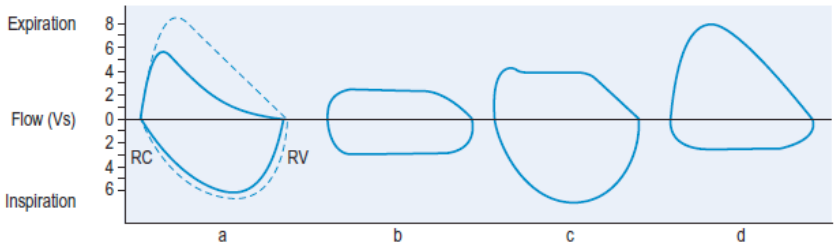


Figure 29.3 Flow–volume loops. Patterns resulting from different pathological lesions: (a) lower airway obstruction (e.g. chronic obstructive pulmonary disease or asthma); (b) fixed, non-variable upper airway obstruction (e.g. fibrous ring in trachea); (c) variable upper airway obstruction, intrathoracic (e.g. tumour in the lower trachea); (d) variable upper airway obstruction, extrathoracic (e.g. vocal cord tumour or paralysis).

Complications of intubation and mechanical ventilation

Equipment

> Malfunction or disconnection
> Incorrectly set or prescribed
> Contamination

Pulmonary

> Airway intubation (e.g. damage to teeth, vocal cords, trachea)
> Ventilator-associated pneumonia (reduced lung defence)
> Ventilator-associated lung injury (diffuse lung injury due to regional overdistension or tidal recruitment of alveoli)
> Overt barotrauma (e.g. pneumothorax)
> O2 toxicity
> Patient–ventilator asynchrony

Circulation

> Reduced right ventricular preload and reduced cardiac output
> Increased right ventricular afterload (if the lung is overdistended)
> Reduced splanchnic blood flow with high levels of positive endexpiratory pressure (PEEP) or mean Paw
> Increased intracranial pressure with high levels of PEEP or mean Paw
> Fluid retention due to lower cardiac output and impaired renal blood flow

Other

- Gut distension (air swallowing, hypomotility)
- Mucosal ulceration and bleeding
- Peripheral and respiratory muscle weakness
- Sleep disturbance, agitation and fear (which may be prolonged after recovery)
- Neuropsychiatric complications

Suspected aeitologies for different pneumonias CXR in immunocomprimised

Diffuse infiltrate

- CMV and other herpes viruses
- Pneumocystis carinii
- Bacteria
- Aspergillus (advanced)
- Cryptococcus (uncommon)
- Non-infectious causes, e.g. drug reaction, non-specific interstitial pneumonitis, radiation pneumonitis (uncommon), malignancy, leucoagglutinin reaction

Focal infiltrate

- Gram-negative rods
- S. aureus
- Aspergillus
- Cryptococcus
- Nocardia
- Mucor.
- Tuberculosis
- Legionella
- Non-infectious causes (e.g. malignancy, non-specific interstitial pneumonitis, radiation pneumonitis)

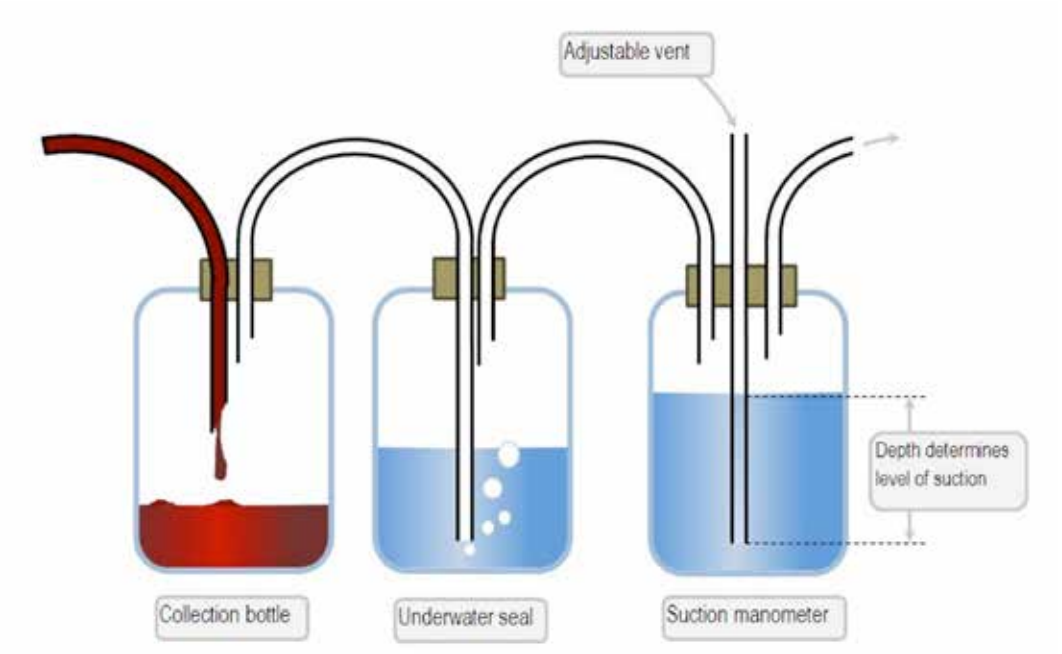


Table 35.1 Assessment of asthma severity

	MILD	MODERATE	SEVERE
Conscious state	Alert, relaxed	Anxious, difficulty sleeping	Agitated, delirious
Speech	Sentences	Phrases	Words
Accessory muscles	Nil	Mild	Significant sitting upright
Wheeze	Moderate	Loud	Loud or silent
Pulse rate (BPM)	<100	100–120	>120
Peak expiratory flow (% predicted)	>80%	60–80%	<60%
Pa_{CO_2} (mmHg) (kPa)	<45 (5.98)	<45 (5.98)	>45 (5.98)

Contraindications and complications of NIV

Contraindications

- Respiratory arrest
- Unprotected airway (coma, sedation)
- Upper airway obstruction
- Inability to clear secretions
- Untreated pneumothorax
- Marked haemodynamic instability
- Facial trauma or recent ENT surgery
- Recent oesophagectomy

Complications

- Mask discomfort, patient intolerance
- Facial or ocular abrasions
- Nasal congestion, sinus pain
- Oronasal dryness
- High intraocular pressure (particularly in patients with glaucoma)
- Increased Intracranial pressure (particularly in patients with neurotrauma)
- Hypotension (if hypovolaemic)
- Aspiration pneumonia (rare)
- Aerophagy and gastric distension (uncommon; routine gastric decompression is unnecessary)

Factors that decrease vital capacity

Decreased muscle strength

- Myopathy
- Neuropathy
- Spinal cord injury

Reduced lung compliance

- Pulmonary oedema

- Atelectasis
- Pulmonary fibrosis
- Loss of lung tissue

Reduced chest wall and diaphragm compliance

- Kyphoscoliosis
- Burns
- Obesity
- Ascites and other intra-abdominal patholology

Increased residual volume

- Gas trapping due to COPD or asthma

Reduced total lung volume

- Previous pneumonectomy or lobectomy
- Pleural effusion
- Haemothorax
- Pneumothorax
- Atelectasis

Cardiology and Cardiovascular surgery

Cardiopulmonary Bypass Complications

2011/2 List the complications and their likely underlying mechanisms specifically related to cardiopulmonary bypass that may be seen in the Intensive Care Unit following cardiac surgery.

Cardiovascular complications

Mechanical complications

> Tamponade of the heart due to bleeding causing hypotension
> Prosthetic valve leak causing incompentance and hypotension/pulmonary oedema/right heart failure
> Systolic anterior motion of the mitral valve causing impaired outflow from the LVOT and hypotension
> Spasm of a coronary graft causing acute ischaemia

Physiological complications

> Inadequate preload
  - Reduced vascular tone due to systemtic inflammatory response is induced by
    - nonendothelialized circuit
    - pulmonary and myocardial reperfusion injury
    - formation of heparin-protamine complexes stimulate the release of proinflammatory mediators
  - Hypovolaemia due to blood loss or inadequate post bypass resuscitation
> Excessive afterload - characterised by increased vascular tone due to cooling
> Decreased inotropy - which may be due to ischaemia, poor premorbid function, myocardial stunning

Dysrhythmias

> Atrial Fibrillation
> Ventricular arhythmias
> Brady arhythmias - due to injury or oedema to the conduction system

Metabolic complications

> Hypothermia post bypass / exposure
> Deranged electrolytes, pH

Respiratory complications

> Atelectasis due to lung deflation during surgery, phrenic nerve injury, poor spontaneous inspiration due to pain
> Pneumonia associated with ventilator use, atelectasis, poor cough and mucocillary transport
> Acute lung injury - due to systematic inflammation and cytokine release, associated with transfusion
> Increased pulmonary vascular resistance due to protamine complexes

Neurological complications

> Stroke may occur due to dislodged calcium or clot, watershed infarcts may occur due to transient hypoperfusion
> Delerium and decreased cognitive function may also occur for multifactorial reasons

Renal complications

> Dysfunction associated with decreased renal perfusion, non pulsitile flow, boderline pre PCB function

Haematological complications

> Bleeding
  - Surgical causes - from surgical sites
  - Medical causes - from impaired coagulation (platelets, fibrinogen, factors) haemodilution, low temp, low pH
> Thrombosis - DVT, PE, CVA, peripheries (toes, fingers), mesentry, coronary vessels

Aortic dissection diagnosis

2012/1 Q13 Outline the advantages and disadvantages of a CT scan, Transoesophageal echocardiography, MRI and an aortogram for the evaluation of suspected aortic dissection.

Aortogram

Advantages

> High sensitivity (86-88%) and specificity (75-94%)
> Can detect blocked coronaries in Type A dissection

Disadvantages

> Not easily available and time consuming, Large contrast load
> Ineffective in detecting intramural haematoma, false negative results when a thrombosed false lumen prevents contrast entry
> Slightly lower sensitivity and specificity than TOE, CT or MRI; has been largely replaced by them.

CT

Advantages

> Easily available, quick, high sensitivity (83-94%) and specificity (87-100%)
> Information about end-organ ischaemia
> Imaging of the vascular tree allows planning of surgical or endovascular approach
> Able to exclude conditions which mimic aortic dissection

Disadvantages

> Contrast exposure
> No information about the valves, motion artefact may also be an issue
> Risk of transfer to CT

MRI

Advantages

> High sensitivity and specificity (95-100% for both)
> Contrast is less nephrotoxic
> Information about end-organ ischaemia
> Imaging of the vascular tree allows planning of surgical or endovascular approach

Disadvantages

> Significant risk of transfer, duration of scan > CT, Not easily available
> Certain patient groups excluded (eg. recent trauma with surgical staples)
> Often fails to characterize the relationship of an intimal flap & aortic root structures, specifically the coronary art

TOE

Advantages

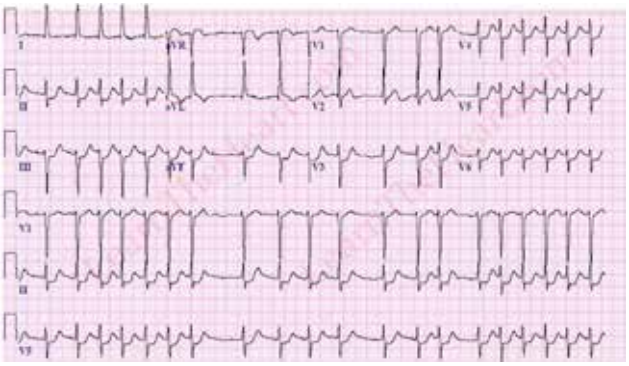
> Can assess valves, tamponade, proximal coronaries, intramural haematoma
> No transfer and no contrast
> Decent sensitivity (35-80%) and specificity(39-96%)

Disadvantages

> Invasive and operator dependent
> Requires sedation, potential intubation and may cause hypertensionchea/left main bronchus between the oesophagus and aorta

Atrial fibrillation post AVR

2012/2 A 71-year-old man is transferred to your intensive care unit following a mechanical aortic valve replacement and coronary artery bypass surgery. The anaesthetist reports that he came off bypass readily, has not required any inotropic support, and has epicardial pacing wires in situ. However, shortly after arrival his blood pressure falls to 60/30. Twenty four hours later, he develops a new-onset tachycardia as shown in the ECG below. a) What is your interpretation of the ECG? b) Outline your initial management of the tachycardia b) List 3 primary non-cardiovascular causes of the above tachycardia



ECG interpretation

> Atrial fibrillation with increased ventricular rate (100-160)
> Probable LVH

Management of post cardiac surgery AF

Patient assessment

> Brief assessment of airway
> Ascultate chest for evidence of rate related failure, sats, RR, ABG
> Check blood pressure ?unstable arrythmia, listen to heart for murmurs, ultrasound probe to rule out tamponade
> Pain management
> Check electrolyes
> Review notes for past hx of same

Management

> Ensure adequate ventilation and afterload (BP support) to enable oxygen delivery to the cardiac myocytes
> 10mmol of Mg empirically target Mg of >1.0 and potassium of >4.0
> If remains in AF after several hours consider chemical cardioversion - sotalol or amiodarone
> Rate control with metoprolol or a shorter acting agent such as esmolol
> Electrical cardioversion is an option if unstable although has a reasonably high chance of reverting
> Atrial pacing is a good preventative option and has been shown to reduce incidence of post surg AF
> Long term AF - assess CHADS2 score, stratify risk and consider anticoagulation

Other causes of AF

> Hyperthyroidism
> Alcohol binge
> Sepsis /Pneumonia

Central Venous Pressure

Created Question a) List the determinants of central venous pressure (CVP) b) Discuss the role of CVP monitoring in the critically ill.

Definitions

Central Venous Pressure is the pressure measured in the great veins as they enter the right atria

Determinants

> Pressure = flow x resistance
> Determinants of flow
- Volume status
- Venous return to the heart (=cardiac output)
- RV function
- Tricuspid and pulmonary valve function
- LV function (lesser importance)

> Determinants of resistance
- Venous constriction
  - Sympathetic tone
- Pulmonary artery constriction
  - Hypoxic pulmonary vasoconstriction
  - Pulmonary hypertension (primary/secondary)
  - Pulmonary embolism

> Transmitted pressure
- Decreased intrathoracic pressure - inspiration
- Increased intrathoracic pressure - valsalva, PPV, tension PTx, cardiac tamponade, constrictive pericarditis

Role of CVP monitoring

> Except at extremes, mean CVP as an isolated number is of limited utility
- Although often adovcated as a surrogate for preload multiple studies have demonstrated poor correlation
- A markedly elevated CVP however supports the dx of tamponade or contrictive pericarditis in appropriate pts

> A CVP trend over hours in a patient may be useful in guiding fluid therapy although this remains controversial
> Second to second CVP variation (characterised by the a, c and v wave morphology) is useful to determine
- Line placement for CVC, Swan and Pacing wire insertion
- Valvular dysfunction expecially TV and PV
- Right heart infarction

My practice

I find the CVP useful in assisting in line placement especially Swan catheters and pacing wires. I do not use the CVP in isolation as a measure of fluid responsiveness and would not insert a CVC with the sole reason of measuring the CVP. I will however use a CVP trend as one of the many components in determining the overall gestalt of a patient's cardiac and fluid status especially in patients following cardiac surgery.

Circulation status and O2 extraction ratio

2012/2 1. List the techniques / measurements that are available to assess the circulation status of a patient in the intensive care unit. 2.a) How do you calculate the oxygen extraction ratio (O2ER)? b) In a patient with septic shock, how would you interpret the following values for the oxygen extraction ratio (O2ER): (i) O2ER = 0.5 (ii) O2ER = 0.2

Circulation status

Physical examination

> Peripheral perfusion indicators - temp of hands and feet, evidence of mottling, colour of peripheries
> Evidence of hypervolaemia - peripheral/sacral oedema, coarse crepitations at lung bases, raised JVP, pulsitile liver
> Evidence of hypovolaemia - dry mucous membranes, skin turgur, sunken eyes, fontanelle in babies, urine colour
> Vital signs - HR, BP, UO, urine dipstick, pulse oximetry

Invasive monitoring

> Central venous pressure - in combination with other parameters
> Arterial pressure - stroke volume variation (intubated patients on mandatory ventilation), GEDI
> Thermodilution measurements of cardiac output
  - Pulmonary artery catheter measurement
  - Transpulmonary techniques
> Combination methods - global end diastolic volume index, extra-vascular lung water index
> Oxygen saturation monitoring
  - Serial ABGs
  - Central venous O2 saturations
  - Mixed venous O2 saturations
  - Microvascular perfusion

Non-invasive monitoring

> Transthroracic ECHO - IVC collapsability, LV filling and ejection fraction
> Transcutaneous doppler
> Cardiac impendance monitoring
> Near infrared oxygen saturations

Oxygen extraction ratio

It represents the amount of O2 extracted during one circulation through the peripheral vascular bed

It is the SaO_2 - MVO_2

The normal value is 25% (MVO_2 usually = 75%)

Delivered O_2 = Heart Rate x Stroke Volume x (1.36 x Hb x O_2 saturation + 0.03 x paO_2)

In the event of an O_2 ER of 0.5 is either due to increased extraction - due to a hypermetabolic state (sepsis, inflammation) and/or decreased O2 delivery. I would assess the patient for the hypermetabolic causes and look at the components of the delivered O_2 equation (cardiac output, Hb, O2 saturation) to identify the problem and then attempt to correct this.

In the event of an O_2 ER of 0.2 is usually due to decreased extraction - and may be as a result of shunting at the vascular bed.

Digoxin use in ICU

Created Question With respect to the use of digoxin in the ICU:

> a) What key cardiac effects are observed with acute digoxin toxicity? List two rhythm disturbances highly associated.

> b) List three drugs known to enhance digoxin serum level. Provide a mechanism for each.

> c) Other than drugs, what other factors are known to exacerbate digoxin toxicity?

> d) With respect to the use of digoxin specific Fab fragments:

> i) Outline your indications for use in suspected acute digoxin toxicity.

> ii) Total serum digoxin level continues to remain high after the administration of an appropriate dose of digoxin specific Fab fragments. What action would you take and why?

A **Digoxin toxicity** the key cardiac effects are manifested by a diverse range of arrhythmias usually bradycardia and premature ventricular complexes but also any type of AV block, ventricular tachycardias, junctional rhythms and bigemini.

B **Amiodarone** inhibits p-glycoprotien actions (which cause digoxin efflux into the gut and kidney) thereby increases digoxin levels

Spironolactone decreases renal tubular secretion of digoxin and interferes with most digoxin assays

Verapamil impairs both metabolism and secretion (via the same mechanism as amiodarone)

C Other proarrhythmogenic factors:

> Previous cardiac surgery or ischaemia

> Electrolyte disturbances - hyper and hypokalaemia, hyper and hypocalcaemia, hypomagnesaemia

> Physiological extremes - hyper and hypothermia, dehydration, low pH

> Renal failure increases levels (as most digoxin is secereted unchanged)

Di Digoxin specific Fab fragments

Fab fragments should be given in all cases of severe digitalis poisoning, as there is no alternative therapy with comparable efficacy and safety. Fab fragments be given to patients with digitalis toxicity and any of the following:

> Life-threatening or hemodynamically unstable arrhythmia (eg, ventricular tachycardia; ventricular fibrillation; asystole; complete heart block; Mobitz II heart block; symptomatic bradycardia)

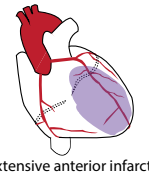
> Hyperkalemia (serum potassium >5 to 5.5 meq/L [>5 to 5.5 mmol/L])

> Evidence of end-organ dysfunction from hypoperfusion (eg, renal failure, altered mental status)

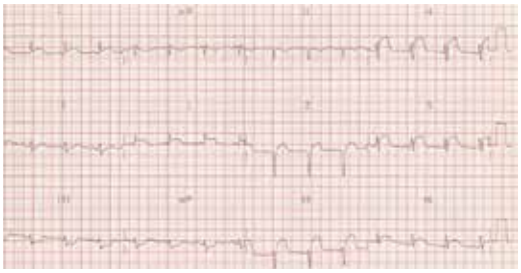
II After Fab administration free Digoxin levels are decreased to zero within minutes. Total Digoxin level will increase markedly since assays measure bound and free. Bound fraction rises due to an increase in Digoxin-Fab complex. These high levels have no correlation with toxicity and the serum level may be unreliable for several days and no action should be taken based on total level after digoxin-specific Fab fragments administration.

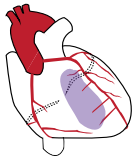
ECG Cheat Sheet

Patterns of myocardial injury

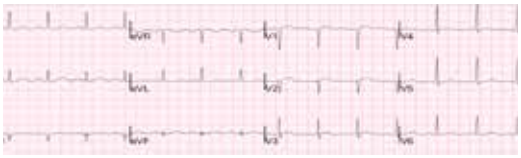

Extensive anterior infarct

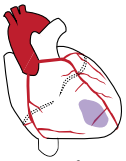
Extensive anterior infarct is caused by occlusion of the LAD proximal to both the initial septal and diagonal branches. There are Q waves and ST elevation (acute) in V1-V6, aVl and sometimes lead I.



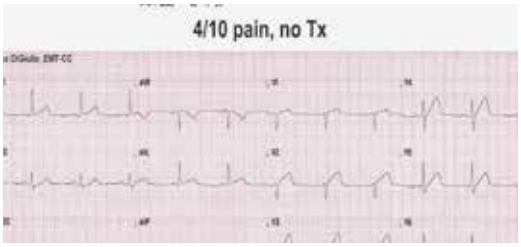

Septal infarct

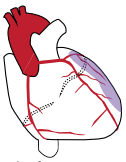
Septal infarction is caused either by occlusion of septal branches or LAD distal to origins of the diagonal branches. The ECG shows Q waves and ST elevation in leads V1 and V2.



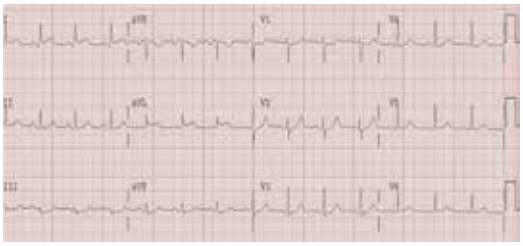

Mid-anterior infarct

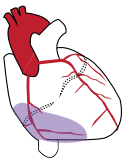
Mid anterior infarction occlusion of the first diagonal branch of the LAD. ECG shows abnormal Q waves in leads aVL and sometimes I but not in leads V5 and V6. A Q wave in leads V2 and V3 may be present.



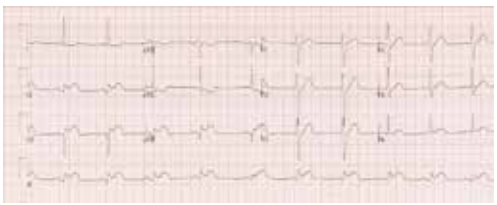

Lateral infarct

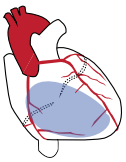
Lateral infarction is caused by occlusion of branches of the left anterior descending (LAD) and left circumflex (LCx) arteries and produces ST elevation in the lateral leads (I, aVL, V5-6). Reciprocal ST depression in the inferior leads (III and aVF).



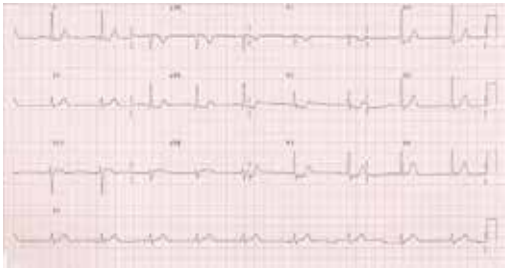

Inferior infarct

Inferior Infarction due to occlusion of the dominant RCA (80%) or dominant LCx (20%). These infarcts produce Q waves and ST elevation in leads II, III, and VF but without increased R waves in leads V1 and V2. There may be STR depression in aVL




Posterior infarct

Posterior infarction is usually due to either an RCA or LCX occulsion. ECGs demonstrate Septal ST depression as well as tall, broad R waves (>30ms), upright T waves and a dominant R wave (R/S ratio > 1) in V2



Heart block patterns

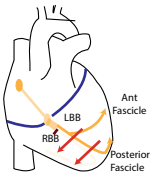
First degree heart block PR interval > 200ms (five small squares)

Second degree heart block

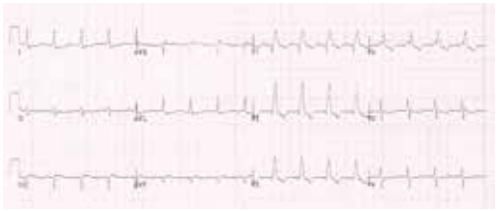
> Mobitz I - progressive lengthening of PR then dropped beat due to reversible conduction at AV node

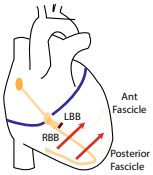
> Mobitz II - Intermittent non-conducted P waves without progressive prolongation of the PR interval usually due to structural damage to HIS-Purkinje. Usually requires PPM

Third degree heart block - dissociation at AV node

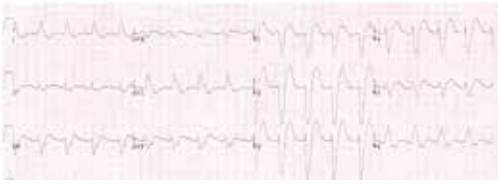


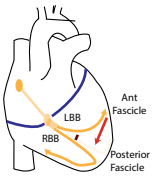
RBBB - QRS > 120 ms, RSR' pattern in V1-3 ('M-shaped' QRS complex), Wide, slurred S wave in the lateral leads (I, aVL, V5-6. Normal axis



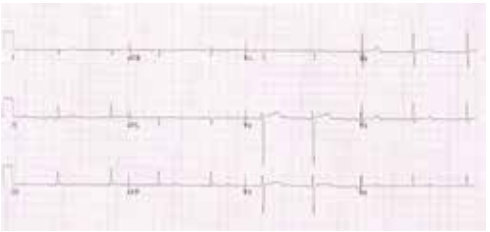


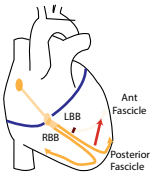
LBBB - QRS > 120 ms, Dominant S wave in V1, Broad monophasic R wave in lateral leads (I, aVL, V5-V6), Absence of Q waves in lateral leads (I, V5-V6; small Q waves are still allowed in aVL)



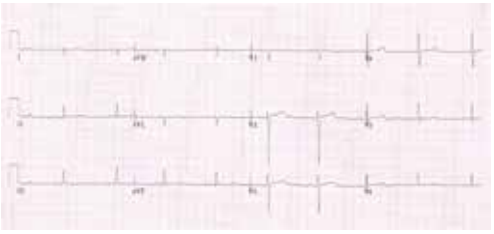


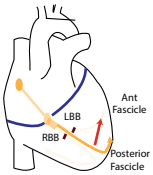
Left posterior fascicular block Demonstrates right axis deviation (> +90 degrees) Small R waves with deep S waves (= 'rS complexes') in leads I and aVL Small Q waves with tall R waves (= 'qR complexes') in leads II, III and aVF. QRS duration normal or slightly prolonged (80-110ms. Prolonged R wave peak time in aVF Increased QRS voltage in the limb leads



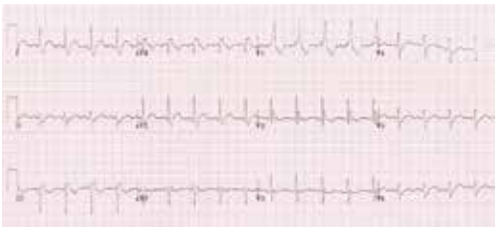


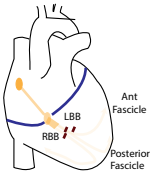
Left anterior fascicular block Demonstrates left axis deviation (usually between -45 and -90 degrees). Small Q waves with tall R waves (= 'qR complexes') in leads I and aVL. Small R waves with deep S waves (= 'rS complexes') in leads II, III, aVF. QRS duration normal or slightly prolonged (80-110 ms)



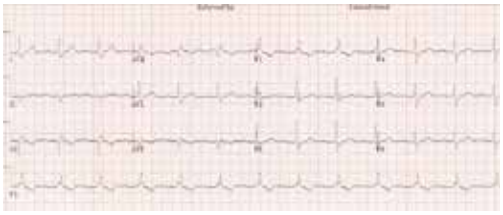


Bifascular block is a RBBB with LPFB or LAFB. and therefore is a RBBB with an axis deviation. Ventricular conduction is via the remaining fascicle.



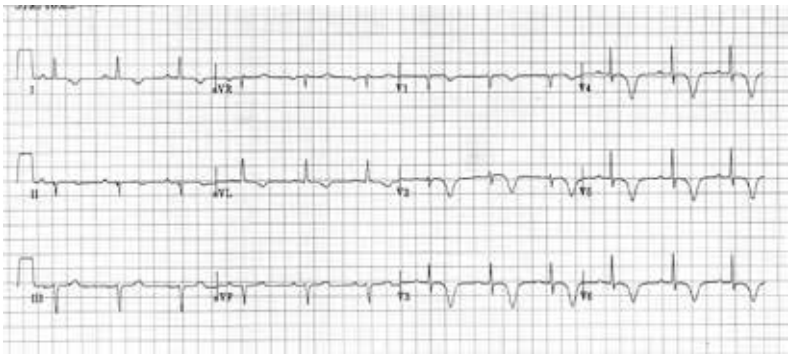


Trifascicular block is when all three conduction pathways are blocked and can be complete or incomplete. Incomplete is bifascicular block with prolonged PR. Complete is bifascicular block with complete heart block.

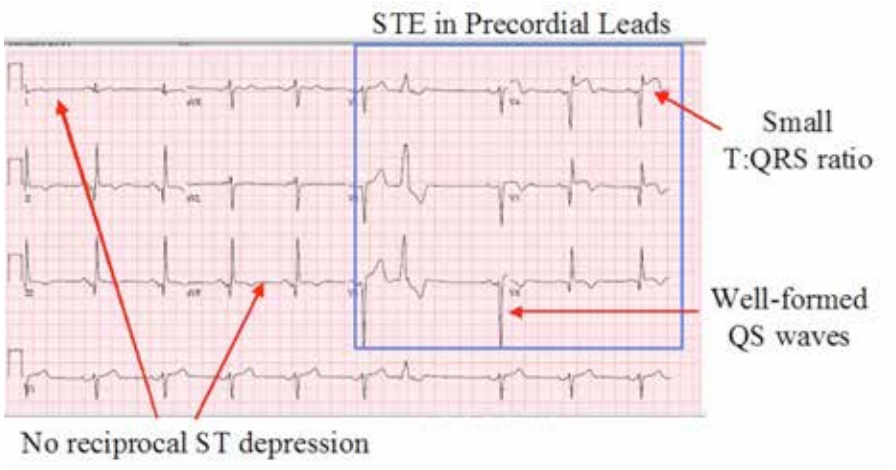


Spot diagnoses

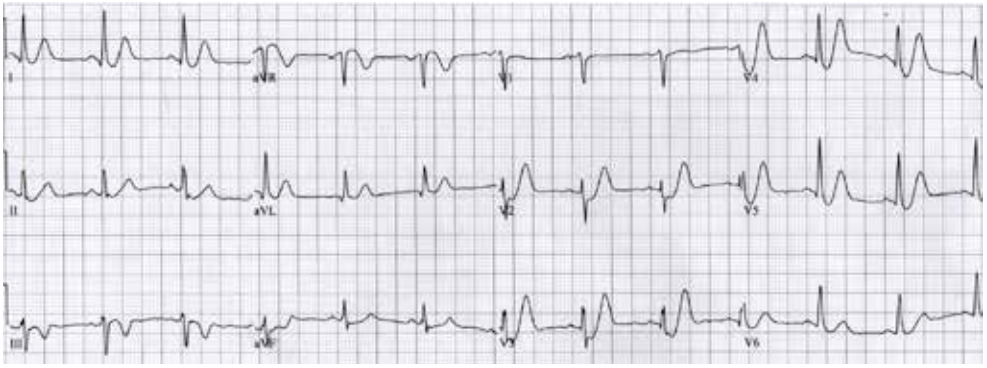
Wellen's Syndrome is a pattern of deeply inverted or biphasic T waves in V2-3, which is highly specific for a critical stenosis of the left anterior descending artery (LAD). Due to the critical LAD stenosis, these patients usually require invasive therapy, do poorly with medical management and may suffer MI or cardiac arrest if inappropriately stress tested.



Left ventricular aneursym Persistent ST elevation following an acute myocardial infarction.

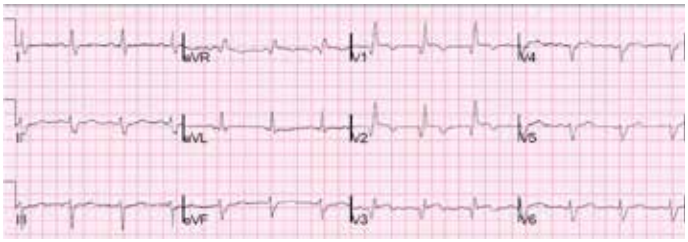


De Winter's Waves anterior STEMI equivalent that presents without obvious ST segment elevation. Key diagnostic features include ST depression and peaked T waves in the precordial leads. The de Winter pattern is seen in ~2% of acute LAD occlusions and is under-recognised by clinicians



ECGs 1

Created question Part 1 A 65-year-old male esents to the Emergency Department (ED) with persisting chest pain for one week, following an acute severe episode that lasted for two hours. His 12-lead ECG, (ECG 1), taken on presentation to ED, is shown below. a) Describe the ECG changes. b) What is the most likely diagnosis? The patient develops worsening chest pain and becomes more tachypnoeic and hypotensive. c) Give two likely causes for this deterioration.



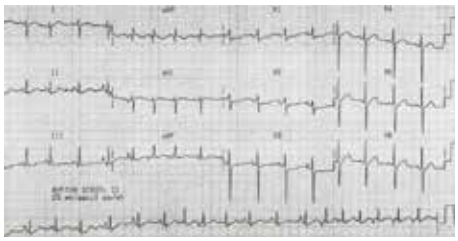
> a) Sinus, regular, rate 75, left axis deviation, deep Q waves in V1-V3, slightly widened QRS, ST segment elevation in V1-V5, TWI V1-2

> b) Acute anterior lateral myocardial infarction likely due to LAD stenosis/occulsion

> c) Acute LV failure due to ischaemia with poor forward flow and pulmonary oedema, Ventricular tachyarrhythmia classically associated with LAD occlusions and subsequent impaired output.

Part 2

> A 75-year-old female admitted to the ICU with community-acquired pneumonia suddenly develops a tachycardia. Her 12 lead ECG is shown below

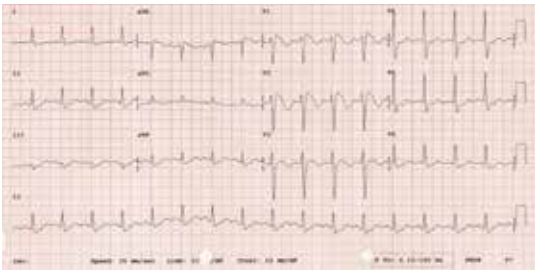


> a) Multifocal atrial tachycardia

> b) COPD and congestive cardiac failure

Part 3

A 45-year-old male has been admitted to the hospital for investigation of syncope. He has a MET call for another syncopal episode. His 12 lead ECG is shown below (ECG 2). a) Describe the ECG changes. b) What is the most likely diagnosis?c) What is the underlying pathophysiology? d) List four clinical situations that can worsen this condition.



> a) Coved ST segment elevation V1 – V2 > 2 mm, Subsequent negative T wave in the same leads.

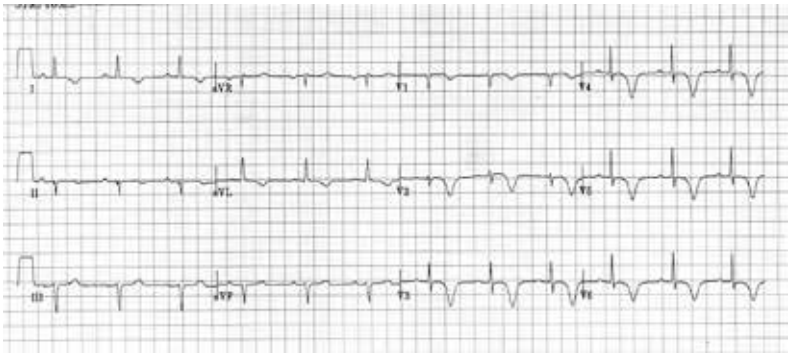
> b) Brugada syndrome (Type 1).

> c) A mutation in the cardiac sodium channel gene.

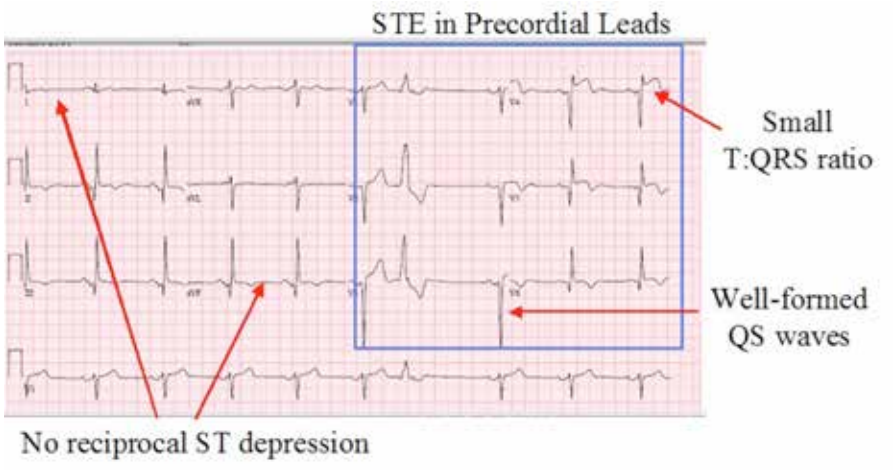
d) Fever, MI, Medications (Flecainide, Amitriptyline, Lithium, Bupivacaine, Propofol, Alcohol), Hypokalaemia, Hypothermia, Cardioversion

Spot diagnoses

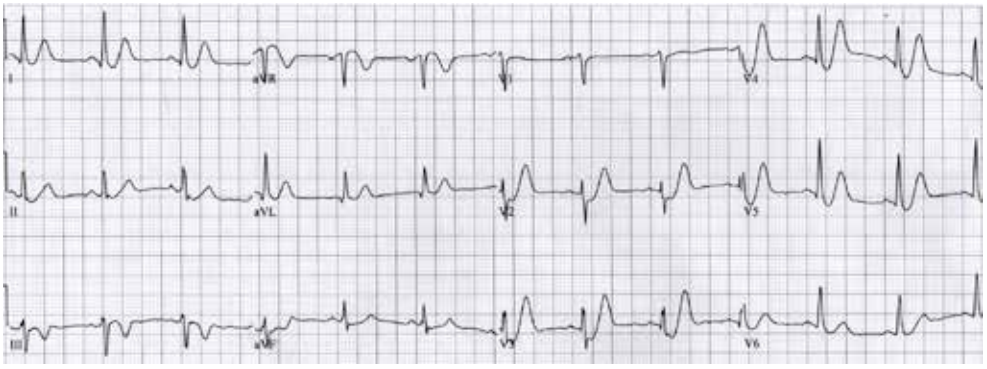
Wellen's Syndrome is a pattern of deeply inverted or biphasic T waves in V2-3, which is highly specific for a critical stenosis of the left anterior descending artery (LAD). Due to the critical LAD stenosis, these patients usually require invasive therapy, do poorly with medical management and may suffer MI or cardiac arrest if inappropriately stress tested.



Left ventricular aneursym Persistent ST elevation following an acute myocardial infarction.



De Winter's Waves anterior STEMI equivalent that presents without obvious ST segment elevation. Key diagnostic features include ST depression and peaked T waves in the precordial leads. The de Winter pattern is seen in ~2% of acute LAD occlusions and is under-recognised by clinicians



Aortic regurgitation versus Mitral Stenosis

2013/1 In each part of this question, list clinical examination findings for each of the two underlined conditions that would help you to distinguish between them: Aortic regurgitation or mitral stenosis as the cause of a patient's diastolic murmur.

Aortic Regurgitaion

- Collapsing pulse / wide pulse pressure
- Decrescendo murmur heard over left 3rd intercostal space parasternally
- Murmur loudest sitting forward in expiration
- Signs associated with large pulse volume and peripheral vasodilation; eg Corrigans, De Musets. Quinckes, Duroziez.
- Evidence of associated conditions; Infective endocarditis, ankylosing spondylitis, other seronegative arthropathies, Marfans.
- Soft 2nd heart sound
- 3rd heart sound
- Displaced apex beat
- Signs of LV failure

Mitral stenosis

- Malar flush
- Atrial fibrillation
- Small pulse pressure
- Loud 1st heart sound
- Opening snap
- Low-pitched, rumbling diastolic murmur over apex loudest in left lateral position
- Pulmonary hypertension

Cardiac Murmurs Descriptions

Pan-systolic murmurs

These tend to be the result of a high pressure chamber draining into a low pressure chamber.

> Mitral regurgitation
> Tricuspid regurgitation
> Ventricular septal defect
> Aortopulmonary shunts

Ejection systolic murmurs

These tend to involve a ventricle ejecting blood through some sort of stenotic orifice, be it a conventional valve or some sort of catastrophically narrow outflow tract. They follow a classical crescendo-de-crescendo pattern.

> Aortic stenosis
> Pulmonary stenosis
> Atrial septal defect
> Hypetrophic cardiomyopathy - with LVOT obstruction, and turbulent flow through this narrowed tract

Late systolic murmurs

These are the outcome of some sort of regurgitant valve, leading backwards out of a ventricle.

> Mitral valve prolapse: This one typically commences with a click
> Pulmonary stenosis: this may be present in the company of an S4, and there may be features of right heart failure. Its a late ejection systolic murmur which does not radiate to the carotids.

Early diastolic murmurs

> Aortic regurgitation
  - This tends to occur together with aortic stenosis.
  - Blood regurgitating back through the aortic valve forms a high-pitched early diastolic murmur, best heard at the 3rd and 4th intercostal spaces.
> Pulmonary regurgitation
  - Blood regurgitating back through the pulmonic valve forms an early diastolic murmur along the left sternal border. They also call it the Graham Steell murmur.

Mid-diastolic murmurs

> Mitral stenosis
  - This tends to be associated with a loud S1 and an opening snap.
  - It is best heard in the left lateral position, with the bell of the sthethoscope. It is louder on expiration.
> Tricuspid stenosis
  - This is best heard at the left sternal edge. It is louder on inspiration.
> Atrial myxoma
  - The tumour makes various sounds, but usually one expects to hear a diastolic murmur as the blood finds its way around the mass in diastole.

Presystolic murmurs

- Mitral stenosis, tricuspid stenosis, atrial myxoma.

Continuous murmurs

- Patent ductus arteriosus or Aortopulmonary connection (eg. Blalock-Tausig shunt)

Cardiac Murmurs

2013/1 Aortic regurgitation or mitral stenosis as the cause of a patient's diastolic murmur.

Aortic Regurgitation

- Collapsing pulse / wide pulse pressure
- Decrescendo murmur heard over left 3rd intercostal space parasternally
- Murmur loudest sitting forward in expiration
- Signs associated with large pulse volume and peripheral vasodilation; eg Corrigans, De Musets. Quinckes, Duroziez.
- Evidence of associated conditions; Infective endocarditis, ankylosing spondylitis, other seronegative arthropathies, Marfans.
- Soft 2nd heart sound
- 3rd heart sound
- Displaced apex beat
- Signs of LV failure

Mitral stenosis

- Malar flush
- Atrial fibrillation
- Small pulse pressure
- Loud 1st heart sound
- Opening snap
- Low-pitched, rumbling diastolic murmur over apex loudest in left lateral position
- Pulmonary hypertension

- 2011/2 List 4 causes of a diastolic murmur over the apical area.

Apical diastolic murmurs

- Mitral stenosis
- Severe mitral regurgitation (flow murmur)
- Significant left to right shunt (VSD)
- Austin-Flint murmur of aortic regurgitation
- Carey-Coombs murmur

2010/2 On palpation of the arterial pulse, a double peak was noted with each cardiac cycle. List 4 conditions/ situations which can produce this phenomenon.

Double peak arterial pulse

- AS + AR
- Severe AR
- HOCM
- IABP

2006/1 Clinical examination of a 35 year old man who is short of breath reveals a pansystolic murmur. Outline the salient clinical features and investigations which will help you distinguish between mitral regurgitation, tricuspid regurgitation and a ventricular septal defect in this setting

Mitral regurgitation

- Sx - PND, orthopnea, chest pain, palpatations
- JVP - Raised
- Apical to axilla murmur
- CXR - straight left heart border, pulmonary oedema
- ECHO!

Tricuspid regurgitation

- Sx - Pedal oedema, chest pain, dyspnoea
- JVP - V waves
- Left sternal border murmur, increases with inspiration
- Large right atrium on CXR
- ECHO!

VSD

- Sx - Chest pain, dyspnoa
- JVP - Prominent a waves due to pulmonary hypertension
- Left sternal border
- May have other congential features
- ECHO!

ECMO

2014/1 Q23 A 39-year-old female is admitted to a tertiary centre and intubated and ventilated for severe Legionella pneumonia. Two days after admission to ICU she remains profoundly hypoxaemic (PaO2/FiO2 = 55), despite optimising ventilatory support and appropriate antimicrobial therapy. a) Outline the factors that would influence your decision whether or not to institute extra-corporeal membrane oxygenation (ECMO) in this patient. b) Outline the relative merits of veno-venous (V-V) and veno-arterial (V-A) ECMO for this patient.

Indications for ECMO

> The condition must be reversible; OR the patient qualifies for a heart/lung transplant
> The conventional management strategies have failed.

When to consider

> Cardiac arrest (in certain settings)
> Failure to wean from cardiopulmonary bypass
> Cardiogenic shock
> Hypoxic respiratory failure
> Hypercapneic respiratory failure

Contraindications for ECMO

> Contraindications to anticoagulation: recent surgery, uncontrolled bleeding, intracranial haemorrhage
> Irreversible condition
> Contraindications for heart/lung transplant
> Caveats to ECMO
> Conventional therapies have been attempted prior
  - Recruitment manoeuvres
  - Prone positioning
  - NO/inhaled prostacyclin
  - Diuresis
  - Fluid resuscitation and decreased PEEP to improve V/Q matching

Veno-venous vs veno-arterial ECMO

> VA ECMO has the advantage of providing complete cardiorespiratory support, and is therefore applicable in patients with very poor cardiac function (LVEF less than 25%)
> VA ECMO has the disadvantage of large-bore arterial puncture, which is a major problem. VV ECMO has less vascular access issues, but is only indicated for patients with good myocardial function.

Extracorporeal therapies

2007/1 Q28 List the extracoporeal therapies used in the critically ill and outline the indications for their use.

Dialysis

- Oliguria with volume overload
- Oliguria is relative; urine output may be high and still inadequate in clearing the fluid.
- Uremia with symptoms
- Hyperkalemia (K+ over 6.0)
- Metabolic acidosis due to renal failure (pH < 7.2)
- Removal of dialysable drugs/toxins
- Control of electrolytes
- Control of body temperature

Hemoperfusion

- There is severe life-threatening intoxication with substances which are not going to be well removed by the liver or kidneys.
- There is an impairment of liver and kidneys, preventing clearance.
- If a toxin is equally well cleared by hemodialysis and hemoperfusion, then hemodialysis is preferred, because it will also correct any underlying acid-base disturbance

ECMO

- Cardiac arrest (in certain settings)
- Failure to wean from cardiopulmonary bypass
- Cardiogenic shock
- Hypoxic respiratory failure
- Hypercapneic respiratory failure

ECCO2R

- Hypercapnic respiratory failure with adequate oxygenation
- MARS
- Fulminant hepatic failure with encephalopathy, awaiting transplant

Plasma exchange

- HELLP syndrome
- Multiple sclerosis
- HIV-related neuropathy
- Pemphigus
- Coagulation inhibitors
- DIC

LVAD/RVAD

- Cardiogenic shock
- Cardiac arrest
- Fulminant myocarditis
- Failure to wean off bypass

Heart lung transplant

2013/2 Discuss the issues with heart lung transplant patients in the ICU.

Airway

> The risk of intubation in the immunocompromised patient must be weighed, as it places them at considerable risk of VAP.

Ventilation

> Obliterative bronchiolitis is a graft v host disease manifested as an irreversible decline in FEV1. It is a major cause of morbidity and mortality

Circulation

> Accelerated ischaemic heart disease due to
  - Obliterative disease of the vessels (graft v host)
  - Atherosclerosis
  - Reduced collateralisation

> Increased responsiveness to infused inotropes
  - Increased receptors due to denervation

> Insensitivity to normal autonomic stimuli:
  - Impaired responses to changes in blood pressure, posture, or volume.
  - For example there will be no compensatory tachycardia when the patient is hypovolemic.

Renal and electrolyte abnormalities

> The use of steroids will result in a hypernatremia, fluid retention, and hypokalemia.

> Renal function may be very poor, and drug clearance may be affected.

> Cyclosporine may also cause a distal renal tubular acidosis.

Infectious agents

> In 60% of cases, pneumonia in the heart-lung trasplant recipient is due to an opportunistic pathogen.

> The pathogens are as follows:
  - Opportunistic:
    - CMV
    - Aspergillus
    - Pneumocystis
    - Nocardia
  - Community-acquired
    - H.influenzae
    - S.pneumoniae
    - Moraxella catarrhalis
  - Hospital-acquired
    - Acinetobacter
    - Pseudomonas
    - Stenotrophomonas
    - Klebsiella
    - Legionella
    - E.Coli

IABP versus VAD

2007/1 Q13 Compare and contrast the advantages and limitations of the intra-aortic balloon pump (IABP) and ventricular assist devices (VAD)

IABP

Advantages

> Can be inserted percutaneously in ICU or CCU

Indications

> Used post cardiac surgery when unable to come off bypass / cardiogenic shock following an infarct
> Severe AS, MR and VSD

Contraindications

> Aortic regurgitation, Aortic aneurysm, Aortic dissection, Severe sepsis, Uncontrolled coagulopathy
> Not effective in the setting of CI <1.2 and tachyarrhythmias

Logistics

> Intensivists more familiar with IABP
> Can be used during transport

Anticoagulation

> Usually no need for anticoagulation

Complications

> Lower limb ischemia (3-4%) hematoma, aortic trauma

VAD

Advantages

> While percutaneous insertion is possible, frequently require anaesthesia and a surgeon for insertion and removal.
> Allows greater control of both left and right cardiac output

Indications

> Frequently used in post cardiac surgical patients.
> Fulminant myocarditis, cardiogenic shock
> Used as a bridge to transplantation.

Logistics

> Less familiar with VAD, greater degree of complexity, more difficult to use during transport

Anticoagulation

> Requires high degree of anticoagulation

Complications

> High rate of infection (up to 50% in some series)
> Bleeding, thrombotic complications despite anticoagulation
> Thrombocytopaenia

Intracranial bleeding post PCI

Created Question A 65 yo male has been admitted to the ICU following evacuation of a large subdural haematoma. He has a history of ischaemic heart disease and insertion of a a coronary artery stent 2 weeks prior to this admission. Briefly list the additional information you would attempt to obtain regarding the coronary artery stents and the clinical implications of this information.

Introduction

Dual antiplatelet therapy (typically aspirin and clopidogrel) is the standard of care for patients post coronary artery stenting. This significantly reduces the risk of stent thrombosis (ST). In addition it also reduces the risk of thrombosis associated with plaque rupture at a site distant to the stent location. Thrombosis is more likely to occur in the first 30 days.

Development of ST following premature discontinuation of clopidogrel is associated with a OR of up to 36 times. This is the most important risk factor for ST.

Reducing the incidence of thrombosis must be balanced with the risk of bleeding and adverse outcomes such as intracranial bleeding as seen in this patient. The information related to to the stents I would seek includes;

Presenting features

The reason for the stent placement strongly relates to the risk of ST in the first 30 days post procedure

- Stable angina is associated with up to 0.5 % risk of ST
- NSTEMI is associated with a up to 2.0% risk of ST
- STEMI is associated with up to 3.0% risk of ST

Procedural aspects

Location of the stent - in a more important vessel such as the left main ST is of increased clinical consequence

Type of stent inserted

- Bare metal stents were developed initially. They confer a slightly reduced risk of ST in the first 30 days.
- Drug eluting stents were developed later as they reduce the risk of revascularisation however have a slightly increased risk of ST.

Stent issues such as side branching placement, incomplete expansion or greater stent length may increase risk of ST

Anticoagulation - no aspirin pre-procedure or sub-therapeutic anticoagulation during increase risk of ST

Patient factors

Large case controlled studies have demonstrated

- More severe coronary artery disease may increase the risk of ST up to 4 times
- An LVEF <30% increases the risk of ST by 3 times
- Malignancy increases the risk by up to 3 times

Standard cardiovascular risk factors - dyslipidaemia, hypertension, smoking hx, increased BMI, diabetes, family hx are also believed to increase the risk of ST

Summary

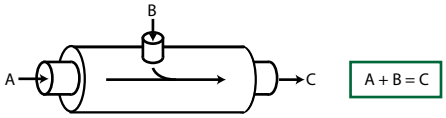
Using this information and the information related to the patients intracranial bleeding would inform my decisions on continuation of antiplatelet therapy. In consultation with the neurosurgeons and cardiologists I would be inclined towards recommencement of antiplatelet therapy at the soonest possible junction.

Measuring cardiac output

Created question Compare and contrast the techniques for measurement of cardiac output.

Pulmonary artery catheter

> Principle
  - Uses the Fick method - an application of conservation of mass



  - Dye is inserted at B, there is nothing at A and the amount at C = flow(concentration). The concentration is measured at C and via the PAC tip is represented by the area under the curve (in a period of time). Therefore the equation is solved to calculate flow = C/AUC. Using cold saline is the same although the temp at A is also measured to zero the equation.

> Pros - Gold standard, Sound physiological priniciples

> Cons - Invasive technique associated with up to 10% complication rate. Has been demonstrated not to change outcomes. Inaccurate with significant TR, shunting, catheter movement, poor injection technique

Transpulmonary thermo or dye dilution

> Principle - as per PAC but requires a full cardiac cycle to measure AUC

> Pros - Less invasive than PAC, Sound phsyiological priniciples

> Cons - Still invasive technique and requires femoral arterial line which limits patient mobility , May be inaccurate in significant pulmonary or valvular disease, intracardiac shunting, technique

CO production or O2 consumption methods

> Technique - also use the Fick method (indirect) of conservation of mass

> Pros - sound physiological principle

> Cons - measures every 3 minutes, multiple assumptions required, only for intubated pts, limited validation in critical illness

Arterial wave form analysis

> Principle - uses calculation of the area under the pulse pressure curve (using a proprietary formula) to derive the stroke volume which is multiplied by the HR to give CO

> Pros - less invasive as most patients requiring CO analysis have a-lines. Gives a second to second reading

> Cons - requires regular calibration to be more accurate and this is often via transpulmonary dilution - hence may be as invasive anyway

Ultrasound methods

> TTE uses may simpson's technique to calculate the SV and SVxHR = CO

> Dopples techniques - uses the doppler effect to measure flow, may be transthroacic or oesophageal

> Pros - TT is less invasive. oesophageal is more accurate and gives a more constant reading

> Cons - may be inaccurate in severe heart disease, multiple assumptions used, image quality and plane is an issue in Simpsons.

Bioelectrial impedence

> Principles - bioimpendence is dependent on the blood flow direction, and assumptions are then used to calculate CO.

> Pros - non invasive

> Cons - experimental, difficult to apply, uncertain influence of assumptions

Noradrenaline use in the post cardiac surgery setting

2013/1 Discuss the role of nor-adrenaline in the management of hypotension post cardiac surgery.

Nor-adrenaline (NA)

> Naturally occuring catecholamine that is released by mammalian postganglionic sympathetic nerves
> Main action is on alpha 1 receptors increasing peripheral vasoconstriction although at higher doses it exerts beta 1 adrenergic effects.
> Exogenously it is presented in clear vials and usually diluted in 5% dextrose
> Delivered IV (usually via CVC to reduce risk of extravasation and necrosis
> It has a very short half life and is metabolised by COMT and MAO independent of renal and hepatic function
> It is used extensively in critical care for maintainence of blood pressure in pathological states

Post cardiac surgery patients

Often return from theatres with hypotension especially in the setting of recent coronary bypass.

Causes of hypotension in this setting include

> Hypovolaemia - due to fluid shifts/removal, bleeding
> Distributive - vasodilation secondary to SIRS response and warming, drug agents such as propofol and milrinone
> Obstructive - Tamponade, tension pneumothorax
> Pump failure - Poor LV fn pre-op, ischaemia, low calcium

Role of nor-adrenaline

The cause of the hypotension should be established

> Significant tamponade requires a return to OT
> Cardiac failure may be due to a range of reasons including poor presurgery function and ischaemia
> Hypovolaemia - requires fluid resuscitation, correction of coagulopathies and a return to OT if "surgical" bleeding
> Vasodilation - May be treated with a range of therapeutic options however noradrenaline is the most commonly used
    - Pros
        - NA is that it is less arrhythmogenic than adrenaline and dobutamine
        - NA's short half life make it more easily titrated than other agents such as vasopressin
        - NA is very common and widely used in ANZ and therefore people are comfortable with its use
        - NA increases DBP and therefore may improve myocardial perfusion
    - Cons
        - May mask a pathology requiring urgent intervention
        - Postulated effects on mesenteric and renal perfusion due to vasoconstriction
        - Increases afterload and may exacerbate myocardial ischaemia via increase O2 demand

My practice

Noradrenaline is my agent of choice for managing post cardiac surgery hypotension caused by vasodilation however I always consider the other major categories of shock and treat these aggressively if indicated.

Mechanical strategies in AMI cardiogenic shock

2012/2 Discuss the potential mechanical strategies for supporting myocardial function in a 45- year-old man presenting with cardiogenic shock post-revascularisation for an acute anterior myocardial infarction. In your answer include the physiological rationale for each strategy.

Positive End Expiratory Pressure

> Via non invasive or invasive ventilation
> Reduces preload and in the failing ventricle may bring the myocytes back to the optimal point on the Starling curve
> Reduces transmural pressure of the LV and therefore reduces afterload

Intra Aortic Balloon Pump

> Inflates to augment diastolic pressure at the coronary root therefore improves coronary perfusion, especially in the LV
> Deflates to reduces the afterload during systole improving the LV ejection
> Contraindicated in an incompetent aortic valve, or hx of aortic dissection
> May be of benefit in refractory cardiogenic failure but the evidence in all comers (SHOCK II trial) is not supportive of its use

Pacing

> Emergency transcutaneous, temporary transvenous and permanent multi-chamber pacing.
> Cardiac output = HR x Stroke Volume
> Pacing therefore can increase the heart rate and theoretically the cardiac output
> A-V pacing may synchronise atrial kick
> Overdrive pasing may correct tachyarrhythmias

Ventricular Assist Devices

> This provides either a continuous or pulsatile pumping of blood from the;
  - Left ventricle directly into the aorta (LVAD)
  - Right atrium or right ventricle directly to pulmonary artery (RVAD)
  - Both right and left sides of the heart (BIVAD).
> Used as a bridge to decision or transplant
> Requires cardiac surgical expertise for insertion and so not available in all centres.

Veno-Arterial Extra Corporeal Membrane Oxygenation

> Venous blood is extracted, oygenated externally and then pumped and returned to the arterial system providing both oxygenation and circulation.
> Decreases workload of heart and lungs whilst maintaining flow, blood pressure and oxygenation.
> Requires expertise for insertion and maintenance and not available in all ICUs.

Perioperative myocardial infarction

1993/2 Outline the criteria used to diagnose perioperative myocardial infarction. Briefly outline your approach to the patient in which the diagnosis is confirmed.

Perioperative MI

Aetiology previously believed to be primarily mismatched supply and demand due to increased physiological demands and dysregulated autonomic function during operations however plaque rupture likely to play a significant role and many patients.

Diagnosis is made by the elevation of cardiac enzymes from known baseline not explained by an alternative cause such as renal impairment, sepsis, or prolonged tachycardia. ECG changes are present in around 30-40% but are not required to make a diagnosis.

Risk factors are similar to the standard risk factors, hx of IHD, obesity, smoker, vascular disease, dyslipidaemia, and renal impairment. High risk surgery is an additional risk factor.

Management

> History to establish risk profile
> Monitored bed for minimum of 24 hours
> Standard supportive care measures - analgesia, sedation, thromboprophylaxis, consideration of PPI, diet
> ECG, CXR, fasting cholesterol and BSL, FBC, EUC, blood gas

STEMI

> Requires reperfusion. Thrombolytic treatment is complicated post operatively and therefore PCI (despite the heparinisation) is recommended.
> Aspirin and a platelet inhibitor should be commenced in consultation with a cardiologist and the surgeon
> High dose statin should also be commenced unless contraindicated.
> The patient should remain in a monitored bed post reperfusion incase of arrhythmias
> Commencement of ACEI/ARB and betablocker for disease modifying actions when blood pressure will tolerate
> Cardiologist to maintain continuity of care

NSTEMI

> Risk stratify according to comorbidities
> Consider PCI if high risk and/or history of unstable angina
> Aspirin and statin
> Referral to cardiology
> Plan for outpatient/inpatient investigations to look for reversible ischaemia (MIBI or exercise stress test).

Temporary pacing troubleshooting

Created Question You are asked by the bedside nurse to assess a patient who has been admitted to the ICU 4 hours ago following an apparently uncomplicated aortic valve replacement. He has noticed that the pacemaker has stopped reliably capturing and occasionally paces inappropriately. Outline your approach to this problem

Epicardial Pacing

Epicardial wires may be placed during surgery to provide a temporary mode of pacing post cardiac surgery. They vary according to the site of placement and method of establishing an electrical circuit. Management in ICU involves thorough patient assessment, regular system checks and trouble shooting the common problems associated with their use.

Initial assessment (optimising as required)

> Brief airway check
> Brief ventilation and oxygenation check K and pH may cause issues
> Detailed cardiac assessment
  - Examine the patient
  - Assess the fluid status
  - Check the current physiological parameters CI, CVP, HR, BP PAP
  - Consider risk of cardiac ischaemia - ECHO, ECG changes when pacing off, quality of the grafting
> Check the post op CXR and bloods

Routine pacemaker check

> Check the battery power indicator
> Check the current mode is appropriate (ideally DDD or DDI in this setting)
> Assess the underlying rhythm by gradually reducing the rate
  - If there is no underlying rhythm attach transcutaneous pads
> Assess the sensitivity (and compare to intra and post op values to see if there has been a major change)
  - Gradually increase the voltage (reduce sensitivity) until sensing is lost
  - Set the sensing threshold at half the voltage when the pacemaker stops sensing
  - Consider increasing the value if there is ongoing inappropriate sensing
> Assess the capture threshold (assuming there is an underlying rhythm)
  - Set the rate above the endogenous rate and reduce the current until capture is lost
  - Set the output current at a value twice the capture threshold

Trouble shooting options

> Failure to pace (no electrical output from epicardial wires)
  - Check the leads are attached appropriately from the patient to the pace generator
  - Recheck the battery
  - Trial an asynchronous mode VOO - if the problem resolves then it likely due to inappropriate inhibition
    - Cross talk is when the atrial spike is interpreted as ventricular - reduce the sensitivity or atrial voltage
    - Over-sensing is other electrical signals detected as ventricular contractions - reduce the sensitivity
> Failure to capture (electrical output but no cardiac contraction)
  - May be due to cardiac ischaemia, electrolyte imbalances, medications
  - Often due to inflammation and fibrosis of the epicardium
  - If bipolar change the polarity or convert to unipolar by placing a skin electrode
> If ongoing or worsening pacemaker dysfunction and pacing dependency discuss with surgeons and consider a trans-venous pacing option as a temporising option.

Transvenous pacing

Created Question Describe the technique of establishing transvenous cardiac pacing

Indications transvenous pacing is based primary on evidence of haemodynamic deterioration in settings where there is a dysarrythmia ammenable to pacing. Bradyarrhythmias include 2nd or 3rd degree heart block, sinus node dysfunction, MI with new LBBB or bifasicular block. Tachyarrythmias may also respond to overdrive pacing.

Contraindications include a mechanical tricuspid valve and severe hypothermia where there is an increased risk of inducing refractory VF. Where a bradyarrythmia has been induced by antiarrythmics pacing is of marginal benefit (if any).

Patient Factors Explicit or implied consent should be attained. The patient should be compliant or sedated to permit safe practice. The patient should be positioned in the head down position. Constant monitoring of blood pressure, ECG and O2 saturations is optimal. Placement and usage of transcutaneous pacing may be required if the patient is acutely unstable

Equipment

> Pacing generator - should have a fresh battery and connector leads
> Pacing catheter
  - Are generally bipolar implying that there are two electrodes spaced apart at the end of the catheter
  - Stiffer catheters are useful in fluoroscopic guidance although increase the risk of perforations
  - May have a balloon at their tip to assist with 'floating' the catheter into position (not useful in asystole)
  - Are designed for pacing either the RV or the RA (which is J-shaped to 'hook' the RA appendage)
> ECG attached to catheter and to the patient
> Standard equipment for CVC insertion

Vascular access the right internal jugular vein is the preferred access point for establishing TV pacing as it provides the straightest venous pathway to the heart. Other options include the left IJ, or subclavian veins (with slight increased risk of PTx). In some circumstances such as short term pacing for OT the femoral vein may be accessed although lead stability is worse than superior approaches. Antecubital veins are associated with phebilitis and lead movement and are generally avoided. Venous access should be attained using landmarks or US guidance. A seldinger technique is followed and a 5 or 6 Fr sheath is inserted to provide an access point for the pacing leads.

Catheter placement

> May be via a previously inserted PA catheter with atrial and venous ports which have been transduced to confirm placement.
> Can be either floated using a balloon at the end of a catheter or inserted without a balloon
> Several methods are used to ascertain position
  - In ideal situations placement fluoroscopically guided with frequent imaging
  - The position may be confirmed by ECG output from the inserted catheter monitoring changes in V1 or V5
  - In arrest situations the pacing generator may be set to max ampere, asynchronous mode (VOO) and the wire inserted until pacing capture then changed to a more appropriate mode VVI etc.
  - US guidance (generally with a subcostal view) may also be utilised
> Xray confirmation is required to confirm position and the catheter should be secured with sutures to the skin

Testing of pacing leads The pacing leads should be tested for sensitivity and thresholds. The desired mode of pacing, sensing and inhibiting should also be selected

Complications

> Related to CVC placement - infection, bleeding, pain, pneumothorax, haemothorax, surgical emphysema, phlebitis, thrombosis
> Related specifically right heart catheterisation - dysrrhythmia, misplacement into coronary sinus, pulmonary artery or through septal defect, perforation of atria/ventrical with associated risk of tamponade, pulmonary infarction

> Related specifically to pacing - mechanical failures (fracture of lead, displacement, inappropriate sensing), organic failures (inflammation, fibrosis and thrombosis at insertion point), electrical failures (battery failure, capture loss)

Transthoracic ECHO in critical care

2011/1 With reference to transthoracic echocardiography (TTE) in the critically ill: a) Outline the potential uses of TTE in the management of a patient in cardiac arrest. b) Which TTE view is the most appropriate to use during cardiac arrest resuscitation?

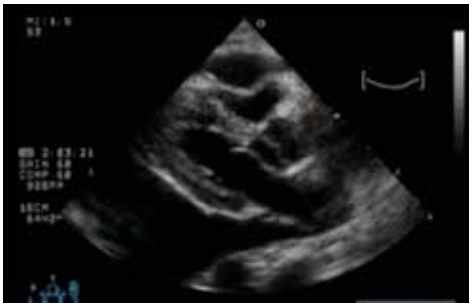
For each TTE image: Describe the main abnormalities. Give the underlying diagnosis.

Uses of TTE in the critically ill

> Enable rapid diagnosis of potentially treatable causes of cardiac arrest e.g. PE, tamponade, hypovolaemia
> Guide interventions undertaken during cardiac arrest e.g. guide needle placement for pericardiocentesis
> Assess response to therapy e.g. IVC diameter post fluid bolus in hypovolaemia
> Subcostal view (below the xiphoid sternum) – can be done without interfering with CPR.

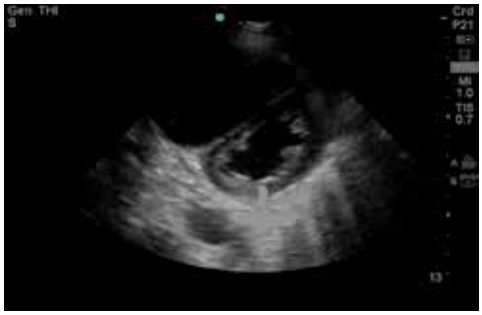
Diagnose the following ECHOs

Image 1



> Very large pericardial effusion
> Right ventricular compression.
> Cardiac tamponade

Image 2



Grossly dilated right ventricle (and atrium in fig 4)

D-shaped septum

Underfilled left heart

Consistent

Cardiology and CTSx lists from Oh's

Causes of PA Catheter Inaccuracy

- Catheter malposition
  - Wedge position
  - Thermistor impinging on vessel wall
- Abnormal respiratory pattern
- Intracardiac shunts
- Tricuspid regurgitation (common in mechanically ventilated patients)
- Cardiac dysrhythmias
- Incorrect recording of injectate temperature (minimised by siting thermistor on injection port)
- Rapid intravenous infusions, especially if administered via the introducer sheath
- Injectate port close to or within introducer sheath
- Abnormal haematocrit values (affecting K2 value)
- Extremes of cardiac output (room temperature injectate)
- Poor technique
  - Slow injection (> 4 s)
  - Incorrect injectate volume

ECG patterns mimicking ST segment elevation myocardial infarction

- Normal variant (non ischaemic STE usually in V2-V3)
- Early repolarisation (notched J point mainly in anterolateral leads)
- Metabolic disturbance (mainly hyperkalaemia and hypercalcaemia)
- Drug toxicity
- Brugada syndrome
- Pre-excitation (WPW)
- Pericarditis
- Myocarditis
- Previous MI
- LV aneurysm
- Spontaneously reperfused myocardium
- Takotsubo due to catechoilamine release

ECG patterns of myocardial injury

Localization	Leads (predominant)	Anatomy
ANTERIOR WALL		
'Extensive' anterior (anterior-lateral)	V_1–V_6, I, aVL	Proximal LAD occlusion
Septal	V_1–V_3(V_4)	Septal perforators of LAD
Anterior (localised or true)	V_4–V_6 (I, aVL, V_2)	Diagonal (supplies anterior LV wall). Occasionally marginal branches of Cx
Lateral (apical)	V_5, V_6 I, aVL	Distal LAD or circumflex
INFERIOR WALL		
Inferior (localized)	II, III, aVF	RCA or posterolateral branch of Cx
Inferior (extended)	II, III, aVF plus	
Infero-lateral	I, aVL, V_5, V_6	RCA or dominant Cx
Infero-posterior*	V_1–V_2	Posterior descending branch or RCA or posterolateral branch of Cx
Right ventricular	V_1, V_3R, V_4R (additional right chest leads helpful)	Proximal RCA occlusion

Contraindications and cautions in fibrinolysis post MI

> Absolute
- Previous haemorrhagic stroke
- Other stroke or CVS <6 months
- Intracranial neoplasm
- Active internal bleeding
- Aortic dissection - known or suspected

> Relative
- Severe uncontrolled hypertension >180/110
- Known bleeding diathesis including anticoagulation
- Recent major surgery or head trauma
- Traumatic CPR
- Active gastric ulcer disease
- Pregnancy
- Recent streptokinase use (risk of antibodies)
- Chronic hypertension

Assessing risk of stroke in AF

> CHADSVAS Score
- C ongestive heart failure/LV dysfunction 1
- H ypertension 1
- A ge 75 y 2
- D iabetes mellitus 1
- S troke/TIA/TE 2
- V ascular disease (prior MI, peripheral artery disease, or aortic plaque) 1
- A ge 65-74 y 1
- S ex category (ie female gender) 1

> Annualised risk of stroke based on CHADSVAS Score (ballpark figures)
- 0 0
- 1 1 (%)
- 2 2

- 3 3
- 4 4
- 5 7
- 6 - 9 10 - 15

> Risk of bleeding on warfarin score HAS-BLED
  - H ypertension 1
  - A bnormal renal or liver fn 1+1
  - S troke 1
  - B leeding 1
  - L abile INRs 1
  - E lderly 1
  - D rugs or alcohol 1+1
- Maximum score 9
- 1-2 = 2 bleeds per hundred patient years
- 3 = 4,
- 4 = 9
- higher than 4 has insufficient data

Indications for pacing following myocardial infarction

> Haemodynamically unstable bradycardia
> Mobitz type II second degree AV block
> Third degree heart block
> Bilateral bundle branch block
> Left anterior fascicular block
> New LBBB
> BBB and new 1st degree block

Causes of long QT syndrome

> take from new Oh's
>

Factors facilitating antiarrhythmic drug proarrhythmia

> Toxic blood levels due to excessive dose or reduced clearance from old age, heart failure, renal disease or hepatic disease
> Severe left ventricular dysfunction; ejection fraction less than 35%
> Pre-existing arrhythmia or arrhythmia substrate
> Digoxin therapy
> Hypokalaemia or hypomagnesaemia
> Bradycardia
> Combinations of antiarrhythmic drugs and concomitant drugs with similar toxicity

Conditions associated with atrial flutter

> Valvular heart disease
> Myocardial infarction
> Pericardial disease
> Cardiac tumours
> Hypertrophic cardiomyopathy

- Congenital heart disease
- Post surgical repair of congenital heart disease
- Post cardiothoracic surgery
- Post major non-cardiac surgery
- Severe pulmonary disease
- Pulmonary embolus
- Thyrotoxicosis
- Acute alcohol intoxication

Causes of acute heart failure on the intensive care unit

- Coronary artery disease
- Cardiac arrhythmias – atrial fibrillation
- Infection – systemic sepsis, viral myocarditis
- Mechanical – endocarditis, pulmonary emboli, valve problems, septal defects, tamponade, high intrathoracic pressure with inadequate preload
- Drugs – beta blockers, calcium antagonists, cytotoxic therapy (e.g. doxorubicin), alcohol, cocaine
- Hypoxaemia
- Metabolic – acidaemia, thiamine deficiency, thyrotoxicosis, hypocalcaemia, hypophosphataemia
- Myocardial contusion – blunt thoracic trauma
- Myocardial infiltration – tumour, sarcoidosis, amyloidosis
- Vasculitis – rare
- Neuromuscular conditions – Duchenne muscular dystrophy, Friedrich's ataxia, myotonic dystrophy

Table 24.3 Comparison of methods for assessing cardiac output

METHOD	INVASION/RISK	VENTRICULAR PRELOAD ASSESSED	COMPLEXITY	MEASUREMENT ERROR	COST
Indicator dilution					
Thermodilution (using PA catheter)	+++	From 'wedge' pressure	++	+	++
Fick	+++	No	+++	+	++
Indocyanine green	+++	No	++	+	++
Lithium	++	Yes	+	+	+
Respired gas					
Modified Fick	+	No	++	++	+
Inert gas rebreathing	+	Yes	+++	++	+
Doppler (oesophageal)	+	Yes	++	++	+++
Echocardiography	0	Yes	++	+++	+
Impedance cardiography	0	No	++	++	+
Pulse contour analysis	+	Yes (ITBV)	+	++	+
Clinical assessment	0	Yes	+	++	0

Correction of metabolic factors in critically ill cardiac patients

- Hypoxaemia ($PaO_2 < 60mmHg$)
- Acidaemia ($pH < 7.20$)
- Hyperkalaemia ($K^+ > 5.5$)
- Hypomagnesaemia ($Mg^{2+} < 0.9$)
- Hypocalcaemia ($Ca^{2+} < 1.0$)
- Anaemia (contraversial given FOCUS trial, certainly <80 g/L is reasonable threshold)
- Thiamine deficiency

Postoperative complications in mitral valve replacement

- Valve-related complications
  - MV repair
    - LVOT obstruction (SAM, systolic anterior motion)
    - Acute failure
  - MV replacement
    - Para-prosthetic regurgitation
    - Prosthetic block (usually in mechanical valves)
- General complications
  - Generalised LV dysfunction
  - Circumflex coronary artery disruption
  - Pulmonary hypertension which is common in this cohort
  - RV dysfunction
  - Tamponade

Causes of low cardiac output post CTSx

- Reduced preload
  - Hypovolaemia, including haemorrhage
  - Tamponade, pericardial constriction
  - Left ventricular diastolic dysfunction
    - Hypertrophy
    - Ischaemia
    - Oedema
    - Hypertrophic or restrictive cardiomyopathy
    - Pulmonary hypertension
    - Right ventricular failure
- Afterload
  - Excessive vasoconstriction
  - Aortic stenosis
  - Functional left ventricular obstruction
    - Obstructive cardiomyopathy
    - Systolic anterior motion of the mitral valve
- Myocardial function
  - Mechanical (ventricular septal defect, valve pathology)
  - Cardiomyopathy
  - Ischaemia, post-ischaemic stunning
  - Metabolic, electrolyte abnormalities, pharmacological depression

Indications for intra-aortic balloon counter pulsation

- Prophylactic
  - Cardiac surgery
    - Two of: left main >70%, left ventricular ejection fraction <0.4, unstable angina, reoperation
    - Failure to wean from cardiopulmonary bypass
  - Non-cardiac procedures in the presence of severe left ventricular impairment, unstable angina
- Cardiogenic shock
  - Reversible myocardial depression

- Support for reperfusion, revascularisation
- Bridge to transplant

Infective species in endocarditis

> Streptococci (around half of all presentations)
  - Strep viridans
  - Strep faecalis (prostatism and younger women with UTIs)
  - Strep bovis (bowel polyps and carcinoma)
> Staph aureus (IVDU)
> Stap epidermis (recent valve replacement)
> Gram-negative coccobacilli
  - HACEK organisms (Haemophillus, Actinobacillus, Cariobacterium, Eikonella, Kingella)
> Fungi (Candida and aspergillus in immunosuppressed and IVDU)
> Culture negative (Q fever, Brucella, Bartonella, Chlamydia, Legionella, Mycoplasma)

Resuscitation and OOHCA

Assessment of brain death

2014/2 With regards to the determination of brain death: a) Apart from identifying evidence of sufficient intracranial pathology, list the preconditions that must be met prior to the determination of brain death by clinical criteria: b)What is the recommended minimum time for observation in cases of hypoxic-ischaemic brain injury, prior to performing clinical testing of brain-stem function? c)For each of the following brainstem reflexes, list the cranial nerves that are tested: d) List three contraindications to performing apnoea testing: e) List the acceptable imaging techniques that may be used to demonstrate brain death as an alternative to clinical testing as recommended by the ANZICS Statement on Death and Organ Donation.

Preconditions for testing

- Minimum period of 4 hours in which the patient is observed to have unresponsive coma, unreactive pupils, absent cough/tracheal reflex and no spontaneous respiratory effort
- Normothermia (temp >35oC)
- Normotension (SBP >90 mmHg, MAP >60 mmHg in adult)
- Exclusion of sedative drugs
- Absence of severe electrolyte, metabolic or endocrine disturbance
- Intact neuromuscular function
- Ability to examine the brainstem reflexes including at least one ear and one eye
- Ability to perform apnoea testing

Minimum time of observation prior to testing

24 hours

Brainstem reflexes and associated cranial nerves

Cough reflex	cranial nerve X
Vestibulo-ocular reflex	cranial nerve III,IV,VI,VIII
Pupilary light reflex	cranial nerve II & III
Corneal reflex	cranial nerve V & VII
Gag reflex	cranial nerve IX & X

(for each part of this question ALL cranial nerves are required in order to receive the 5 marks, no marks should be given for an incomplete response)

Contraindications to apnoea testing

- Concomitant high cervical cord injury
- Severe hypoxaemia
- Haemodynamic instability

Imaging techniques as alternative to clinical testing

- Four vessel intra-arterial catheter angiography with digital subtraction (preferred)
- Radionuclide imaging with Tc-99m HMPAO and single photon emission computerised tomography (SPECT) (preferred)
- CT angiography (limited experience to date) (acceptable)

Examination findings during brain death testing

2014/2 Comment on the significance of the following signs in a patient on whom you are performing brain death testing: a) a generalised tonic clonic seizure b) slow drifting of one eye away from the ear in which cold water is injected during caloric testing c) flexion of the arm at the elbow following imposition of a painful stimulus to the nail bed on that side d) sitting up during apnoea testing e) an increase in pulse from 70 bpm to 110 bpm during apnoea testing

Observations compatible with brain death

> Spinal reflexes in response to noxious stimulus:
  - Extension-pronation movements of the upper limbs
  - Nonspecific flexion of the lower limbs
  - Undulating toe reflex
  - Lazarus sign
  - Deep tendon reflexes
  - Plantar responses (flexor or extensor)
  - "Respiratory-like movements" without much of a tidal volume
  - Head turning
> Sweating
> Blishing
> Tachycardia
> Normal blood pressure in absence of vasopressors
> Absence of diabetes insipidus

Observations incompatible with brain death:

> Extensor posturing (decorticate)
> Flexor posturing (decerebrate)
> True extensor or flexor responses to painful stimuli
> Seizures

Prognosis post OOHCA

2014/2 Outline the value of the following in determining prognosis for neurological recovery in an adult patient admitted to ICU, after successful cardiovascular resuscitation from an out-of-hospital cardiac arrest: a) Peri-arrest data b) Clinical examination c) Neuro-imaging d) Neurophysiology e) Biomarkers

Peri-arrest data:

> Initial rhythm, bystander CPR, time to ROSC intuitively helpful and commonly considered, but have not been shown to correlate with individual outcome.

> Co-morbidities and pre- arrest performance status may determine overall survival.

Clinical Examination:

> Unreliable and of no predictive value before 24 hours, clinical assessment at ≥ 72 hours conventional

> Appropriate pre-conditions: absence of sedation/relaxants, adequate CVS

> resuscitation, normothermia, corrected biochemistry etc.

> All data pertains to studies before the common use of therapeutic hypothermia, and the effect of this intervention unknown. May need longer than 72 hours to obtain reliable data from CNS examination in patients treated with induced hypothermia

> GCS < 4, absent corneal response, absent pupillary response to light indicative of poor prognosis

> myoclonus not sufficiently predictive to be reliable in isolation but myoclonic status epilepticus is a poor prognostic feature

Neuro-imaging:

> CT may be performed early to exclude a CNS cause of arrest

> CT signs of poor prognosis include qualitative assessment, and quantitative assessment of white matter Hounsfield unit ratio. Optimum timing not clear

> MRI demonstration of diffuse cortical lesions or sub-cortical lesions is associated with poor outcome

Neurophysiology:

> No neurophysiology study reliably predicts outcome at < 24 hours

> EEG findings of: diffuse suppression to < 20 mV, burst suppression, generalised seizures, diffuse periodic complexes indicate poor prognosis

> EEG shown to have increased false positive prediction for poor outcome after induced hypothermia

> SSEP: bilaterally absent cortical responses to median nerve stimulation seems highly accurate (0% False Positive Rate), not studied after induced hypothermia

Biomarkers:

> Neurone specific enolase (NSE) most studied, some studies show 0% FPR for poor outcome, but cut-off levels vary, studies small

Poor neurological outcome after cardiac arrest

2013/2 Describe the clinical signs and investigations available to predict poor neurological outcome in comatose survivors of cardiac arrest. Include in your answer the factors that may confound the interpretation of these signs and investigations

Introduction

Assessing neurological outcome occurs within a patient context and the past medical history has an important influence on prognosis. A history of malignancy (metastatic > non metastatic), sepsis, functional status, renal function,pneumonia, and age should be taken into consideration.

Clinical Signs

> Absent brain stem reflexes.

> Myoclonic status epilepticus within the first 24 hours.

- (Generalised and repetitive myoclonus is strongly associated with poor outcome, with a reported false positive rate of 0%. Conversely, single seizures and sporadic myoclonus, do not accurately predict poor outcome.)

> Absence of pupillary responses – within days 1 to 3 after CPR.

> Absent corneal responses - within days 1 to 3 after CPR.

> Absent or extensor motor responses – after 3 days post CPR.

Electrophysiological

> EEG patterns of generalised suppression, burst suppression, or generalised periodic complexes are strongly associated with poor outcome, but the prognostic accuracy is not considered as high as SSEP.

> Bilateral absence of N20 component of SSEP with median nerve stimulation within 1-3 days post CPR is strongly associated with poor outcome.

Biochemical

> Serum neuron-specific enolase levels > 33mg/L at days 1-3 strongly associated with poor outcome.

> (S100, CSF CKBB are not considered accurate enough for prognostication.)

Radiological

> Imaging may reveal catastrophic intracerebral cause for the arrest.

> (Diffuse swelling on CT scan is common, but predictive power not known, role of MRI/PET also unclear

> Brain herniation indicates poor prognosis

Confounding Factors

> Induced Hypothermia – majority of studies carried out before induced hypothermia widely used. Evidence that cooling may alter interpretation of these results, but to what extent remains unclear

> Time of assessment: Period of at least 72 hours post CPR recommended. Unclear how hypothermia effects this.

> CT scan done too early may not show changes

> Sedatives / neuro-muscular blockers, Metabolic derangements, Presence of shock, Organ failure -

> Role of "self-fulfilling prophecy" in interpreting studies

> Difficult to prognosticate in very young patients, near drowning etc

Somatosensory evoked potentials

2014/2 a) What are short-latency (N20) somatosensory evoked potentials (SSEPs)? b) Describe how SSEPs can be used for prognostication in patients with hypoxic- ischaemic brain injury. c) Explain whether, and if so how, induced hypothermia impacts on the validity of SSEP results.

Somatosensory evoked potentials (SSEP)

- Evoked potentials are a method of assessing the intergrity of a neural pathway.
- In SSEPs a stimulus is applied to a peripheral nerve (typically the median in upper limb and tibial in lower limb as they result in the strongest signal) and the response is measured centrally.
- SSEPs appear as a series of waveforms and the amplitude (signal strength) and the latency (delay in time) are monitored
- Age and height should be factored in
- Metabolic status, temperature and sedation may influence results
- N20 represents a common latency point measured from the median nerve
- Pronlonged latency or reduced amplitude is suggestive of pathology

Prognostication in brain injury

- SSEPs have emerged as a reliable prognostic test in brain injury
- The N20 is the most extensively evaluated
- In a meta-analysis of 1136 patients, all 336 patients with absent bilateral N20 never recovered
- It therefore had a PPV or 100%,
- The main issue is that it has sensitivity of 42% therefore normal SSEP does not indicate a good outcome
- It should also not be performed until at least 24 hours post injury

Influence of hypothermia

- Hypothermia affects SSEP test results: mainly delayed peaks (prolongation conduction times); no consistent effect on voltages (amplitudes).
- After rewarming of the patient SSEPs have comparable test characteristics as compared with studies done before therapeutic hypothermia and as such have been validated for prognostication following hypoxic-ischaemic brain injury after rewarming with similar low false positive rate.

Management of organ donor patient

2013/1 Outline the Intensive Care management of a 25-year-old male who has fulfilled brain death criteria and is awaiting surgery for organ donation.

Temperature Maintenance

> Some evidence to support hypothermia 34-35 degrees on the basis of a recent NEJM article looking at graft function post renal transplant but most guidelines still recommend normothermia

> I would target low normal temps using cooling of warming strategies

Respiratory support

> Aim to avoid fluid overload

> Aim for adequate Sp02 and normocarbia with lowest Fi02 and limit tidal volumes

> Bronchoscopy for persisting collapse

> Chest physiotherapy may be helpful

Circulatory Support

> Immediately prior to brain death there is often a period of sympathetic hyperactivity with associated tachycardia and

> hypertension. This is lost following brain death commonly resulting in vasodilation and hypotension

> Maintain adequate mean arterial pressure. Use judicious volume expansion and low doseinotropes (usually noradrenaline)

> Monitor peripheral perfusion and urine output regularly

> Continue maintenance fluids

Metabolic haematology and biochemistry

> Diabetes insipidus is common and if not recognized and treated can quickly lead to hypernatraemia and hyperosmolality

> Measure electrolytes and creatinine regularly and treat as appropriate to maintain normal ranges

> Treat Diabetes insipidus with desmopressin (DDAVP) 4-8µgrams intravenously and repeat ifnecessary, or low dose vasopressin

> Start low dose insulin infusion if blood glucose persistently above 12mmol/L

> Stop bleeding, correct coaguloapthy, thrombocytopaenia and anaemia

> Avoid hypernatraemia

> Other electrolyte abnormalities – K, PO4, Ca, Mg

> Consider thyroxine replacement

Communication:

> Family - counsel, explain, keep updated

> Liaison with donor coordinator and surgical retrieval team

Trauma and Burns

Burns

2007/1 A 28-year-old man has been referred to the intensive care unit for management after being pulled from a house fire.a) Briefly describe the injury shown below in figure 1 b) List 4 possible complications. c) What are other important features on the initial clinical assessment of this patient?

Descriptions of burns

There is an extensive burn injury of the left lower leg consisting of areas of:

> Superficial - (epidermis only) erythematous areas of skin without blistering
> Partial thickness (into the dermal layer) and likely deep partial thickness with blistering
> Full thickness - white and mottled area although 4th degree cannot be excluded.

Complications of burns

> Infection
> Ischaemia
> Scarring
> Contracture
> Pain
> Amputation
> DVT

Clinical assessment of burns

> Other areas of burn – extent and type
> Basic resuscitation status, adequacy of resuscitation status to date and vital signs including urine output
> Associated trauma
> Evidence of airway burn or inhalational injury
> Evidence of inhalation of toxic gases
> Evidence of facial, corneal or perineal burns
> Circumferential burns or evidence of compartment syndrome
> Temperature
> Analgesia requirements
> Vascular access issues
> Co-existing conditions such as epilepsy or drug intoxication

Burns II

2011/1 A 45 year old man was admitted to the intensive care unit after sustaining 40% BSA burns in a house fire. He was transported initially to a local hospital where initial resuscitation was commenced including mechanical ventilation for suspected inhalational injury. On arrival in your ICU an arterial blood gas was taken which is shown below: a) List four potential contributing causes of the metabolic derangement b) How would you classify the acid base derangement and explain your reasoning? c) The serum albumin is 18g/L. Outline how would this affect the anion gap. d) Whilst on your ward round the RMO asks your opinion on the Stewart approach to acid base physiology. List the 3 independent variables that comprise this approach

pH	7.14
pCO2	34 mmHg
pO2	195 mmHg
Bicarbonate	8 mmol/L
Standard Base Excess	-16.1 mmol/L
Chloride	120 mmol/L
Sodium	145 mmol/L
Potassium	4.8 mmol/L
Haemoglobin	180 g/L
Arterial Lactate	3.8 mmol/L

a) List four potential contributing causes of the metabolic derangement

> • Shock/Underesuscitation/hypovolaemia (elevated Hb and Lactate)
> • Normal (0.9%) Saline fluid resuscitation
> • Carbon monoxide poisoning
> • Cyanide toxicity from smoke inhalation (elevated anion gap acidosis)
> • Other missed injuries e.g. abdominal trauma, bleeding etc leading to hypoperfusion/shock
> • Potential concurrent ingestions e.g. methanol, ethylene glycol

b) How would you classify the acid base derangement and explain your reasoning?

• Mixed metabolic acidosis

(Note: CO2 is also high for pH but less relevant because patient on IPPV) Delta ratio indicates a greater fall in [HCO3-] than expected given increase in AG. This can be explained by a mixed metabolic acidosis, i.e. a combined high anion gap and normal anion gap acidosis.

c) The serum albumin is 18g/L. Outline how would this affect the anion gap.

> the normal AG = 0.2 x [albumin] (g/L) + 1.5 x [phosphate] (mmol/L)
> therefore for every decrease of 5 in the albumin the anion gap reduces by 1
> thus the normal anion gap is probably 7-8 in this patient

d) Whilst on your ward round the RMO asks your opinion on the Stewart approach to acid base physiology. List the 3 independent variables that comprise this approach

> Strong ion difference
> Partial CO2 tension
> Total concentration of weak acid (ATOT)

Burns III

2011/1 With respect to the clinical assessment of a patient presenting with a severe burn injury sustained in a house fire: a) Outline how burns are classified. b) List three methods for estimating the total body surface area affected by a burn injury. c)Other than the burn type and extent,list the other important features of the physical examination that should be noted as part of the initial clinical assessment of the patient described above.

Classification of burns

> Burns are classified by depth of injury.
  - Superficial (formerly first degree):
    - Epidermis only
  - Partial Thickness (formerly second degree):
    - Superficial - Epidermis and upper layer of dermis
    - Deep - Extend to deeper layer of dermis
  - Full Thickness (formerly third degree)
    - All layers of dermis and may involve underlying tissue

Estimated burn extent

> Lund-Browder Chart
> The Rule of Nines
> The Rule of Palm

Assessment of the burn patient

> Simultaneous resuscitation, assessment and management
> Airway
  - Evidence of airway burn and inhalational injury: stridor, burns around nose and mouth, carbonaceous sputum
> Breathing
  - ABG performed - correlation between sats and paO2
  - Evidence of inhalation of toxic gases eg CO
  - FiO2 %100 if concerns re inhalational injury
> Cardiovascular
  - Adequacy of resuscitation to date: heart rate, blood pressure, urine output
  - Potential problems with vascular access
> Disability
  - Adequacy of analgesia
  - Evidence of associated trauma
  - Presence of facial and/or corneal burns, perineal burns
  - Presence of circumferential burns, evidence of extremity compartment syndrome, ventilator inadequacy
  - Evidence of drug / alcohol ingestion and/or co-morbid conditions eg epilepsy
> Electrolytes
  - Evidence of rhabdomyolysis
> Temperature management

CT Scans in aortic trauma

Created Question Critically appraise the use of CT in aortic trauma

Caveats

Unstable patients should not be transferred to the CT Scan as this represents an austere environment which may place the patient at greatly increased risk

Routine use of CT Scans in all blunt trauma should be avoided as this will unnesseccarily expose a large number of patients to increased radiation and contrast induced nephropathy

Alternatives

> Aortagram - is a largely superceeded intervention in the intital management of suspected aortic injuries due to technical aspects and patient disposition although it has a high diagnostic accuracy.

> Echocardiography - is gaining popularity but is unlikely to replace CT scans for the diagnosis of suspected aortic injuries as its negative predictive power remains uncertain

> MRI - may be considered in stable patients although the risk of acute deterioration, test duration and the other technical aspects of the investigation make it problematic

Evidence

> They have been no major RCTs

> The NEXUS research group has developed a clinical decision tool which they have subsequently validated. In patients without any of the following criteria their likelihood of chest trauma is very low

- Rapid deceleration mechanism (ie, fall >20 feet [>6 m], or MVC >40 mph [>65 km/hour])
- Chest pain
- Intoxication
- Abnormal alertness or mental status
- Tenderness to chest wall palpation
- Distracting painful injury

> There have been several moderate sized observational trials that have demonstrated that if there is any significant mechanism of injury then a CT Scan is reasonable as it may identify occult injuries

My practice

I would CT Scan all patients who are stable enough for transfer and has a positive CXR of moderate to high pre test probability of aortic injury. I would employ the NEXUS criteria and not scan patients very low pretest probability unless there was additional clinical suspicion.

Damage control surgery

2008/1 What do you understand by the term "Damage Control Surgery" (DCS) in relation to abdominal trauma? What important complications may occur following the initial admission to ICU after DCS?

Definition

Rapid termination of an operation after control of life-threatening bleeding and contamination followed by correction of physiologic abnormalities and definitive management.

Rationale

> Hypothermia, acidosis, and coagulopathy render attempts at definitive surgical repair less likely to succeed.
> The surgical control of immediately lifethreatening injuries and the establishment of haemostasis must be achieved early, but definitive management can be delayed in most cases.
> Definitive management can take place safely once the physiological abnormalities are corrected.

Key principles

> Control of haemorrhage
> Control of contamination
> Use of temporary shunts to bypass ligated vascular injuries
> Delay of abdominal closure, or temporary wound closure

Complications upon returning to the ICU

> Old, uncontrolled traumatic bleeding
> New, uncontrolled surgical bleeding
> Uncontrolled coagulopathy, hypothermia and acidosis
> An open abdomen (thus, high sedation and analgesia requirements)
> Abdominal compartment syndrome (if they decided to close it)
> Missed injuries

Near drowning complications and prognostication

2009/1 A 23 year old man is admitted to your intensive care following a near drowning at the local beach. On admission to ICU he has a GCS of 4 and is intubated and ventilated. a) Briefly list the potential complications from his clinical presentation. b) What are the risk factors for severe neurological injury?

Complications

Breathing

- Aspiration pneumonitis (water, sand, vomit)
- Pneumonia/Acute lung injury/ARDS
- Negative pressure pulmonary oedema
- Atelectasis

Cardiovascular

- Arrhythmia (severe hypothermia)
- Myocardial ischaemia

Disability

- Hypoxic encephalopathy
- Spinal cord injury (especially in the surf or from dives into shallow water)
- TBI

Electrolyte

- Disturbances - especially in salt water emersion

Gasto

- Ischaemic hepatitis

Haemotology

- Coagulopathy

Kidney

- Acute kidney injury (ischaemia)

Risk factors for severe neurological injury

At scene

- Immersion > 10 minutes
- Delay in CPR commencement

In ED

- Asystole on arrival in ED
- CPR > 25 minutes
- Fixed dilated pupils and GCS< 5
- Fixed dilated pupils and pH < 7.0

In the ICU

- No spontaneous movements and abnormal brainstem function at 24 hours
- Abnormal CT scan within 36 hours of submersion

Oxygenation and ventilation issues with burns

2012/1 In patients suffering from major burns, outline the possible physiologic derangements and their underlying mechanisms that could contribute to problems of oxygenation and ventilation.

Ventilation

> Decreased respiratory effort due to a decreased level of consciousness
> Reduced chest wall compliance due to burns of chest and abdomen resulting in poor lung expansion
> Reduced lung complicance due to pulmonary oedema, ARDS, thermal injury of the lungs reducing ventilation
> Increased airways resistance due to oedema of the oropharynx, trachea and bronchial tree causing obstructive lung disease and gas trapping

Oxygenation

Parenchymal damage

> Decreased gas exchange due to parenchymal lung injury

VQ matching

> Increased shunt fraction (Q >> V) due to collapse of oedematous lungs, sputum plugging
> Increased zone 1 fraction (V >> Q) due to gas trapping from obstructive ventilation

Oxygen transport

> Decreased oxygen delivery to tissues, due to:
  - Metabolic/respiratory acidosis and consequent right shift of oxygen-haemoglobin dissociation curve
  - Carbon monoxide poisoning preventing Hb carriage of O2
  - Cyanide poisioning of the electron transport chain impairing O2 delivery and ATP production

Profound hypothermia

2002/2 List the clinical effects of severe accidental hypothermia

Endocrine and metabolic consequences

> Decreased metabolism and oxygen consumption
> Decreased carbohydrate metabolism and hyperglycaemia
> Decreased drug metabolism and clearance
> Essentially unchanged electrolytes

Haematological consequences

> Increased hematocrit and blood viscosity
> Neutropenia and thrombocytopenia
> Coagulopathy and platelet dysfunction

Respiratory consequences

> Decreased respiratory rate and medullary sensitivity to CO2
> Acid-base changes: alkalosis and hypocapnea
> Rise of pH with falling body temperature
> Fall of PCO2 with falling body temperature
> Increased oxygen solubility and O2-haemoglobin affinity

Cardiovascular consequences

> Decreased cardiac output and bradycardia
> QT prolongation and the J wave
> Arrhythmias - classically AF and VF
> Resistance to defibrillation
> Vasoconstriction

Renal consequences

> "Cold diuresis" due to decreased vasopressin synthesis

Central nervous system effects

> Confusion and decreased level of consciousness
> Shivering
> Increased seizure threshold

Immunological consequences

> Decreased granulocyte and monocyte activity

Regional anaesthesia

2013/1 Outline the role of regional anaesthetic techniques in the management of pain in the critically ill

Advantages

> reduced narcotic use to achieve analgesia– less respiratory depression, especially in chest injury or high risk of respiratory failure (elderly, COPD, etc)

> less ileus (reduce risk of aspiration, tolerance of enteral feeds, etc)

> less interference with mental status (harder to attribute obtundation to drugs or injury)

> reduces use of non narcotics, eg NSAIDS (renal impairment, platelet function); tramadol (confusion in elderly); paracetamol – all just adjuncts anyway and less efficacious than regional in severe pain; ketamine – hypertension, tachycardia, dissociative effects, etc)

Disadvantages (general)

> Often redundant in sedated, ventilated patient

> Limited evidence of mortality benefit

> LA toxicity

> may still need narcotic adjuncts

> technical expertise required

> difficulty covering multiple sources of pain

> sympathetic blockade, problems with coagulopathy, need for patient positioning, anatomical landmarks may be difficult

> catheters over longer term => risk of infection. Also confused patients more likely to dislodge them

> monitoring of blockade in uncooperative patient may be impossible

> removal with DVT prophylaxis may be an issue

Disadvantages (local)

> Complications may be rare but can be catastrophic

- Epidural haematoma or abscess for example may result in paralysis

> Dependent on injection site may lead to pneumothorax, nerve injury

Thoracic epidural analgesia versus systemic analgesia

Created Question Compare thoracic epidural analgesia with PCA for the management of a patient with a flail chest following a MVA

Flail Chest is defined as the presence of fractures in three or more consecutive ribs in two or more places, which creates a floating segment in the chest wall.

Pain control is fundamental to the management of rib fractures to decrease chest wall splinting and alveolar collapse. Patients with pain due to rib fractures seek to minimize their chest wall motion by reducing their tidal volume and coughing effort. There are a range of pain management options incl. thoracic epidural and PCA.

Thoracic Epidural

Involves the insertion of an epidural catheter and an infusion of local anaesthetic with or without adrenaline or narcotic agents. Patient controlled epidural analgesia involves bolus doses delivered by a triggering device.

Advantages

> Associated with a shorter duration of mechanical ventilation and decreased incidence of nosocomial pneumonia
> Some trials have demonstrated a mortality benefit at one year in pts with 3 or more rib # who had epidural analgesia
> Other trials have demonstrated improved respiratory function.
> Sympathetic block is likely to ensure gastrointestinal motility is maintained

Disadvantages

> Is not a suitable technique if there has been any spinal trauma
> Is associated with increased risk of hypotension which may also increase diagnostic uncertainty in the setting of trauma and potential bleeding
> Increased risk of infection
> May be associated with delayed respiratory depression due to rostral spread of the analgesia (rare)
> Need close monitoring for complications
> May cause incomplete pain blocks nescessitating systemic analgesia
> Requires a high level of technical skill for the insertion and is associated with complications including;
  - haematoma
  - nerve injury
  - total spinal anaesthesia due to inappropriate insertion
  - pneumothorax

Patient controlled analgesia

Involves the use of opiate medications delivered intravenously in a bolus fashion initiated by the patient with a triggering device. A background infusion may also be run on the PCA.

Advantages

> PCA enables the patient to take control of their pain management and this may reduce anxiety about pain.
> Does not cause the hypotension associated with epidural analgesia
> Is simple and requires minimal technical skill to initiate
> Reduced cost

Disadvantages

> Causes respiratory depression and sedation although the requirement for patient initiation negates this somewhat
> Increased risk of constipation
> May potentiate the risk of opiate abuse

Neurointensive care

Delerium management

2013/2 Define delirium and describe your management approach to this problem in the ICU.

Delerium

Delerium is an acute confusional state characterized by an alteration of consciousness with reduced ability to focus, sustain, or shift attention. This results in a cognitive or perceptual disturbance that is not better accounted for by a preexisting, established, or evolving dementia and therefore due to an acute pathology or toxidrome.

Management in ICU

Indentify and treat the underlying cause via history, exam and investigations

> Acute physiological derangements
  - Hypoxia
  - Hypercarbia
  - Low output state/hypotension
  - Hypertensive

> Metabolic disturbances
  - Hypoglycaemia or hyperglycaemia
  - Acidosis
  - Hyponatraemia
  - Uraemia

> Neurological
  - Embolic or haemorrhagic stroke
  - Inflammatory - Encephalitis, vasculitis, meningitis
  - Seizure related

> Toxidromes
  - Poisoning
  - Wernicke's Encephalopathy
  - Other withdrawal states

> Infection
  - Wound, anastomotic leaks etc., UTI, VAP, bacteraemia

Provide supportive care

> Treat pain adequately and regularly reassess

> Minimise sedation as this is associated with increased delerium

> Avoid polypharmacy if possible

> Regular reorientation, reassurance, get family to bring familiar objects and pictures etc

> Ensure patient is using hearing aids, dentures, glasses etc

> Reduce disorientating stimulation such as monitor alarms, artifical light, waking through the night if possible

> Bowel care, ensure IDC not blocked, pressure area care

> Aim for early mobilisation

Consider medication treatment if patient at risk to self or staff

> Avoid benzodiazepenes except in withdrawals or seizures

> Haloperidol or quetiapine are probably suitable, Soft restraints should be a last resort as they are likely to worsen delerium

Sedation interruption in ICU

2012/1 Critically evaluate the role of a daily interruption of sedation for mechanically ventilated patients in the ICU.

Introduction / Rationale

A daily interruption of sedation is a strategy designed to reduce exposure to sedative agents, allow assessment of neurological status and assess readiness for extubation and to reduce duration of mechanical ventilation.

Evidence

Initial trials showed a marked reduction in duration of mechanical ventilation, and decreased duration of intensive care length of stay (e.g. Kress et al, NEJM 2000). It was notable that no sedation target nor protocol was used in the control group, thus this group may have been oversedated, analogous to the 12ml/kg TV group in the ARDSNET low TV trial.

Subsequent studies have been somewhat conflicting:

ABC study (Girard et al, Lancet 2008) showed improved outcomes (mortality, less time on mechanical ventilation, reduced ICU length of stay) in patients treated with a paired daily interruption of sedation and a spontaneous breathing trial compared to usual care plus a spontaneous breathing trial.

SLEAP study (Mehta et al JAMA, 2012) showed no difference in outcomes comparing protocolised sedation to protocolised sedation plus daily interruption of sedation.

Disadvantages / Adverse effects / Limitations

Potential adverse effects of daily interruption of sedation:

- Patient discomfort and risk of PTSD and other long term psychological issues
- Dislodgment of ETT, CVC, arterial lines etc.
- Increased nursing workload.
- Cessation of sedation could lead to agitation which can be associated with

Physiological instability, hypertension, tachycardia, ventilator dysynchrony and hypoxaemia, which could be associated with exacerbation of primary disease in certain conditions, e.g. myocardial ischaemia, brain injury.

I.e. interruption of sedation contra-indicated in above patient groups.

Own Practice

In my practice I always aim to minimise sedation and aim for a RASS of 0 to -2. I do not routinely conduct sedation holds however would consider this approach in selected patients.

Summary

Daily interruption of sedation may have a role in physiologically stable patients in ICUs that do not routinely use protocolised sedation.

Acute confusional state in elderly patient

1996/1 List the common causes of acute onset of confusion and decreased LOC in a 60 yo diabetic man. Briefly outline how they would be differentiated.

Delerium

is an acute confusional state characterized by an alteration of consciousness with reduced ability to focus, sustain, or shift attention. This results in a cognitive or perceptual disturbance that is not better accounted for by a preexisting, established, or evolving dementia. It is generally due to a medical condition, substance intoxication, or medication side effect.

The causes of confusion or altered LOC in a middle aged diabetic male are numerous. Most causes could be delineated by a thorough history, examination and a few simple investigations.

Metabolic causes - most likely in the setting of diabetes

- Hypoglycaemia – Assess BSL and take history of glycaemic management
- Diabetic ketoacidosis – history of DKA, polyuria, polydipsia, thrist, compliance with medications, type I or II diabetes, ABG, BSL, dehydration on examination.
- Hyper-osmotic Non-ketotic Coma – unwell with concomitant infection, severe dehydration, severe hyperglycaemia, hyperosmolality (plasma).
- Hyperglycaemia – history of control, compliance, BSL.
- Lactic acidosis – type II diabetics on metformin (biguanides) -> sepsis or renal failure.

Neurological causes - DM is a risk factor for stroke

- Ischaemic stroke - CTB and MRI, focal neurological signs on examination, history of onset of symptoms
- Haemorrhagic stroke - CTB, LP, history of aneurysm, bleeding diathesis, medications such as aspirin, warfarin, NOAC
- Head injury from falls
- Non convulsive status epilepticus - needs an EEG for diagnosis

Infective causes - DM results in a relative immunosuppression and increased risk of infection

- Sepsis with encephalopathy/delerium – Febrile illness, unwell contacts, productive cough, dysuria, FBC looking at WCC and neutrophils CRP, culture diabetic wounds/ulcers, sputum, urine, blood
- Meningitis - viral or bacterial as per previous ix plus CTB, and LP

Drug interactions, overdose and withdrawal - DM patients are often on a broad range of medications

- Review the patients medications and usage paterns
- Look for potential drug interactions (such as SSRIs and tramadol)
- Review all psychoactive medications (benzos, antipsychotics, pain medications)
- Perform drug levels of medications if appropriate such as lithium, digoxin, AED etc.
- Get information on drug and alcohol use, give thiamine if there is any doubt

Low perfusion states - DM patients usually have multiple cardiovascular risk factors

- Ischaemic heart disease - history of chest pain, associated features, changes on ECG, raised troponin, impaired LV function on ECHO, positive angiogram
- Arrythmia - history of heart block or AF, history of palpitations, changes on ECG
- Other causes of shock - distributive (sepsis), obstructive (PE or tamponade)

Impaired swallow reflex in critical illness

2004/2 List the possible causes of an altered swallow reflex in a patient with critical ill patient and outline how you would assess this.

Swallowing reflex

Is a complex reflex requiring different phases:

- oral preparatory - responsible for readying the bolus for swallowing (voluntary)
- pharyngeal - most complex, requiring the most precise timing and coordination ~ 1 second (involuntary)
- oesophageal - involves multiple peristaltic waves~ 3-4 seconds (involuntary)

Causes

Drug induced – anti-cholinergics, neuroleptics, chemotherapy induced mucositis

Mechanical – presence of tracheostomy is one of the most important causes as it tethers the larynx preventing the upward motion of the larynx which closes the airway and flops the epiglottis over, trauma from TOE or ETT, damage to CN X, trauma as presenting complaint

Structural – pouches/diverticula, tumour, CREST

Infectious – mucositis, candida oesophagitis

Metabolic – thyrotoxicosis

Myopathic – specific or non-specific neurological syndromes effecting bulbar function

Neurological – stroke, head injury, GBS, MSG, critical illness polyneuropathy, tumour

Assessment

History – previous problems, recent procedures, medications

Examination – local mechanical and bulbar function, systemic disease, systemic neurological, watching attempts to swallow.

Investigations – Speech path assessment (signs of aspiration), naso-endoscopy, video-fluoroscopy or barium swallow.

> The use of measures of tissue oxygenation using parenchymal sensors and microdialysis for monitoring biochemical indices of ischaemia are largely research tools.

Guillaine Barre Syndrome

Created question Discuss the cause, clinical features and the management of GBS

Introduction

> Guillian Barre Syndrome (GBS) is a an autoimmune condition where lymphocytes invade and demyelinate peripheral and cranial nerves

Aetiology

> Aetiology remains uncertain however it involves antibodies directed against peripheral nerves
> It usually occurs post bacterial infection (campylobacter) viral (60% – URTI, CMV, EBV, hepatitis A, B and C, HIV) surgery or vaccination (10%)

Course

> preceding infection (e.g. Campylobacter diarrohoea, viral or Mycoplasma), absence of fever at onset, progression over days to 4 weeks
> Motor-sensory features
  - bilateral, symmetrical weakness, typically ascending
  - bilateral cranial nerve involvement with bulbar symptoms may occur (Miller-Fisher variant)
  - areflexia
  - paraesthesia (sensory symptoms and signs are common; usually milder than motor)
  - neuropathic pain (e.g. back)
> Other
  - autonomic dysfunction: diarrhoea, vomiting, dizziness, abdominal pain, ileus, orthostatic hypotension, urinary retention, bilateral tonic pupils, fluctuating heart rate and dysrhythmias, decreased sweating, salivation and lacrimation
  - respiratory failure
  - corneal ulceration (poor lid closure)

Investigations

> CSF - Elevated protein (only after 5-7 days of disease) in the absence of increased WBC
> Immunological tests: high IgG, antiganglioside GM1 antibodies (axonal forms) GQ1b antibodies (Miller Fisher variant)
> Nerve conduction studies (ALWAYS necessary)
  - Reduced conduction velocity
  - Multifocal conduction blocks
> MRI spine to exclude a high cervical lesion
> Lung function tests
> Screen for infection: viral PCR/ antibodies, stool culture for Campylobacter mycoplasma antibodies and CXR

Management

> If FVC <20 mL/kg transfer to ICU, Intubate if FVC <15 mL/kg or negative inspiratory pressure < -25 cm H2O
> Early tracheostomy
> slow respiratory wean
> Autonomic dysfunction: monitor closely and manage as appropriate
> Painful peripheral neuropathy: gabapentin, tricyclics antidepressants, anti-convulsants, ketamine
> Nutritional supportenteric feeding (fine bore NG tube)
> Immunotherapy plasma exchange: 2-4 plasma exchanges of 50mL/kg over 2 weeks, use albumin as replacement fluid
> IV Immunoglobulin (IV Ig): 0.4 g/kg/day for 5 doses
> No role for steroids

Myasthenia Gravis

Created question Discuss the aetiology, clinical features, diagnosis and management of myasthenia gravis

Introduction

> Myasthenia gravis is an autoimmune disorder characterized by weakness and fatigability of skeletal muscles.
> Weakness is the result of an antibody-mediated, T-cell dependent immunological attack directed at proteins in the postsynaptic membrane of the neuromuscular junction
> Autoantibodies typically target the acetylcholine receptor although Ab levels do not correlate to severity
> It is more common in young women and may be associated with thymus hyperplasia (70% of patients)

Clinical features

> The cardinal feature is muscle fatiguability
> Symptoms are usually therefore worse later in the day
> 50% present with occular symptoms of ptosis and diplopia
> 15% present with bulbar symptoms of dysarthria, dysphagia and fatigable chewing
> Rarely patients present with proximal limb weakness
> Respiratory weakness is the most concerning feature

Diagnosis and investigations

> History and examination
> Tensilon test
> Ach receptor and muscle specific receptor tyrosine kinase antibody testing
> Spirometry
> CXR
> ABG

Management

Initial management

> Assess airway and bulbar function
> Breathing: admit to ICU if VC < 25mL/kg, intubate if myasthenic crisis (critical respiratory or bulbar weakness)
> Cardiac monitoring

Specific Therapies

> Anticholinesterase inhibitors: pyridostigmine, rivastigmine
> Avoid neuromuscular blockers
> Plasma exchange
> IVIG
> Corticosteroids (treatment resistant MG crises)
> Thymectomy – good analgesia

Guillain Barre Syndrome and CIP

Created Question With respect to the Guillain Barre Syndrome (GBS): a) Outline how you would distinguish between GBS and Critical Illness Polymyoneuropathy (CIP). b) What are the current treatment options in GBS? Briefly outline the supporting evidence c) What is the prognosis of GBS and what factors are associated with a worse outcome?

GBS

History and Examination

> Recent GI or resp illness. Progressive bilateral symmetric paralysis. Subtypes can be more localized e.g. MF opthalmoplegia and ataxia.
> Sensory involvement is common.
> Areflexic.
> Autonomic involvement may be present

Investigations

> High protien in CSF.
> Identification of infection with campylobacter, mycoplasma, EBV,Varicella, CMV.

Nerve conduction studies and EMG

When demyelinating form is present, you get a reduction in conduction velocity as well as reduction in CMAP. In axonal forms however it is only the distribution of the findings that helps determine the diagnosis.

CIP

History and Examination

Always occurs in association with a critical illness in particular severe sepsis. May have an association encephalopathy in early stages. It is a symmetrical weakness.

May have muscle tenderness, hyporeflexic, diminished distal sensation

Not associated with autonomic involvement

Investigations

Elevated CK which may be transient.

Nerve conduction studies and EMG

A axonal neuropathy resulting in a decreased CMAP without a reduction in conduction velocity

Treatment options in GBS

> Supportive care
  - Is the mainstay of treatment
  - Respiratory monitoring and intubation if required
  - Managing autonomic dysfunction with close monitoring and interventions to correct
  - Bowel and bladder management
> Disease modifying treatments
  - Plasma exchange may improve reduce time to functional recovery
  - IVIg appears to have similar efficacy to plasma exchange
  - No benefit to combination treatment

Prognosis and recovery from GBS

> Outcomes
  - Usually progressively improve for 2 weeks, then plateau for 2-4 weeks and then recover function
  - Around 60% make a full motor recovery at 12 months
  - Even with treatment, approximately 5 to 10 percent of patients have a prolonged course with very delayed and incomplete recovery, and 5 percent die despite intensive care.
  - Relapses occur in up to 10 percent of patients
> Prognostic factors include;
  - Older age, Rapid onset (less than seven days) prior to presentation, Severe muscle weakness on admission, Need for ventilatory support, An average distal motor response amplitude reduction to <20 percent of normal, Preceding diarrheal illness

Management of status epilepticus

Created Question Outline your principles of management of status epilepticus

Status epilepticus (SE)

Is defined as 5 minutes or more of continuous clinical and/or electrographic seizure activity OR recurrent seizure activity without recovery (returning to baseline) between seizures.

SE is Classified as convulsive or non-convulsive and refractory if they do not respond to standard regimes

Is of concern because it is associated with a relatively high mortality (depending on the underlying cause) and persistent seizure activity of 30 minutes (or possibly less) is believed to result in permanent neuronal injury.

Management

Management priorities are focussed on simultaneous supportive care, treatment of the SE and diagnosis or the precipitating cause.

Supportive care and monitoring

> Ensure appropriate airway protection through standard airway manoeuvres, consider intubation if warranted - although is often not necessary, Apply supplemental oxygen
> Establish venous access, commence IVF, give dextrose if warranted, give IV thiamine if any suspicion of deficiency state
> Establish observations (O2 sats, HR, BP) -correct physiological change in vital signs
> Establish basic EEG monitoring such as BIS or Entropy initially - formal EEG if available
> Insert IDC

SE treatment

> Consists of a stepwise increase in anti-epileptic drugs
> Commence with midazolam (lorazepam or diazepam also an option and have the benefit of longer half lives) 5mg IV. It can be absorbed buccally/IN and IM as well. I would use a further 5mg if the seizure does not terminate.
> I would then escalate to IV phenytoin (20mg/kg). We have limited Fosphenytoin in my practice setting however this may be superior to phenytoin due to its water solubility and reduced risk of precipitating. Sodium valproate is an excellent alternative to phenytoin. Levertiracetam may be a useful adjunctive treatment although there is limited evidence to support it's use.
> Failure to terminate following the above AED would represent a refractory situation. In this setting I would most likely employ propofol (1-2mg/kg induction followed by an infusion of up to 0.02mg/kg/min) unless the cardiac depressant issues were a concern for the patient. This would require a definitive airway and I would increase the propofol until seizure control and maintain the sedation for 24 hours. My main alternative would be a midazolam infusion. My next line of treatment would be a barbiturate such as thiopentone as I am more comfortable with this drug than phenobarbitone.

Diagnosis

> Definitive management of SE involves identification and treatment of the precipitating cause. Establishing a comprehensive history from the notes or family is critical, in particular the medications, alcohol and illicit drugs use, hx of epilepsy, screening questions for malignancy, infection, vasculitis, hypertension, other IHD/stroke risk factors, renal and trauma hx.
> Send bloods when IV is established- in particular FBC, EUC, CMP, and VBG (pH and glucose), drug levels if on an AED
> Requires full neurological examination as quickly as possible
> Perform a CTB as soon as is safe (tumours, bleeding, abscess, other structural) , consider MRI (PRES, other structural), LP (infection, lymphoma, SAH)
> Other bloods toxicology screen, troponins, errors of metabolism)

Non convulsive status epilepticus NCSE

2012/2 With respect to non-convulsive status epilepticus (NCSE) in the critically ill: a) Give a definition for NCSE b) Outline the difficulties in making the diagnosis c) List the risk factors for NCSE d) Outline your approach to the management of a patient with suspected NCSE

Non convulsive status epilepticus

Definition:

> 5 min or more of (i) continuous electrographic seizure activity or (ii) recurrent seizure activity without recovery (returning to baseline) between seizures without clinical findings associated with GCSE. (Neurocritical care consensus 2011)

Difficulties in Diagnosis:

> Little agreement on diagnostic criteria, clinical forms, consequences and treatment

> Difficulty telling when coma is due to ictal symptomatology and differentiating it from non ictal symptoms associated with underlying pathology such as posthypoxic, metabolic or septic encephalopathies and effects of sedative drugs.

> On EEG there are cross over features between epilepsy and encephalopathies which are being still standardized and the diagnosis of NCSE should not be on EEG changes alone.

> Early recognition and treatment are essential to optimize response to treatment and to prevent neurological and systemic sequelae. However overdiagnosis and aggressive use of anticonvulsants may also contribute to morbidity and mortality.

Risk factors:

> Systemic infection in patient with pre-existing epilepsy

> Stroke including intracerebral & subarachnoid haemorrhages

> Dementia

> Neoplasia

> Previous neurosurgery

> Patients with pre-existing epilepsy have a lower mortality (3%) than where NCSE is due to acute medical disorders (27%).

Management:

> Difficulties in diagnosis as outlined above

> Index of suspicion in patients with risk factors and suggestive clinical features

Investigations

> Blood tests to exclude electrolyte abnormalities (low Ca, low Mg), liver and renal dysfunction, haematological causes (e.g TTP)

> Lumbar puncture: looking for CNS infection

> EEG and response on EEG and clinically to Benzodiazepines

> MRI to exclude structural cause not evident on CT

Treatment

> Treatment of underlying cause

> Benzodiazepines: Diazepam or Lorazepam

> Valproate: if failure to respond to benzodiazepines

> Keppra increasingly used

> Reversal of factors that lower seizure threshold eg drugs such as cefepime, fever, hypoxia, hypoglycaemia, hyponatraemia

Horner's syndrome

Created question Discuss the clinical findings and aetiologies of horners syndrome

Clinical manifestations

Horner syndrome is a classic neurologic syndrome whose signs include

> Ptosis is usually minor (2mm) and is due to Muller muscle paralysis
> Miosis is on the same side as the ptosis
> Anhidrosis (in first and second level lesions)

Aetiology

It can be produced by a lesion anywhere along the sympathetic pathway that supplies the head, eye, and neck.

First order

> Lesions of the sympathetic tracts in the brainstem or cervicothoracic spinal cord
> Common causes
  - Lateral medullary infarction
  - Other strokes
  - Tumour Demyelinating lesions

Second order

> Due to lesions from the sympathetic trunk, down and over the lung apex and then up to the mandible
> Common causes
  - Trauma due to surgery
  - Tumours such as a Pancoast tumour

Third Order

> Due to lesions above the mandible (it travels adjacent to the ICA, through the cavernous sinus and becomes the V1)
> Common causes
  - Carotid artery dissection
  - Cluster headache (transient horners)

Early management of brainstem stroke

2012/1 You are asked to admit a 46-year-old man who has just been intubated in the Emergency Department after collapsing from what appears clinically to be a brain stem stroke. His Glasgow Coma Score prior to intubation was 6. Outline your management strategy for him for the first 24 hours.

Outline your management strategy for him for the first 24 hours.

Initial assessment

> Airway - confirm ETT, ties are secure but not too tight, cuff pressure <20cm
> Breathing - mandatory mode, pressure less than 30cm, target pCO2 35-40, pO2 >70
> Circulation - aim for SBP 100 -130 (non invasive until aeitology determined and then relax to 100-150 is not aneurysmal), arterial line and CVC - preferably subclavian, noradrenaline or SNP as required
> Disability - reassess when not paralysed
> History - CVS risk factors, other comorbidites, bleeding diathesis, medications, allergies, social circumstances, assume for full treatment as only 44
> IDC, OG or NG if non traumatic, Temperature probe

Investigations

> Needs urgent CTB and potentially an MRI
  - Need to rule out SAH or space occupying lesion, identify territory
> Routine bloods - FBC, EUC, CMP, Coags, LFTs, CRP
> ECG

Definitive management

> Will require transfer to ICU
> Non haemorrhagic stroke
  - Activate the stroke team
  - Consider thromboectomy and local thrombolysis
  - Systemic thrombolytics if within hospital guidelines (usually 4-6hrs)
  - Heparin infusion
  - Aspirin
  - Repeat CTB at 24 hours
> Haemorrhagic stroke
  - Liase with neurosurgeons
  - Decision regarding management if aSAH - clipping versus coiling
  - EVD
  - Nimodipine
  - Consideration of anticonvulsants (limited evidence)

Supportive care

> Physiological monitoring and maintenance of normal parameters (BP, Na, BSL etc)
> Ongoing neurological assessment – at risk of progressing to locked in syndrome
> Standard feeds, minimal analgesia and sedation, ulcer prophylaxis,
> Discussion with family re therapy and outlook plus risk factors for poor outcome
> Notify donation coordinator if indicated
> Education of JMOs and nurses
> Documentation

Cytotoxic cerebral oedema post infarct

2014/2 A 42 year old stroke patient on ward develops post infarct swelling in MCA territory and drop in GCS - a) Outline your initial plan of management. The family asks if there is any surgical option to "save" the patient. b) What is the evidence for surgery in this situation, and how would you advise the family

Introduction

Approximately 10% of ischaemic strokes are classified as malignant due to cytotoxic cerebral oedema, generally due to thrombotic occulsion of the ICA or proximal MCA. Patients with this syndrome have a mortality rate as high as 78 percent due to herniation of the temporal lobe onto the brainstem.

Initial management

Treatment priorities

- Secure airway there are concerns regarding airway protection or to facilitate treatment
- Normoxia
- Tight blood pressure control SBP 100-150 (IV agents to achieve)
- Baseline bloods including coags and osmolarity
- Disposition - transfer to neuro-intensive care unit

Based on simple measures to reduce the intracranial pressure

- Nurse at 30 degrees head up
- Ensure no restriction on venous return from the head - loose ETT ties etc.
- Reduce brain metabolism by sedation, paralysis or barbituate infusion
- Aim for normoglycaemia
- Avoid fevers - aim 35-36.5
- Employ osmotic therapy with 3% saline or mannitol

Decompressive craniectomy

Remains a controversial area of treatment. Several European studies (50-100 patients in each)

- Demonstrated improved survival
- No change in good survival which was a modified Rankin score of 0-2 (therefore more patients with poor outcomes)
- Overall likelihood of a good outcome was as low as 14%

Family advice

- Establish rapport
- Family member <60 with associated clinical deterioration consistent with herniation would meet inclusion criteria
- Is likely to be a non-dominant hemisphere infarct (assuming right handed) may confer some benefit
- Warn that the almost all survivors are left with permanent disability of varying degrees
- Mortality is still at least 30%
- Should balance the decision on survival versus disability

Vertebral artery occlusion

2013/1 A 60-year-old male presents 2 hours after the onset of vertigo and loss of consciousness. CT brain is performed and shows right basilar and vertebral occlusion with no evidence of infarction. Discuss two possible definitive treatment strategies for this condition, including the indications and contra-indications of each.

Intravenous thrombolysis

The patient is within the suggested time window for thrombolysis and by current guidelines should receive intravenous rtPA (alteplase). Overall this treatment reduces deaths and dependency but is associated with a risk of potentially fatal intracranial haemorrhage.

Indications include patients with acute ischaemic stroke presenting within the appropriate time window (note to examiners – while initial guidelines suggested a time window of three hours there is data suggesting use up to 4.5 hours may be beneficial)

Contraindications include:? Stroke or head trauma in previous 3 months Intracranial haemorrhage: past or present ?major surgery in previous 14 days, ?GI or urinary tract bleeding in previous 21 days?, MI in previous 3 months, ?Non-compressible arterial puncture in previous 7 days Persistent severe hypertension, ?Active bleeding or acute trauma?, Thrombocytopaenia

Intra-arterial thrombolysis

Although intra-arterial thrombolysis results in higher rates of re-cannulation there is no evidence that it reduces mortality or morbidity. However in patients who have undergone recent surgery (and therefore have a contra-indication to intravenous thrombolysis) or exceed the 6 hour time window for intravenous thrombolysis intra- arterial thrombolysis may be useful

Endovascular Thrombectomy

This technique may be used in large vessel thrombus,especially if recanalisation has not occurred with intravenous thrombolysis, or the patient is outside the time window . It requires specialist expertise that may not be generally available, and carries the risk of vascular damage or dissection with potential worsening of symptoms.

Indications would include ischaemic stroke in a large vessel in patients who have either failed thrombolysis or have a contraindication to it.

Contraindications include:? Tortuous vessels precluding angiographic access, Pre exisiting coagulopathy, ?Established infarct on imaging?Contrast allergy

Prognosis and physiology of SDH

2012/1 You are asked to review an 88-year-old man who has fallen from a ladder. He is in the ED with a large subdural haematoma (SDH) and significant mid-line shift on CT scan. His GCS is 6/15. He has a past medical history that includes atrial fibrillation (treated with warfarin and digoxin), chronic renal impairment (creatinine 190 µmol/L), non-insulin-dependent diabetes and mild cognitive impairment. a) List the factors in this patient's history that suggest his outcome may be poor? b) Outline how age-related changes in i. Cardio-respiratory physiology and ii. Response to medications would impact on the management of this patient

Prognostic factors in SDH

> Severity of TBI based on Glasgow coma scale (GCS) score
> Head CT findings, mainly SDH clot thickness, degree of midline shift, and presence of associated brain lesion
> Neurologic examination, including pupillary signs
> Clinical stability or deterioration over time
> Acuity of SDH
> Presence and severity of comorbidities and associated trauma
> Age

The poor prognostic factors in this setting are; advanced age, large haematoma with midline shift, severe TBI (GCS <8), and comorbidites including renal impairment, diabetes and AF on warfarin.

Age related changes in cardiovascular system

> Impaired cardiac conduction evidenced by AF
  - increased risk of poor rate control and stroke when the warfarin is reversed
> Increased blood pressure lability due to;
  - Reduced complicance of the left ventricle and peripheral vasculature (less windkessel effect)
  - Impaired cardiac reflexes
  - Increased risk of ischaemic heart disease
> Increased risk of valvular heart pathology

Age related changes to the respiratory system

> The closing capacity will exceed the FRC and therefore there will be worsened shunting and VQ mismatch
> The chest wall is likely to be more rigid and the elastic recoil reduced shifting the lung function from the optimal resistance point
> Impaired diffusing capacity of the lungs
> Reduced sensitivity to pCO2 and therefore greater fluctations in ventilation patterns
> Reduced upper airway patency and increased risk of obstruction and sleep apnoea with associated desaturations

Age related changes to medications

Pharmacodynamics

> Increased risk of adverse drug reactions/side effects
> Reduced receptors may influence drug affects

Pharmacokinetics

> Absorption may be reduced via the GIT, reduced peripheral vasculature may affect absorption of IM drugs
> Distribution may be affected if there is an increased fat content
> Metabolism may be affected by other drugs especially CYP metabolised drugs (elderly more likely to have polypharm), decreased liver and renal function (especially in this patient. Excretion of renally excreted drugs a major issue in this patient

Intracranial monitoring and traumatic brain injury

Created Question Critically appraise the role of intracranial monitoring in traumatic brain injury

Traumatic Brain Injury (TBI) Is most commonly classified according the clinical assessment despite the diversity of presentations and aetiologies.

> Mild TBI - Glasgow Coma Scale of 13-15
> Moderate TBI - GCS 9-12
> Severe TBI - GCS 3-8

Intracranial pressure (ICP) Is an established biomarker which, if elevated above 20-25mmHg, is associated with an increased likelihood of impaired recovery and is therefore used as evidence of disease severity. Normal ICP is accepted as <15mmHg. An extension of the Monro-Kellie doctrine demonstrates that very high ICPs result in cerebral herniation or global ischaemia.

ICP monitoring is an invasive procedure that requires placement on an monitoring device under sterile conditions into a patient's ventricle, parenchyma or adjacent sub dural space. The most common method with an intraventricular catheter and whetstone pressure transducer which also allows drainage of CSF. Solid state systems that use a strain gauge mechanism or fibre optics and may be placed in the parenchyma or the ventricles. ICP monitors are associated with an increased risk of infection, bleeding, misplacement, damage to brain parenchyma and CSF leakage.

ICP monitors in TBI have been advocated based on concerns about elevated ICPs in TBI as an adjunct to guide and assist in management. They allow targeting of cerebral perfusion pressure, titrating treatment of raised ICPs and if possible drainage of CSF. ICP monitors are not recommended in mild to moderate TBI. It use is severe TBI has become common place in the past thirty years although the evidence base for their application is not robust.

Brain Trauma Foundation is an American NGO which publishes influential evidence based guidelines on the management of TBI. The most recent interation was in 2007. Regarding ICP monitoring the BTF evidence base was equivalent to NHMRC grade III (poor RCTs, cohort and case control studies).

> recommends ICP monitoring in severe TBI
  - if there is a significantly abnormal CT
  - if the CT is normal but age is >40, there is motor posturing or the SBP is <90
> recommends treatment of ICPs greater than 20-25mmHg
> identifies intraventricular devices as the best ICP monitoring device

BEST TRIP Trial was a randomised, multicentre, parallel group trial which hypothesised that aggressive management of TBI guided by pressure measued by ICP monitors was superior when compared to aggressive management based on clinical and radiological findings. The primary outcome was a composite of survival, consciousness level and functional outcome at 3 and 6 months. The trial was based in Bolivia and Equador and published in NEJM in 2012. Randomisation was stratified and the populations were well matched at baseline. The trial did not show a difference in the primary outcome but post hoc analysis demonstrated that the ICP group was subjected to fewer treatments overall.

Conclusion ICP monitoring remains commonplace of managment of severe TBI. Some have argued that the findings of BEST TRIP should discourage the use ICP monitors in the place of appropriate clinical assessment. Although this probably over-reads the trial findings.

There have been some concerns about the external validity of the trial given its setting in a resource depleted setting. More importantly however is to appreciate that the trial compared to different management guidelines

Secondary brain injury following TBI and ICP monitoring

2014/1 A 59-year-old male is admitted to the ICU following a severe traumatic brain injury sedated, intubated and ventilated. a) List the arguments for and against intracranial pressure (ICP) monitoring in this patient. b) Explain the term "secondary brain injury" and list the steps to avoid this.

Traumatic brain injury is classified according to the GCS of a patient. Severe indicates a GCS of 3-8

ICP Monitoring

is achieved via an invasive procedure whereby a pressure monitoring device is placed in the patients ventricle, parenchyma or adjacent subdural space. The device is typically a fluid filled catheter with a wheatstone bridge (EVD) although may also be a solid state strain gauge (Codmans).

Advantages

- Increased ICP is associated with increased likelihood of impared recovery
- Helpful in prognostication
- EVDs may also be used to drain CSF and therefore are therapeutic
- Recommended by the Brain Trauma Foundation and an accepted standard of care in most settings
- May enable early detection of secondary insult such as delayed SDH
- May lead to reduced interventions overall (BEST TRIPS)

Disadvantages

- BEST TRIPS RCT did not show an improvement in outcome
- Invasive procedure usually performed in OT
- Causes parenchymal damage
- Increases risk of infection and bleeding

Secondary Brain injury

Secondary injury occurs at any time after the primary injury, and thus should theoretically be preventable and is caused primarily by:

Hypoxia

- Ensure a PaO2 > 80 and/or SpO2 > 92%

Hyper/hypocarbia

- PaCO2 35 - 40mmHg

Hypotension

- SBP > 90 mmHg and/MAP > 70 mmHg / CPP > 50 mmHg

Metabolic disturbance (Na, glucose, osmo)

- Na+ of 140 – 150 mmol/L, glucose 6 – 10, Serum osmo 320 mOsm/L

Fever

- Normothermia

Seizures

- Phenytoin x 72hrs

Raised ICP

- ICP lowering therapy (head up 30o, neck neutral alignment, sedation and paralysis, osmotherapy, drain CSF, surgical decompression)

Secondary surgical lesion (delayed subdural/parenchymal haemorhage)

- Repeat CT, surgical therapy

Spinal Cord Syndromes

2010/1 Q5 With respect to pathological conditions of the spinal cord, list 2 causes of and the clinical findings for each of the following syndromes: Complete cord transection, Cord hemisection, Central cord syndrome, Anterior cord syndrome (anterior spinal artery syndrome), Cauda Equina syndrome. You may tabulate your answer

Cord transection	• Lost bilateral motor • Flaccid areflexia • Lost bilateral sensory	• Transverse Myelitis
Cord hemisection	• Lost ipsilateral motor • Lost ipsilateral proprioception • Lost ipsilateral light touch • Lost contralateral pain and temperature	• Penetrating spinal injury • Radiation inury • Spinal metastases
Anterior cord injury	• Preserved bilateral proproception • Lost bilateral pain, temperature, touch • Lost bilateral motor control	Interruption of the blood supply to the anterior spinal cord: • Aortic dissection • IABP complication
Posterior cord injury	• Lost proprioception • Other sensation preserved bilaterally • Preserved power bilaterally • Ataxia results	• Hyperextension injury • Posterior spinal artery injury • Tertiary syphilis • Friedrich's ataxia • Subacute degeneration (Vitamin B12 deficiency) • Atlantoaxial subluxation
Central cord syndrome	• Sacral sensation preserved • Greater weakness in the upper limbs than in the lower limbs.	• Hyperextension injury with pre-existing canal stenosis • Ependymoma • Syringomyelia
Conus medullaris syndrome	• symmetrical paraplegia • Mixed upper and lower motor neuron findings	• The same sort of pathologies can give rise either to a cauda equina syndrome or a conus medullaris syndrome; the difference is the level.
Cauda Equina syndrome	• asymmetrical, lower motor neuron lower limb weakness • saddle area paraesthesia • bladder and bowel areflexia	

Diagnosis and monitoring of vasospasm post aSAH

2013/2 Outline the advantages and disadvantages of the various techniques used in the diagnosis and monitoring for vasospasm following aneurysmal SAH

Vasospasm

Clinical vasospasm

> Definition - usually classified as a drop in GCS of 2 points or more or new focal neurology not explained by a different reason (rebleed, hydrocephalus)

> Advantages - Cheap, should be performed frequently anyway, easy to assess, changes in consciousness are an important clinical outcome and patient centred.

> Disadvantages - Operator dependent, generally lead to further investigations with imaging anyway (CT or angio), easily confounded by other diagnoses, doesn't offer a therapeutic option

Conventional 4 vessel DSA angiography - .

> Advantages Remains the gold standard for diagnosis of vasospasm. May allow therapeutic intervention (angioplasty) at the time

> Disadvantages invasive, risks of bleeding, embolism, radiation/contrast exposure and transport. Requires skilled interventional radiology, and therefore resource heavy. Risk of stroke (quoted about 1%, but probably a little lower) just from the angio, plus the dissections etc. that occur as well.Detects vessel narrowing, not necessarily poor flow to distal tissue in all cases (either increased flow rate through narrow vessel or collateral supply. May lead to over treatment.

Transcranial Doppler (TCD)

> Advantages It is low risk, performed at the bedside, non-invasive and able to be repeated daily enabling trend analysis. May be useful to augment clinical findings

> Disadvantages The technique is however operator dependent and there is high inter- observer variability. Debate exists regarding correlation of flow velocity and vasospasm and although high velocities (> 200cm/sec) are predictive, lower velocity may not be as good. - The technique may be more accurate when MCA velocity is indexed to the ipsilateral extracranial carotid artery (Lindegaard index, >3 strongly predictive).

CTA/MRI

> Advantages May be combined with perfusion allowing characterisation of both vascular anatomy and associated perfusion abnormalities. MR diffusion weighted imaging accurately identifies brain tissue at high risk of infarction; perfusion weighted imaging reveals asymmetries in regional perfusion. Both methods show correlation with delayed ischaemic neurological deficit (DIND)

> Disadvantages Image clarity will be affected by clip/coil and contrast related issues need consideration. The overall diagnostic capability of this modality however remains unclear until further prospective studies are performed. Similar disadvantages as per angiography with respect to transport, radiation (for CT), contrast exposure, interpretation by experts.

SPECT/PET

> Advantages - Can be used to obtain a picture of brain perfusion and metabolism and have shown variable correlation with vasospasm as assessed by more conventional methods.

> Disadvantages - They are resource heavy not easily available, radiation exposure, patient transport are issues.

EEG

> Advantages May provide prognostic information, focal areas of slowing correlate with angiographic vasospasm and a decrease in alpha to delta ratio strongly correlates with ischaemia. Sensitivity and specificity for detecting vasospasm is high

> Disadvantage: Not readily available however and their may be issues with interpretation.

Tissue sensors:

Clipping versus coiling in aSAH

Created Question Compare and contrast advantages and disadvantages of clipping verses coiling of aneurysms in SAH

Subarachnoid haemorrhage (SAH)

SAH is a subset of stroke which accounts for around 5% of all strokes but often affects younger patients and is associated with a high mortality and morbidity burden. Although SAH may be traumatic when used in this answer it refers to aneurysmal presentations.

Invasive management of aSAH has traditionally been with surgical clipping however increasingly coiling via an endovascular approach has been adopted in anuerysms located appropriately.

Surgical clipping

Introduction

Involves the placement of a clip across the neck of the aneurysm via a craniotomy.

Advantages

> wide neck aneurysms are better treated with clipping
> Less likely to need retreatment when compared to coiling - better for younger patients
> Blood can be removed intraoperatively reducing risk of vasospasm

Disadvantages

> More invasive procedure
> Collateral damage to brain due to retraction, temporary artery occlusion and intraop haemorrhage
> Requires a general anaesthetic
> Associated with higher cost

Endovascular coiling

Introduction

Platinum coils are inserted into the lumen of the aneurysm. A local thrombus then forms around the coils, obliterating the aneurysmal sac.

Advantages

> Less invasive procedure - does not result in craniotomy
> Able to access some lesions more safely such as those in the posterior fossa
> ISAT trial demonstrated increased independent survivors at 12 months
> Generally associated with reduced costs
> May be better for elderly and those with poor grades

Disadvantages

> Risks of aneurysm rupture or occlusion of adjacent vessel causing ischaemia
> Increased risk of thrombosis therefore requires anticoagulation
> If major complications, still need neurosurgical procedure

Acid-Base, Electrolytes and Endocrine

ABG Analysis Cheat Sheet

Assess the aA gradient or P:F ratio if FiO2 ≥ 50%

> Alveolar gas equation FiO_2(760-47) - pCO_2(1.25)

> Quick references (assuming pCO2 ~ 40)

- FiO_2 = 0.21, A = 100 FiO_2 = 0.25, A = 130 FiO_2 = 0.30, A = 165 FiO_2 = 0.40, A = 235

Describe the pH of the blood

> alkalaemia versus acidaemia

Check the anion gap for unmeasured ions

> CICM seem to use [Na] - [Cl] - [HCO3] normal value is 12

Describe the most obvious acid base disturbance

Metabolic acidosis

> Defined as a high anion gap or a reduced HCO3 (or both)

> Describe in terms of the anion gap

> Check the delta ratio Δ anion gap / Δ bicarbonate

- <0.5 suggests a pure NAGMA
- 0.5-1.0 suggests a mixed NAGMA and HAGMA
- 1-2 suggests a pure HAGMA
- > 2 suggests a pre-existing metabolic alkalosis (high HCO3

> **Causes** of NAGMA

- "ABCD" **A**ddisons, **B**icarb loss (diarrhoea or renal), **C**hloride infusion, **D**rugs (acids, acetazolamide)

> Urinary anion gap measures [Na] + [K] - [Cl] and can differentiate bicarb loss from diarrhoea (negative UAG) and renal causes (postive UAG)

> **Causes** of HAGMA -

- "GOLDMARK" **G**lycols (ethylene and propylene), **O**xoproline (paracetamol, flucloxacillin assoc. glutathione depletion), **L**-Lactate (anaerobic metabolism) and **D**-Lactate (secondary to bacterial metabolism in patients with short gut, or resections), **M**ethanol, **A**lcohol, **R**enal failure, **K**etones

> Check the respiratory compensation: pCO2 should = 1.5(HCO3) + 8 (margin of error -2 to +2)

Metabolic alkalosis

> Defined as a higher than expected HCO3

> **Causes**

- Gain of bicarbonate - NaHCO3 infusion, citrate in blood or for CVVHDF, metabolism of ketoanions
- Loss of hydrogen - via kidneys through use of diuretics, via gut through vomitting or NG suction

> Check for respiratory compensation pCO2 should = 0.7(HCO3) + 20 (large margin of error -5 to +5)

Respiratory acidosis

> Defined as a pCO2 higher than expected

> **Causes**: : impaired ventilation due to lung pathology, CNS impairment, neuromuscular problems, airway obsturuction, reduced chest wall compliance, inadequate ventilation

> Check the metabolic compensation: acute buffering ΔpCO2/10 + 24, chronic compensation 4(ΔpCO2/10) + 24

Respiratory alkalosis

> Defined as a pCO2 lower than expected

> **Causes**: always due to hyperventilation - mandatory ventilation, pain, agitation, brain injury, hypoxic drive

> Check the metabolic compensation: acute buffering 24 - 2(ΔpCO2/10), chronic compensation 24 - 5(ΔpCO2/10)

Other electrolyte calculations

Osmolar gaps

> Measured osmolar gap is performed using the colligative properties of a fluid
> Calculated osmolar gap is 2xNa + Urea + Glucose
> Normally there is a gap <10, a large osmolar gap represents unmeasured osmols
- mannitol
- methanol
- ethylene glycol
- sorbitol
- polyethylene glycol (IV lorazepam) or propylene glycol (IV lorazepam, diazepam and phenytoin)
- glycine (TURP syndrome)
- maltose (IV IG – Intragram

Sodium correction in hyperglycaemia

> Sodium + glucose/4
> Useful in hyperglycaemic hyperosmolar syndrome

Anion gap correction in hypoalbuminaemia or hyperphosphataemia

> the normal AG = 0.2 x [albumin] (g/L) + 1.5 x [phosphate] (mmol/L)
> therefore for every decrease of 5 in the albumin the anion gap reduces by 1
> for every increase in 1 of the phosphate the anion gap increase by 1.5

Hypercalcaemia

2013/1 a) List the clinical features of severe symptomatic hypercalcaemia and outline the treatment of this condition. b) List four common causes of ionised hypocalcaemia and for each give the underlying mechanism.

Symptoms of severe hypercalcaemia

> Gastrointestinal
  - Nausea, Abdominal cramping
  - Constipation

> Renal
  - Polyuria
  - Renal stones and associated colic
  - Renal tubular acidosis

> Cardiovascular
  - Shortened QT
  - Bradycardia
  - Hypertension
  - Cardiomyopathy

> Musculoskeletal
  - Muscle weakness

> Neurological
  - Anxiety, Depression
  - Cognitive dysfunction

Treatment of hypercalcaemia

> Effective treatments reduce serum calcium by inhibiting bone resorption, increasing urinary calcium excretion, or decreasing intestinal calcium absorption
  - Bisphosphonate treatment with IV Zoledronic acid
  - Hydration with normal saline commencing at 200-300ml/hr and then adjusted to maintain UO of 100-150ml/hr whilst monitoring for evidence of overload
  - Calcitonin treatment for 48 hours (short course due to tachyphylaxis) . Dosage is 4 units per kg QID

> Identify and manage the underlying cause

> Supportive care

Low ionised calcium

> Medications
  - One of the more common causes in a critical care setting is hypocalcaemia secondary to citrate anticoagulation during CRRT - the calcium is chelated to reduce clotting and is inadequately replaced

> Parathyroid damage
  - Usually due to surgery or autoimmunity

> Vitamin D deficiency
  - Decreased production or action of vitamin D may cause hypocalcemia with a high PTH

> Chronic renal impairment
  - This reduces the renal production of 1-25 dihydroxyvitamin D and increases phosphate levels leading to both a reduction in absorption and an increase in the binding of ionised calcium

Hypocalcaemia, osmolar gap, respiratory quotient

2010/2 1) A 50 year old patients is admitted to the ICU for airway observation following a difficult parathyroidectomy. No immediate airway problems were evident. About 24 hours later, the patient was noted to be in fast atrial fibrillation, and complained of difficulty in breathing with aches and pains. a) What is the likely explanation for the patient's symptoms? b) Outline your management.

What are the potential diagnoses:

2) Case 1

- Na+ 134, K+ 3.7, Cl 110, HCO3 23, urea 4.3, blood glucose 11.7 mmol/l. Creatinine normal.
- Serum osmolality 320 mOsm/kg H2O
- pH 7.43 pCO2 36 mmHg pO2 137 mmHg HCO3 20 mmol/l

4) The following haemodynamic and metabolic data were obtained from a patient admitted to the ICU with sepsis.

- Pulmonary artery catheter data: CI 4.2L/min/m2 DO2 900 ml/min VO2 190 ml/min
- Indirect calorimetry data: VO2 220 ml/min VCO2 290 ml/min

> a) Why is the VO2 different between the two methods? (Assume no measurement errors).

> b) What changes in patient management will you consider based on the indirect calorimetry data?

Hypocalcaemia

Post parathyroidectomy (or thyroidectomy)

> Hypocalcemia is a common problem after parathyroidectomy or thyroidectomy.

> It is due to functional hypoparathyroidism, and subsequent reductions in bone re absorption, increased bone formation, increased renal excretion of bone and decreased intestinal absorption of calcium as PTH mediates vitamin D production

> Hypomagnesaemia may also be observed

> In this setting it causes muscle aches and pains, arrhythmias, and laryngospasm

> A rarer and more severe form is hungry bone syndrome which is more protracted and may have normal PTH levels

Management

> Management is focused on replacement of calcium (gluconate or chloride) and magnesium

> Managing the arrhythmias with an anti-arrhythmic

Osmolar gap

> This patient has a mild normal anion gap metabolic acidosis characterised by hyperchloraemia (110)

> There is also a relatively large osmolar gap calculated (2xNa+Urea+Glucose) of 284 versus measured of 320

> This suggests an unmeasured solute such as ethanol, glycine or mannitol

Metabolic calculations

> a) The indirect method also includes oxygen that is consumed by the lungs, in this case 30ml/min, whereas the PAC measures pre lungs.

> b) The respiratory quotient is Co2 produced/O2 consumed. Therefore in this setting is 290/220 = 1.31! and this suggests overfeeding with high RQ substances such as carbohydrates

Hypomagnesaemia

2007/1 Write short notes on hypomagnesaemia

Introduction

> Magnesium is the fourth most common cation in the body, most is intracellular and there is a serum concentration of 0.8-1.2mmol/L.

> Magnesium is an essential co factor in ATP requiring enzymes including the NA.K.ATPase pumps thus a reduction can cause a cellular regulation of Na and K to be disrupted

> Hypomagnesemia is a common entity occurring in up to 60 to 65 percent in patients in an intensive care setting

Aetiology

There are two major mechanisms by which hypomagnesemia can be induced: gastrointestinal or renal losses

> GI losses
  - Gastrointestinal secretions contain some magnesium, therefore acute or chronic diarrhea, malabsorption and steatorrhea, and small bowel bypass surgery increases losses
  - Acute pancreatitis may cause GI losses
  - PPIs may also reduce magnesium absorpotion

> Renal losses
  - Medications, including loop and thiazide diuretics and various potential nephrotoxins (see 'Medications' above).
  - Sustained expansion of the extracellular fluid volume, as with primary aldosteronism (see 'Volume expansion' above).
  - Alcohol use (see 'Alcohol' above).
  - Uncontrolled diabetes mellitus (see 'Uncontrolled diabetes mellitus' above).
  - Hypercalcemia, as in patients with primary hyperparathyroidism (see 'Hypercalcemia' above).
  - Recovery from acute kidney injury (AKI) and following renal transplantation (see 'Other acquired tubular dysfunction' above).
  - Familial renal magnesium wasting, such as with Gitelman syndrome

Clinical manifestations

> Neuromuscular manifestations, including neuromuscular hyperexcitability (eg, tremor, tetany, convulsions), weakness, apathy, delirium, and coma.

> Cardiovascular manifestations, including widening of the QRS and peaking of T waves with moderate magnesium depletion, and widening of the PR interval, diminution of T waves, and atrial and ventricular arrhythmias with severe depletion.

> Abnormalities of calcium metabolism, including hypocalcemia, hypoparathyroidism, parathyroid hormone (PTH) resistance, and decreased synthesis of calcitriol

> Hypokalemia

Management

> Replacement with slow infusion of 5-10mmol of MgSO4 until the patient is replete

SIADH

2013/1 A 75-yr-old woman on Indapamide for Hypertension presented with seizures after a 7- day history of increasing lethargy. She was unwell, had dry mucus membranes and decreased skin turgor with a BP 88/50. Her serum sodium was 103 mmol/L. Outline your fluid management and discuss relevant physiology. By day 5 of her admission, the serum sodium has increased to 141 mmol/L. The anti- hypertensive therapy was adjusted and she was discharged home. Ten days after the initial presentation, she is readmitted with ataxia and confusion. On examination, the following findings were noted: AfebrileGCS E4, M6, V4. No neck stiffnessTremor++, ataxia ++.Drooling of saliva +Brisk jaw jerk, bilaterally brisk reflexes, extensor plantar reflexes.Full blood count: Nil significant ELFT: normal.You are called to the ED to assess this patient as there are concerns that she might be an aspiration risk. a) List 2 likely differential diagnoses for her presentation. b) List 4 underlying predisposing conditions

Severe hyponatraemia

Presents with severe symptomatic hyponatraemia and features of the history consistent with SIADH secondary to indapamide although complete workup would be warranted, especially any history of malignancy, psychogenic polydipsia, features of intracranial pathology, as well as serum and urine sodium levels and osmolality to guide the diagnosis.

I would admit to ICU, consider definitive airway if GCS reduced, normal ventilation, establish central access and an arterial line, load with phenytoin (20mg/kg), stop the indapamide, and start 3% saline.

The goals of fluid therapy is to replace volume and gradually increase the sodium level. There is a chronicity to this presentation suggesting that the sodium has dropped over at least 7 days and therefore the patient is at increased risk of central pontine demyelination if the sodium is rapidly corrected. This is balanced by the fact that the patient is having seizures and therefore is acutely unwell.

May aim would be to correct the sodium to around 109 in the first six hours and then gradually increase the sodium by around 6-8 mmol/L every 24 hours until it is normalised. I would achieve this primarily with 3% saline at 20-30ml/hr and I would replace the patients volume with normal saline.

Complications of sodium correction

- Osmotic demyelination syndrome
- Brainstem stroke

Predisposing conditions

- Alcoholism
- Malnutrition
- Prolonged diuretic use
- Liver failure

Normotonic hyponatraemia with increased osmolar gap

2010/2 A 77 year old male undergoing transurethral prostatic resection under spinal anaesthesia becomes restless and agitated. He is intubated and ventilated in theatre, the surgery is expedited, and he is transferred to ICU. His initial biochemistry profile is as follows : Sodium 113, Chloride 87, Potassium Glucose 5.1, Urea 5.0, Osmolality (measured) 280

> Describe the important biochemical abnormalities What is the likely cause of this confusional state?
> What transient neurological disturbance is likely in this clinical setting?
> List two confirmatory biochemical features (other than those from the table above)
> Do you believe that hypertonic saline is indicated? Explain your reasoning

Simultaneous arterial blood gas analysis is as follows : FiO2 0.3, pH7.33, pO2 93, pCO233, HCO3 16, SBE -9.5

> Describe the acid-base status
> What is the mechanism of this disturbance?

After 7 hours, the biochemical profile is as follows: Sodium 130 Chloride 103 Potassium 3.7 Glucose 5.5 Urea 10.6 Osmolality (measured) 281

> What important changes have occured since the initial profile, and how should they be interpreted?
> Your registrar is concerned that the sodium is correcting too rapidly. Is there a basis for this concern and what should be done?

Normotonic hyponatraemia

Severe normotonic hyponatraemia. The osmolar gap is increased to >40mOsm/kg (51mosm/kg using the 1.86x(Na+K)+urea + glucose or 44mOsm/kg using 2xNa + urea + glucose).

Part 1

> Absorption of glycine / water irrigation solution causing glycine neurotoxicity. Glycine is an inhibitory neurotransmitter. Increased plasma ammonia may contrinute, but the encephalopathy is NOT due to a primary increase in brain water.
> Visual impairment, blindness, sometimes fixed pupils. Should completely resolve within hours
> Hyperammonaemia, hyperglycaemia, hyperserinaemia, metabolic acidosis
> None. The osmolality is normal. Hypertonic saline should only be considered if measured osmolality <260mOsm/kg

Part 2

> Compensated metabolic acidosis - normal anion gap
> Water absorption (SID zero) reducing extracellular SID (in excess of Atot dilution)

Part 3

> Osmolar gap is now greatly reduced (to 16mOsm/kg, or to 5mOsm/kg using simple formula), indicating rapid glycine elimination. Sodium rapidly normalising, but plasma still normotonic
> Rapid sodium correction is to be expected during glycine elimination and is safe provided no sudden changes in osmolality

Hyperglycaemia in ICU

2011/1 List the causes of hyperglycaemia in the intensive care patient population, and outline your management of hyperglycaemia

Causes of hyperglycaemia in ICU

> Increased release of endogenous hormones and
  - Cortisol
  - Catecholamines
  - Glucagon
  - Growth hormone
> Increased endogensous glucose release
  - Gluconeogenesis
  - Glycogenolysis
> Decreased insulin sensitivity (up to 80% if critically ill patients have increased insulin resistance)
> Medications
  - Glucocorticosteroids
  - Catecholamines, sympathomimetics, beta agonists
  - Dextrose containing fluids, feeds, TPN

Management

> I withhold the normal insulin and oral hypoglycaemic medications until the patient is no longer critically ill and then gradually reintroduce them.
> I will avoid medications if practical that raise the BSL such as dextrose containing fluids
> Due to the many variables of critical illness I generally manage hyperglycaemia with an actrapid infusion which enables approrpiate titration.
> As further methods of measuring BSLs emerge there may be a push towards more aggressive glycaemic control.
> Until robust evidence emerges however my default management of BSLs in ICU is to target a BSL of 6-10 in line with the results of NICE-SUGAR.

Hyperosmolar hyperglycaemic state (HHS)

2011/1 Outline the pathophysiology, complications and treatment of hyperosmolar hyperglycaemic state

Introduction

> HHS is the most serious acute hyperglycaemic emergency in diabetic patients.
> HHS has higher morbidity and mortality than DKA.
> HHS is more commonly associated with type 2 diabetes (insulin resistance) rather than type 1 diabetes (insulin absence).
> HHS and DKA develop when there is high insulin resistance and excess glucagon production.
> There is usually a stressful triggering event such as infection which releases cortisol, catecholamines and growth hormones that oppose insulin actions and increase glucose levels.
> Glucose levels are generally higher in HHS as DKA patients usually present earlier and have greater capacity to excrete glucose
> Ketoacidosis is a feautre of DKA rather than HHS as the residual insulin in DMII is enough to prevent lipolysis and subsequent ketogenesis
> Plasma osmolality is always elevated in HHS but less so in DKA

Complications

> Obtundation and coma occurs due to the increased plasma osmolality
> Clinical features of dehydration are usually present due to osmotic diuresis
> Hyponatreamia and hypokaleamia are usually present (sodium should be corrected)
> Renal impairment is common from pre-renal causes (hypovolaemia)

Treatment

> Treatment is similar to DKA
> Resuscitation
  - Fluid resuscitation with crystalloid +/- potassium replacement, Vasoactives may be necessary if the patient is shocked
> Manage BSL
  - IV actrapid
    - 0.1 units/kg as a bolus then 0.1 units/kg/hr as infusion
    - Continue infusion until patient is GCS 15 (IVF dextrose may be required)
> Supportive care
  - Definitive airway if comatose
  - O2 therapy
  - Establish access - peripheral cannula +/- CVC
  - Arterial line for ABGs
  - Insert IDC to monitor fluid balance
  - Transfer to HDU
> Investigations and work up
  - Aimed at monitoring response to treatment and identifying precipitating cause
  - Up to hourly ABGs depending on severity
  - QID EUCs at a minimum
  - Urine and serum osmolality and ketones
  - Full bloods and septic screen (urine, sputum, blood cultures, CXR)
  - Screen for toxins if indicated, cardiac workup is reasonable (ECG/trop)
> Treatment of precipitating cause

DKA vrs HHS

2014/1 a) List the features which distinguish diabetic ketoacidosis (DKA) from the hyperosmolar hyperglycaemic state (HHS). b) Describe your specific treatment for a 62-year-old female presenting with a decreased conscious state secondary to HHS.

Diagnosis

History

> Known type 1 DM; discontinuation of insulin therapy
> Presentation: DKA evolves rapidly (24 hours); HHS typically days-weeks with polydipsia, polyuria and weight loss.

Clinical features

> Neurological symptoms more common in HHS.
> Abdominal pain and hyperventilation more common in DKA.

Laboratory features

> Degree of hyperglycaemia (HHS typical higher, exceeding 56 mmol/l; DKA usually < 44 mmol/L)
> Degree of acidosis: severe in DKA, mild in HHS
> Anion gap acidosis present in DKA; absent (or mild in case of concomitant lactic acidosis) in HHS
> Ketones: HHS small ketonuria, absent to low ketonaemia [there is sufficient basal insulin secretion to prevent ketogenesis]; both high in DKA
> Hyperosmolality more severe in HHS, typically > 320 mosm/L

HHS Management

Fluid replacement

> Expect fluid replacement of up to 10 litres, but GO SLOW (replace over 48 hours)
> Start with isotonic crystalloids (boluses if in shock, infusion rate up to 1L/hour). Need justification for choice of fluid, while recognising there is substantial controversy in this area.
> Continue isotonic if serum Na low; change to 0.45% NaCl if serum Na is normal or elevated.
> Change to 5% dextrose with 0.45% NaCl when serum glucose reaches 15 mmol/L or below
> Individual tailoring based on heart rate, blood pressure, peripheral perfusion, urine output

Insulin infusion

> 0.05 U/kg/hr. initially following adequate fluid resuscitation aiming for steady but slow reduction in blood sugar levels (e.g. 5 mmol/hr)

Electrolyte replacement

> Expect potassium deficit even if level appears normal
> Give 20 - 30 mmol K in each Litre of fluid or use separate infusion; aim for serum K 4 – 5 mmol/L
> Phosphate depletion only requires treatment if levels are very low (e.g. < 0.3 mmol/L) or symptomatic (Ref: BMJ best practice)

Underlying cause Treat possible precipitating cause (infection? need for broad spectrum antibiotics? Think about underlying precipitant in this case – there is a long list of possible causes (e.g. pancreatitis). What about drugs [both β blockers and HMGCo-A reductase inhibitors have been associated with HHS. Other common precipitating drugs e.g. antipsychotics, steroids…] Does she even have diabetes? [Check HbA1C].

Thromboprophylaxis mandatory

Monitoring Haemodynamic situation, mental state, urine output, BSL and electrolytes, ketones, CTB

Stress induced hyperglycaemia

2011/1 Stress induced hyperglycaemia (S.I.H) is common in critically ill patients. a) Define S.I.H b) Outline the mechanisms thought important in the pathogenesis of S.I.H. c) Outline clinical implications and treatment of S.I.H.

Stress induced hyperglycaemia

Transient hyperglycaemia associated with acute illness – resolves with resolution of illness (reserved for patient without prior evidence of diabetes)

Pathogenesis if SIH

> complex interaction between;

- hormones (catecholamines, GH, cortisol, cytokines)
- treatments: TPN, enteral feed, steroids, vasopressors
- underlying illness
- high hepatic glucose output via gluconeogenesis driven by glucagons, adrenaline and cortisol, TNF alpha.
- insulin resistance
- underlying abnormalities in glucose regulation may be present

Clinical implications

May be a marker of worsened outcomes when compared to DM related hyperglycaemia

It is associated with increased mortality, adverse events, more organ failures compared to those with DMII

Treatment of S.I.H.

Early recognition and interception might prevent persistence and exacerbation

Regular BSL monitoring

Avoid medications and interventions that may elevate BSL if reasonable

Insulin to target a BSL of 6-10 as per findings of NICE Sugar

Treat underlying cause

Avoid hypoglycaemia

Phaeochromocytoma

2011/1 A 43 year old female presents with a severe episode of palpitations, sweating, vomiting and breathlessness after taking a dose of propranolol prescribed by her General Practitioner for panic attacks. She gives a history of similar symptoms occurring episodically over the preceding three months and her past medical history includes medullary thyroid cancer. Vital signs: SaO2 88% on oxygen 15 L/min via mask Heart rate: 150, Atrial Fibrillation BP 175/100 mm Hg-Chest X-Ray: Consistent with acute pulmonary oedema. 1) What is the likely diagnosis? 2) What investigations will help you confirm the diagnosis? 3) Outline your immediate management of this patient. 4) List four complications of this condition.

Phaeochromocytoma

> Catecholamine-secreting tumors that arise from chromaffin cells of the adrenal medulla

> In this setting the previous diagnosis of medullary thyroid cancer suggests a diagnosis of Multiple Endocrine Neoplasia 2

Investigations

> Plasma free metanephrine

> 24 hour urine collection for creatinine, total catecholamines, vanillylmandelic acid and metanephrines

> Imaging

- MRI – most sensitive
- CT scan – less accurate for lesions
- MIBG scan – biochemical confirmation but no tumour seen on CT scan or MRI
- PET scan

Immediate management

> Admission to ICU or HDU for close monitoring

> Increase inspired oxygen concentration

> Start alpha blockade with IV phentolamine to control BP acutely and start phenoxybenzamine orally.

> Rate control of AF with calcium channel blocker

> Once alpha blockade established, beta blockade can be added

> IV fluid replacement as vasodilation occurs to normalise blood volume

> Some authorities recommend magnesium sulphate infusion

> Screen for myocardial damage with serial troponins, ECG and echo. Echo may show Takutsubo type abnormality

Complications of this condition.

> Myocardial infarction

> Arrhythmias

> Seizures

> Stroke

Adrenal insufficiency

2011/1 Outline the causes, consequences and management of adrenal insufficiency in the critically ill

Causes of adrenal insufficiency in ICU

> Causes of adrenal insufficiency in the critically ill can be categorised as primary (ie diseases of the adrenal gland), secondary (interference with pituitary secretion of ACTH) and tertiary (interference with the hypothalamic excretion of CRF).

> Primary causes include
- autoimmune (may have vitelligo)
- haemorrhage (eg meningococcal related Waterhouse–Friderichsen syndrome)
- emboli
- sepsis
- adrenal vein thrombosis

> Seconday causes include destruction of pituitary by
- tumour, cellular inflammation
- infection
- head trauma
- infarction

> Tertiary causes include :
- abrupt cessation of high dose steroids
- hypothalamic damage (tumour, infiltration, radiation)
- The stress of critical illness can unmask partial adrenal insufficiency in patients at risk

Consequences

> Shock (may be refractory

> Symptoms include
- Abdominal tenderness
- Myalgias and arthralgias
- Nausea and vomiting
- Volume depletion
- Fever
- Confusion.

> Electrolyte disturbances include hyperkalaemia, hyponatraemia and hypoglycaemia.

Management

> Management needs to commence before diagnosis is confirmed.

> Administration of corticosteroids (eg hydrocortisone 100mg or dexamethasone 4mg) is required; dex is preferred as it interferes least with cortisol assays associated with high or low dose short synacthen tests),

> fluid resuscitation (reversal of hypovolaemia and electrolyte abnormalities),

> treatment of underlying causative and/or co-existing diseases including sepsis.

> The diagnosis and treatment of stress induced impairment of the hypothalamic-pituitary-adrenal axis (functional adrenal insufficiency) remains controversial.

Thyroid

2014/1 With reference to thyroid function: a) Briefly outline the thyroid function/hormone profile expected in the sick euthyroid syndrome or non-thyroidal illness syndrome (NTIS). b) For each of the following drugs, list its effect(s) on thyroid function. i. Amiodarone ii. Propranolol iii. Glucocorticoids iv. Opiates c) Briefly outline your pharmacological approach to the treatment of thyrotoxic crises. Include in your answer the rationale for each drug used.

Sick euthyroid syndrome

> NTIS is a term that is used to describe patients with non thyroidal illness that have low serum concentrations of T3 and potentially T4 and TSH.

> 5'monodeiodinases catalyse thyroxine reactions and include D1, D2 and D3 subtypes

- The most prominent feature in SES is a reduction in T3 due to decreased cleaving of T4 by D1 and D2 in organs such as muscle, liver, and kidney
- There is also an increase in D3 activity leading to greater conversion of T4 to reverse T3

> Low serum total T3 is most commonly observed-mean values are 40% of normal.

> SES may progress to include a reduction in Serum T4 and TSH or there may be transiently rise then return to normal

> On recovery T3 and rT3 return to normal.

Drug actions on Thyroid function

Amiodarone

> Amiodarone is structurally very similar to iodine and therefore and has several actions on thyroids. Firstly it Inhibits peripheral conversion T4 to T3, It inhibits T3 and T4 entry into the peripheral tissues and has a direct cytotoxic effect on the thyroid.

Propranolol

In addtion to Inhibition of peripheral conversion T4 to T3, propanolol is a beta blocker which blunts the symptomoimetic actions of thyroid hormones.

Glucocorticoids

Inhibition of peripheral conversion T4 to T3 and supressors TSH secretion

Opiates

Suppression of TSH secretion

A sequential, multi-drug approach is vital and the order of therapy is important.

Three pathways need consideration-halting synthesis, preventing release of stored hormone and blockade of peripheral effects including blocking conversion of T4 toT3 as well as control of adrenergic symptoms.

> A beta blocker to control the symptoms and signs induced by increased adrenergic tone

> A thionamide to block new hormone synthesis

> An iodine solution to block the release of thyroid hormone

> An iodinated radiocontrast agent (if available) to inhibit the peripheral conversion of thyroxine (T4) to triiodothyronine (T3)

> Glucocorticoids to reduce T4-to-T3 conversion, promote vasomotor stability, and possibly treat an associated relative adrenal insufficiency

> Bile acid sequestrants to decrease enterohepatic recycling of thyroid hormones

Hypothyroidism

2011/1 Outline the clinical manifestations, appropriate investigations and treatment of hypothyroidism in Intensive Care.

Clinical manifestations

Nonthyroidal Illness Syndrome

> Acutely ill patients typically present with low circulating T3 and increased reverse T3.

> Prolonged critical illness is also associated with a neuroendocrine dysfunction characterized by suppressed hypothalamic thyrotropin-releasing hormone (TRH) expression, reducing TSH and T4 and therefore exacerbating the reduction in T3

> Manifestations are usually mild although some of the classic symptoms of hypothyroidism such as include fatigue, cold intolerance, weight gain, constipation, dry skin, myalgia, and menstrual irregularities may be present

Myxoedema Coma

> Myxedema coma is defined as severe hypothyroidism leading to decreased mental status, hypothermia, and other symptoms related to slowing of function in multiple organs

> Two main causes
  - Severe long standing hypothyroidism - insidious onset
  - Precipitated from an acute event such as infection, MI, head injury etc.

> Manifestations
  - Confusion and reduced LOC (but rarely coma despite then name)
  - Hyponatraemia, Hypothermia, Hypoventilation, Hypoglycaemia
  - Cardiac manifestations include a narrowed pulse pressure and elevated DBP and pericardial effusions.

Investigations

> Work up for a precipitating cause - infection, cardiac, bleeding or coagulopathy diathesis

> TSH, T4 and T3

> Short synacthen test

Treatment

> NTIS
  - Thyroid replacement not generally recommended as reductions no evidence to support its use
  - If the patient is known to be hypothyroid prior to their critical illness thyroid replacement is recommended
  - Drugs that influence the thyroid axis should be used with caution

> Myxoedema coma
  - Administer levothyroxine 200 to 400 mcg (0.2 to 0.4 mg) intravenously followed by daily doses of 50 to 100 mcg, and triiodothyronine 5 to 20 mcg intravenously followed by 2.5 to 10 mcg every eight hours.
  - Change to an equivalent oral dose of levothyroxine when the patient can tolerate oral medications. (Oral dose = intravenous dose ÷ 0.75).
  - Supportive measures:
    - Mechanical ventilation
    - Fluids and vasopressor drugs to correct hypotension
    - Passive rewarming
    - Intravenous dextrose
    - Stress-doses glucocorticoids
    - Consider empirical antibiotic treatment
    - Monitor for arrhythmias and treat when indicated

Renal Medicine

Anticoagulation in CVVHDF

2007/1 Discuss briefly the advantages and limitations of four strategies you would use for prevention of clotting in a continous renal replacement therapy circuit.

Introduction

Although the choice of anticoagulation is very important in terms of preventing clotting there are also non pharmaceutical aspects which should be optimised

- Vascular access should be optimised - ideally with a right IJ approach as this is the straightest
- Interruptions to dialysis should be minimised
- Reducing haemoconcentration should be considered by increasing predilution or reducing the filtration fraction however this will reduce the efficiency

Systemic heparin (low to medium dose)

Pros - Easy to administer, cheap, may not have a significant systemic anticoagulant effect, effectively antagonised by protamine, physician familiarity

Cons - anticoagulation may not always be effective needing higher doses and systemic anticoagulation, risk of bleeding, pharmacokinetics altered in critical illness, need to monitor APTT (cost etc), risk of HITTS

Heparin with protamine reversal

Pros - prevents complications of systemic heparinisation

Cons - more complex to administer, allergy and other reactions to protamine, still need to monitor APTT

Regional citrate

Pros - may be more effective at preventing filter clotting. Not associated with HITTS

Cons - initially unfamiliar, need for calcium free dialysate fluid, can get metabolic alkalosis, hypocalcaemia. Still need DVT prophylaxis

LMWH

Pros - easy to use

Cons - more complex to monitor (need to measure factor Xa levels). More expensive. Cannot reverse effect easily. May get HITTS

Citrate anticoagulation in CVVHDF

2013/1 29. Regarding regional citrate anticoagulation for continuous renal replacement therapy (CRRT): a) What is the mechanism by which citrate provides anticoagulation? b) What is the metabolic fate of the citrate? c) What are the features of citrate toxicity? d) What conditions may increase the risk of citrate toxicity? e) What alternative(s) to citrate could you use in a patient with severe HITS?

Mechanism of citrate anticoagulation

Citrate chelates the ionised calcium prior to entering the circuit and as an important cofactor throughout the clotting cascade and in platelet function prevents clot formation in the filter

Citrate metabolism

> Citrate complexed with calcium is partially removed by the filter, but some enters the circulation.

> Citrate is metabolised in the mitochondria of the skeletal muscles, kidneys (impaired in this setting) and liver

> In the liver (where most metabolism takes place) citrate enters the tricarboxylic acid pathway (Krebs cycle) generating NADH. This also generates bicarbonate (at a rate of 3 bicarb per 1 citrate)

Citrate toxicity

> Metabolic acidosis Patients with severe liver failure and lactic acidosis may have difficulty with citrate metabolism and develop citrate toxicity, which is characterized by low systemic iCa++, elevated total serum calcium, metabolic acidosis and an increased anion gap. Acidosis can occur not only due to failure to metabolize citrate through to bicarbonate, but also due to the continued losses of bicarbonate in the filter

> Metabolic alkalosis Metabolic conversion from accumulated citrate can result in an excessive alkali load with a high bicarbonate and hence metabolic alkalosis

> Hypocalcaemia May result if citrate accumulates systemically. It may also occur by the loss of calcium bound to citrate in the effluent, or by insufficient calcium supplementation.

> Hypernatraemia The citrate is bound to sodium (Na3Citrate) and therefore it's use results in a high sodium load.

Risk factors for citrate toxicity

> Excessive citrate delivery due to a systems error

> Inadequate citrate metabolism

- Mitochondrial disease
- Liver impairment (especially fulminant)
- Poor cardiac output states (poor muscle and liver perfusion)

Alternative regimes in HITS

> Prostacyclin (PGI2)

> Danaparoid

> Bivalirudin

> Fondaparinux

> Lepirudin

> Dabigatran may be an option as the monoclonal antibody reversal agent becomes available

Contrast associated acute kidney injury

2009/1 Critically evaluate strategies that have been used in the prevention of acute kidney injury (AKI) associated with the administration of iodinated radio contrast medium.

Alternative imaging technique

> When possible, use ultrasonography, magnetic resonance imaging (MRI) without gadolinium contrast, or computed tomography (CT) scanning without radiocontrast agents

> This removes the risk of contrast nephropy but may be more expensive or less useful from a diagnostic perspective

Modifying the contrast type or amount

> Avoiding older high-osmolal agents (1400 to 1800 mosmol/kg) has good evidence and reduces the risk

> Use lower doses of contrast and avoid repetitive, closely spaced studies (eg, <48 hours apart)

Optimise patient factors

> Avoid volume depletion and nonsteroidal anti-inflammatory drugs (NSAIDs) as well as other nephrotoxics

Volume expansion

> Isotonic intravenous fluids prior to and continued for several hours after contrast administration has reasonable evidence base

> May not be suitable in patients at risk of overload (lung and cardiac pathology)

> Either isotonic bicarbonate or isotonic NaCl may be used, although there is a slight preference for isotonic NaCl, since NaCl is less expensive and there is no risk of compounding errors.

> Timing and rate of administration are independent of fluid type and vary between inpatients and outpatients:

N-Acetylcycteine

> Has a conflicting evidence base with some studies suggesting a reduced risk of nephropathy and others equivocal.

> Systematic reviews have demonstrated a high level of heterogeniety in the included studies

> Use of NAC is likely to be influenced by local guidelines and physician preference

> In IV formulations there is an increased risk of anaphylaxis

Dialysis

> There is evidence to support dialysis commence prior to contrast being used and post contrast.

> Dialysis is complicated, expensive and time consuming and therefore not routine care

CVVHDF for refractory sepsis

Created question Critically evaluate cytokine clearance using high-flow CVVHDF as an adjunct in the management of refractory sepsis

Rationale

> Immunomodulatory – via removal of inflammatory mediators
> Immunohomeostasis – continuously - adjunct to resuscitation, antimicrobials, steroids, nutrition

Definitions

Cytokine – inflammatory mediator s – pro (TNFalpha, IL-1, IL-8, PAF), anti (IL-10, IL-4, TGF-beta)

High-flow CVVHDF: 70ml/kg/h (IVIORE), 40 ml/kg/h (RENAL)

Refractory sepsis – persistently low MAP despite vasopressors and adequate IVF

Advantages

Has potential to improve outcomes

Disadvantage

Expensive and time consuming

Requires anticoagulation and associated risks of bleeding and/or citrate toxicity

Insertion of vascath required - risks include bleeding, infection, pheumothorax

Evidence

Evidence no clear evidence yet, no consensus

Two main references

> RENAL NEJM 2009, Bellomo – 40 vs 25ml/kg/h
  - The point estimates demonstrated a non significant improvement in mortality for the higher intensity group with sepsis rather than low intensity (51% v 46% therefore ARR 5%)
> IVIORE ICM 2013, – Septic shock, 70 vs 35 ml/kg/h for 96h – stopped early (researcher fatigue)
  - no difference in 28 day mortality - n=140, open, prospective trial, AKI<24h

My practice

I would not use CVVHDF in critically unwell sepsis patients without a clear indication such as refractory electrolye disturbance, fluid overload or acidosis.

I would be open to changing my practice in the face of more conclusive evidence

CRRT principles

2007/2 With respect to continuous renal replacement therapy (CRRT) in the ICU define the terms diffusion and convection and the role they play in solute transport during CRRT define the terms filtration fraction and sieving coeficient and their significance.

Diffusion

From the latin - to spread out

Is the movement of solutes from one compartment to another along a concentration gradient.

Diffusion is the principle mode of solute clearance using dialysis therapies.

Convection

From the latin - to bring together

Is the movement of solute accrose a semipermeable membrane in conjunction with significant amounts of ultrafiltration of water (solvent drag).

Convection is the principle mode of solute clearance during ultrafiltration

Filtration fraction

The fraction of plasma that is removed from blood during haemofiltration.

The optimal filtration fraction at a haematocrit of 30% is of the order of 20-25%.

A higher filtration fraction can lead to haemoconcentration in the filter, increasing the risk of filter clotting.

Sieving coefficient

The efficiency of the removal of drugs or any other solute is related to the sieving coefficient (SC).

The SC is the mathematical expression of the ability of a solute to convectively cross a membrane.

It is determined from the ratio of the solute concentration in the ultrafiltrate to the solute concentration in the plasma

A high sieving coefficient is desirable for middle molecules but undesirable for albumin sized molecules.

CVVHD, IHD and SCUF - compare and contrast

2011/1 Compare and contrast the use of continuous veno-venous haemodialysisv(CVVHD), intermittent haemodialysis (IHD) and slow continuous ultrafiltrationv(SCUF) in the intensive care patient.

	CVVHD	SCUF	IHD
Vascular Access	Double lumen catheter in central vein	Double lumen catheter in central vein	Double lumen catheter or fistula able to manage high flows
Operator skill Set	Requires specialist expertise	Requires specialist expertise	Expertise commonly available
Cost	Is most expenisve	Is less expensive	Is cheapest option
Flows	Low flow 50-200ml/min	Low flow 50-200ml/min	High flow 500ml/min
Fluid Removal	Slow	Slow	Rapid
Electrolyte Removal	Slow	Slow	Rapid
Anticoagulation	Continuous anticoagulation	Continuous anticoagulation	Anticoagulation only on filter

> Advantages
- Increased haemodynamic stability
- Good clearance of small molecules
- Good control over electrolyte and acid-base

> Disadvantages
- Expensive
- Requires anticoagulation
- Prolonged immobilization
- Slow and inefficient

> Advantages
- Achieves good fluid removal
- Well tolerated unless very unstable

> Disadvantages
- Poor solute clearance
- Slow and inefficient

> Advantages
- Rapid
- Rarely requires anticoagulation
- Allows mobilization
- May access fistula

> Disadvantages
- Poorly tolerated by hemodynamically unstable patients
- Risk of disequilibrium syndrome

CVVHDF and filter performance

Created Question An 38 year old woman with a BMI of 35 is day 3 in your ICU with multi-organ dysfunction secondary to community acquired pneumonia. She has an acute kidney injury and is currently receiving CVVHDF however in the past 24 hours she has clotted off three filters. List the potential reasons for the filter clotting and describe how you would do to optimize her dialysis.

CVVHDF - Continuous Veno-Veno HaemoDiaFiltration.

> Dialysis (diffusion) - removes solutes by creating a concentration gradient and solvent by via an osmotic gradient

> Filtration (convection) - removes solutes and solvent by creating an oncotic (pressure) gradient

Premature filter clotting

Patient and access factors

- Pro-coagulant state - due to sepsis, use of the oral contraceptive pill, pro-coagulant diathesis such as factor V Leiden, antiphospholipid antibodies etc.
- Increased cytokines and inflammatory mediators may increase clogging of the membrane
- Increased BMI of the patient may make vascular access difficult
- Impaired LFTs limits citrate use
- High PEEP needed in respiratory failure may reduce flow characteristics

> Circuit factors

- Increased haemoconcentration reduces filter patency
- Turbulent blood flows increase clotting likelihood
- Blood air contact will also increase likelihood of clotting
- Higher transmembrane pressures reduce filter duration
- Frequent interruptions

Optimising filter performance

> Anticoagulation - is one of the most important factors to improving filter performance

- Assess the bleeding risk in the patient - undertake a full coagulation profile to assess a baseline
- Consider increasing anticoagulation - in a CAP with sepsis increased anticoagulation may be reasonable
- Regional anticoagulation may be an option - citrate if liver is OK, heparin with protamine as an alternative
- Minimise transfusion of platelets as this has been shown to increase filter clotting

> Catheter

- Optimise patient position - ensure the catheter is as straight as possible
- Consider adjusting catheter position - remove 1-2cm to improve flows then re-suture
- Consider changing catheter position and type
  - If available use a shorter wider catheter
  - Right IJ is generally the best location
  - Femoral positions may be an issue if the patient needs to sit up to improve lung mechanics
  - Left subclavian is an alternative although may be issues with stenosis and difficulty with permacath placement

> Circuit optimisation

- Reduce the filtration fraction - the ultrafiltrate flow/blood flow by either increasing the blood flow or reducing the ultrafiltrate flow to reduce haemoconcentration
- Consider predilution - this will reduce haemoconcentration although it reduces the efficency of dialysis
- Consider changing the filter size or membrane if possible

> Minimise interruptions

- Enhance nursing care with more experienced staff or further training by a nurse educator
- Schedule scans or surgery together to minimise interruptions

CVVHDF anticoagulation options in HITTS

2014/1 A 55-year-old patient with severe sepsis develops Heparin Induced Thrombotic Thrombocytopaenia Syndrome (HITTS) while on continuous veno-venous haemodiafiltration (CVVHDF). Outline the strategies available for prolonging the life of the CVVHDF circuit in this patient, mentioning the advantages and disadvantages of each strategy.

Intoduction

> Anticoagulation
  - This is the most important characteristic to consider in this setting
  - Major options include citrate anticoagulation, use of a thrombin inhibitor such as Bivalirudin or a heparinoid such as fondaparinuex and are discussed below
  - No anticoagulation is an option although patients will generally require some anticoag with HITTS and this will shorten filter life
  - Theoretical options include NOACs, warfarinisation (caution as initially procoagulant), prostacyclin

> Circuit optimisation
  - Reduce haemoconcentration (but this will also reduce the effeciency of dialysis)
    - Reduce filtration fraction
    - Increase predilution
  - Use a different filter size

> Optimise the catheter position (right IJ) and reduce interuptions (book investigations together etc)

Citrate anticoagulation

> Chelates ionised calcium

> As calcium is a cofactor in clotting pathway this reduces clotting

> Advantages
  - Is regional therefore the patient's coagulation is not affected (although will generally need some anticoag in HITTS)
  - Has been demonstrated to prolong filter life in trials when compared to heparinisation

> Disadvantages
  - Needs close monitoring of ionised clacium levels and replacement
  - Can lead to metabolic alkalosis, metabolic acidosis, hypernatraemia and hypocalcaemia
  - Not suitable in liver impairment, mitochondrial disease and used in caution in low output states

Thrombin inhibitor

> Bivalirudin is a thrombin inhibitor

> It blocks thrombin in the coagulation cascade

> Advantages
  - reversible thrombin binding
  - Extrarenal and extrahepatic clearance mechanisms
  - Shorter half life than other thrombin inhibitors
  - Has been shown to increase filter life when compared with no anticoagulation

> Disadvantages
  - Risk of a false positive increase in INR
  - Still has a long half life despite shorter than other thrombin inhibitors
  - No reversal

Fondaparinux

> A synthetic Xa inhibitor used SC

> OK to use in HITTS type II

> Advantages
  - Single dose of 2.5mg can improve filter life

> Disadvantages
  - Long half life
  - Increased risk of bleeding
  - monitoring difficult although anti Xa levels may assist

CVVHF, SLED and IHD compare and contrast

2009/1 Compare Continuous Venovenous Haemofiltration (CVVHF) , Sustained Low Efficiency Dialysis (SLED) and Intermittent hemodialysis (IHD with respect to a) mechanism of solute clearance b) advantages and c) disadvantages

CVVHF

Mechanism

> In CVVH, solute clearance occurs by convection

> Solutes are carried along with the bulk flow of fluid in a hydraulic-induced ultrafiltrate of blood.

> The rate at which ultrafiltration occurs is the major determinant of convective clearance.

> The ultrafiltration rate is determined by the transmembrane pressure, water permeability, pore size, surface area, and membrane thickness.

Advantages

- Increased haemodynamic stability
- Good control over electrolyte and acid-base

Disadvantages

- Expensive
- Requires anticoagulation
- Prolonged immobilization
- Slow and inefficient

SLED

Mechanism

> Sustained low-efficiency dialysis and extended daily dialysis are slower dialytic modalities run for prolonged periods using conventional hemodialysis machines with modification of blood and dialysate flows.

> It essentially represents a hybrid of IHD and CVVHDF.

Advantages

- Less expensive than CVVHF
- Reduced monitoring costs and expertise in managing SLED/IHD is generally more widespread
- Improved haemodynamic stability when compared with IHD

Disadvantages

- Less efficient than IHD
- May be less tolerated than CVVHF in unstable patients

IHD

Mechanism

> In IHD, solute clearance occurs mainly by diffusion,

> Volume is removed by ultrafiltration.

> The degree of solute clearance, also known as "dialysis dose," and is dependent on the rate of blood flow. Increasing the blood flow increases solute clearance

Advantages

- Rapid
- Rarely requires anticoagulation
- Allows mobilization
- May access fistula

Disadvantages

- Poorly tolerated by hemodynamically unstable patients
- Risk of disequilibrium syndrome

Fluid assessment

2005/2 Outline the way in which you would evaluate and treat oliguria which has developed in a 36 yr old patient who has been admitted to your Intensive Care Unit with severe community-acquired pneumonia

Oliguria

Urine Output< 0.5ml/kg/hr for 2 consecutive hours

Causes (may be multifactorial)

Pre-renal

> 30-40% oliguric patients in ICU

> Hypovolaemic (decreased intake v increased losses), Distributive (v. likely in CAP/sepsis), Cardiac may be due to acute LV dysfunction, Obstructive due to PE

Renal

> Acute Tubular Necrosis (ATN) from any prolonged renal cause (50% ICU patients) such as drugs and toxins

> Other causes include vascultitis, emboli, GTN

Post-renal

> Obstruction (stones, prostate, blocked or kinked catheter tumours Raised intra-abdominal pressure)

Focussed History

> Hypovolaemic shock
  - Assess intake (oral, IVF, NG feeds)
  - Assess fluid losses
    - Sensible losses (drain output, bleeding, diarrhoea, NG aspirates)
    - Insensible (non humidified circuit, open abdomen, hyperthermia)

> Distributive shock - sepsis, spinal cord injury

> Cardiogenic or obstructive shock - hx of CCF, ECHO results, chest pain, PE risk

> Renal function - baseline function, nephrotoxics especially antibiotics in setting of CAP.

> Risk factors for post renal disease

Examination and investigations

> Formal assessment of fluid status (mucous membranes, skin tugor, peripheral oedema, JVP)

> Assess cardiac function - bedside ECHO to check IVC size, LV filling and ejection fraction, CVP trend

> Respiratory - ABG to check K, pH, HCO3, review ventilator settings ? high PEEP and reduced preload

> Abdomen - check for intra-abdominal abnormalities, perform a bladder scan, flush catheter, transduce for pressures

> Genito-urinary - check urine colour, send for micro and analysis, specific gravity, osmolality, sodium, renal tract US

Management

> My management would be guided by the focussed evaluation and likely diagnoses and would ensure that the management of the CAP is optimised. Initially I would give a fluid challenge with 500ml crystalloid or colloid unless contraindicated, noradrenaline to maintain MAP>65. I would usually avoid frusemide unless the patient is comprimised by fluid overload. I would commence CVVHDF only if there is a clear indication (refractory acidosis, hyperkalaemia or overload, ureamia causing confusion etc

Indications for dialysis

2005/2 Outline the clinical scenarios in which you would consider instituting dialysis in the critically ill.

Introduction

> Dialysis is an important tool in critical care which enables the removal of fluid, solutes and toxins to prevent otherwise life threatening complications

> The optimal timing and frequency is not known but institution prior to complications is desirable

> Generally safer and more widely used than previously so indications broadening

Renal indications

> Hyperkalaemia
  - Failure to control rising potassium with medical measures.
  - ECG changes associated with high K+
  - Medical measures should be continued until potassium level is normalised (eg. Calcium gluconate, HCO3-, Salbutamol, Insulin/dextrose, frusemide, resonium)

> Uraemia
  - Manifestations of encephalopathy or pericarditis rather than targeting absolute serum urea value

> Acidosis (refractory)

> Fluid overload
  - Resistant to diuretics
  - Pulmonary oedema

> Oliguria/anuria
  - This is a relative indication
  - Although reduced urine output does not cause harm per se, it often heralds fluid and electrolyte disorders associated with renal failure
  - First, attempts to treat and prevent acute renal failure should occur but if it is expected that renal failure will occur and not resolve immediately, this may be used as an indication to get started with dialysis

> Other electrolyte disorders
  - Mg++, Ca++, hyperuricaemia, Sodium disorders

> Known chronic renal failure usually requiring dialysis

> Trends rather than absolute numbers are important

Non-renal indications

> Toxin removal
  - generally toxin or drug removal by dialysis depends on low molecular size, low protein binding, unionized and water soluble
  - Haemoperfusion sometimes used to bind the offending toxin
  - Common toxins include: Heavy metals, salicylates, lithium, alcohols, theophylline, barbiturates

> SIRS/Sepsis
  - Not a current indication

Summary

> Although dialysis is now a commonly used therapy in intensive care and relatively safe, it has associated risks and requires intensive resource use

> Institution should be based on clinical indications rather than purely biochemical thresholds

> Full consideration of the patients expected clinical course and current physiological state should occur

Mechanisms of renal failure and indications for CVVHDF

2011/1 A 76-year-old man is admitted to the ICU following a laparotomy for faecal peritonitis. He has developed multi-organ failure over two days, requiring ventilatory and inotropic support. He is oliguric, increasingly acidotic, uraemic and has a rising serum creatinine. a) List the likely mechanisms for this patient's renal failure b) What would be your indications for renal dialysis in this man? c) Outline the means by which you would maximise urea clearance when using CVVHDF

List the likely mechanisms for this patient's renal failure

Likely mechanisms include pre-renal, renal and post-renal causes

Pre-renal

> Hypovolaemia (inadequate resuscitation)

> Hypotension (inadequate perfusion pressure compared to his normal BP despite inotropes) Impaired cardiac output (septic cardiomyopathy, myocardial ischaemia/infarction, dysrhythmias)

Renal

> Toxins (eg nephrotoxic drugs – need to specify gentamicin / NSAIDs / contast for CT) Microcirculatory failure (sepsis and inflammatory response) with medullary ischaemia, tubular obstruction and vasoconstriction (acute tubular necrosis)

Post-renal

> Raised intra-abdominal pressure Unrecognised catheter problems

What would be your indications for renal dialysis in this man?

> Uncontrolled electrolyte disturbances (hyperkalaemia, hypernatraemia)

> Uncontrolled metabolic acidosis

> Uraemia 30-35 mmol/l (optimal timing not known, uncontrolled studies suggest early CRRT better than late, candidate should have his/her own threshold level)

> Fluid overload unresponsive to diuretics

> Early intervention to minimise inflammatory response in sepsis may be considered but is unproven

Outline the means by which you would maximise urea clearance when using CVVHDF

> Urea clearance depends on ultrafiltrate flow rate and dialysate flow rate so clearance enhanced by increasing blood flow rate and/or dialysate flow rate

> Use of filters with larger membrane surface areas

> Use of predilution

> Changing filter if failing

> Maximising time on CRRT by ensuring good vascular access, optimising filter life and limiting/rationalising time out of the ICU for imaging, surgery etc

Pathophysiological changes in CRF

2011/1 Outline the pathophysiological changes associated with end-stage kidney disease (dialysis dependent) that may impact on the management of critically ill patients.

Renal

> Major issues with managing fluid load in anuria and oliguria

Pharmacokinetics

> Are greatly altered in this patient cohort
> May have increased volume of distribution
> Changes in metabolism of many drugs
> Marked reduction in renally excreted drugs and therefore accumulation
> Increased drug clearance whilst on the filter for certain drugs
> Changes in protien levels and subsequent binding

Cardiovascular changes

> Increased risk of
  - Ischaemic heart disease
  - Hypertension
  - Peripheral vascular disease
  - Arrhythmias
  - Pericarditis
> More difficult vascular access due to fistulas

Metabolic

> Hyperkalaemia (although in chronic settings may have less adverse cardiac outcomes)
> Hyperphosphataemia
> Calcium dysregulation

Respiratory

> Increased risk of pulmonary oedema due to fluid accumulation

Haematological

> Anaemia secondary to reduced EPO production
> Platelet dysfunction due to uraemia

Neurological

> Myopathy
> Neuropathy
> Increased risk of dialysis dysequilibrium (cerebral oedema post dialysis initiation)
> Confusion and delerium risk increased due to metabolic derangement

Gastrointestinal

> Reduced gut motility
> Increased risk of GI bleeding due to platelet dysfunction

Plasma exchange

2010/1 With respect to plasma exchange therapy: What are the physical principles of plasma exchange therapy? What substances can plasma exchange effectively remove? List 5 acute conditions where therapeutic plasma exchange is indicated List 4 common complications of this therapy, excluding catheter-related complications

Plasmapheresis

- A general term used to denote the automated, selective removal of plasma.
- Plasma can be separated from the blood using centrifugation or filtration.
- Devices separating based on size use filters, whereas those separating by density use centrifugation
- Through the bulk removal and replacement of plasma pathologic substances such as pathologic Abs, immune complexes, and cytokines are removed
- It has been presumed that the removal of these substances represents the major mechanism of action of TPE although it is likely that this also leads to more complex immunomodulation

Substances removed by plasma exchange

- Immunoglobulins and immune complexes
- Antibodies
- Clotting factors
- Fibronogen
- Von Willebrand Factor
- Antithrombin
- Selected medications (Including ceftriaxone, verapamil and diltiazem)

Acute conditions where plasma exchange is indicated

- TTP-HUS
- Catastrophic antiphospholipid syndrome
- Hyperviscosity syndrome (eg. myeloma)
- Guillain-Barre syndrome
- Myasthenia gravis
- Acute fulminant hepatitis with encephalopathy

Complications associated with plasmapheresis

- Paraesthesia due to hypocalcemia (due to regional citrate anticoagulation)
- Urticaria
- Low fibrinogen and coagulopathy
- Hypotension
- Vasovagal syncope
- Nausea and vomiting
- Haemolysis and thrombocytopenia
- Loss of useful drugs
- Immunesuppression
- Anaphylaxis

Renal recovery post Acute Kidney Injury (AKI)

Created Question A 78 yo male is recovering from severe pneumococcal sepsis, which led to his developing anuric renal failure. He remains anuric after 3 weeks, and his family are concerned that he will require long-term dialysis, which he had previously stated he would not want. Outline the specific points you would discuss with the family regarding his prospects for renal recovery.

Acute Kidney Injury is a syndrome characterised by a rapid (hours to days) decrease in the kidney's ability to eliminate waste products such as urea and creatinine as well as dysregulation of extracellular volume and electrolytes.

Introduction - Would firstly introduce myself to the family and then attempt to get an understanding of the family's current interpretation of the critical illness and expectations. Once I appreciate the family's understanding of the medical paradigm I would proceed with the discussion.

Pre-morbid function - I would then proceed to place this data in the context of the patient described in the stem.

> Get the family to explain the pre-morbid functional status

> Baseline renal function - if already poor may increase the risk of dialysis dependence

> Evidence of risk factors for renal disease

- Cardiovascular disease including hypertension, Diabetes, Smoking, Dyslipidaemia

> Other co-morbidities - consider the total burden of disease

Current admission details

> Specific cause of the renal injury - likelihood of improvement given aetiology

> Evidence of other organ involvement

> Cardiac - requirement of vasoactive drugs, hx of cardiac injury

> Respiratory - as the patient has had pneumoccocal sepsis it would be important to characterise this event in terms of ventilation requirements, rescue therapies required

> Brain - Cognition, ability to provide informed consent

> Liver - coagulopathy, evidence of hepatic injury, risk of uraemia etc.

> Use of contrast and other nephrotoxics used as this may further assist with prognostication and probability of recovery

General ICU outcomes of AKI and dialysis - I would then introduce some statistics to the family. The most robust outcomes assessments in an Australasian population are from the RENAL investigators. This well designed RCT demonstrated that at three months patients with acute kidney injury requiring dialysis;

> All cause mortality was ~ 45%

> Dialysis dependence was ~ 5-7% in survivors

> POST-RENAL was a follow up study published in 2014 and showed at 4 yrs 5% of survivors required dialysis.

Epidemiological studies have demonstrated that having an episode of AKI requiring dialysis independently increases the risk in the long term of end stage renal disease threefold even when there is a period post injury where dialysis is not required.

Shared decision making in ESRD - I would then discuss a shared decision making framework for progressing the care of the patient in the stem within the prognostic context described above.

> Aim to involve the patient in the decision making process - opinions may change

> Aim for a multidisciplinary approach with renal and palliative care involvement if the prognosis is uncertain

> Identify important decision points in the process such as the removal of other organ supports (stopping dialysis whilst ventilating the patient may be counterintuitive)

> Present the option of a trial of intermittent haemodialysis via a permacath

> Offer the option of revisiting the issues as the situation evolves

Renal classification systems

Created Question Compare and contrast the RIFLE, AKIN and KDIGO systems for classifying acute kidney injury.

Acute Kidney Injury is a syndrome characterised by a rapid (hours to days) decrease in the kidney's ability to eliminate waste products such as urea and creatinine as well as dysregulation of extracellular volume and electrolytes.

AKI Classification There are a range of different definitions of AKI. Progress in clinical research has been previously hindered by the lack of a clear consensus criteria for characterising AKI. This has reduced the ability of both clinicians and researchers to apply results of different studies to their own populations and has made comparisons between trials more difficult. The RIFLE, AKIN and KDIGO criterias are a response to this lack of consensus.

Implications Several studies large systematic reviews have demonstrated that a progression through different RIFLE stages is associated with a prolonged ICU stay and a stepwise increase in mortality.

Limitations The limitations of this classification relate to it's dependence on measuring urine output and creatinine which is confounded by the following:-

- Accuracy of urine output measures
- Urine output affected by the use of diuretics
- Baseline creatinine may be affected by the patients concurrent health problem eg it maybe falsely high purely because the patient was dehydrated on admission.
- It is uncertain how well balanced urine output and creatinine are even though they have been given an equal weighting.

RIFLE Criteria

Introduction RIFLE is an acronym for Risk, Injury, Failure Loss and End Stage Renal Disease. This was the first of the three classifications and was developed in 2004.

Definition

- Urine output of <0.5ml/kg/hr for >6 hours
- Increase in serum creatinine of >50% developing over <7 days

Staging

Risk (Stage 1) Increase in creatinine of >50% or <0.5ml/kg/hr UO for q6hrs

Injury (Stage 2) Increase in creatinine of >100% or <0.5ml/kg/hr UO for q12hrs

Failure (Stage 3) Increase in creatinine of >200% or a total >350umol/L or GFR decrease of 75% or <0.3ml/kg/hr UO for q24hrs or anuria for >12hrs

Loss (Stage 4) Need for renal replacement therapy for >4 weeks

End Stage (Stage 5) Need for renal replacement therapy for >3 months

AKIN

Introduction This was developed following RIFLE by the Acute Kidney Injury Network (AKIN). It was in response to and epidemiological data that demonstrated increased mortality with an absolute increase in serum creatinine and when changes are abrupt (48hrs versus 7 days).

Definition

- Urine output of <0.5ml/kg/hr for >6 hours
- Increase in serum creatinine of >50% or 27umol/L developing over <48hrs

Staging

Stage 1 Increase in creatinine of >50% or 27umol/L or <0.5ml/kg/hr UO for q6hrs

Stage 2 Increase in creatinine of >100% or <0.5ml/kg/hr UO for q12hrs

Stage 3 Increase in creatinine of >200% or <0.3ml/kg/hr UO for q24hrs or anuria for >12hrs

No stage 4 and 5

KDIGO

Introduction This is the most recent classification developed by Kidney Disease Improving Global Outcomes. It was noted in large epidemiological studies that AKIN was missing a quarter of the RIFLE AKI and that RIFLE was missing 9% of AKIN AKI. The result is that KDIGO captures both AKIN and RIFLE.

Definition

- Urine output of <0.5ml/kg/hr for >6 hours
- Increase in serum creatinine of >50% over 7 days or 0.3mg/dL developing over <48hrs

Staging

Stage 1 Increase in creatinine of >50% or 27umol/L or <0.5ml/kg/hr UO for q6hrs

Stage 2 Increase in creatinine of >100% or <0.5ml/kg/hr UO for q12hrs

Stage 3 Increase in creatinine of >200% or <0.3ml/kg/hr UO for q24hrs or anuria for >12hrs

No stage 4 and 5

CRRT principles

2008/1 List the causes, and features of rhabdomyolysis, and outline the principles of management

Causes

Trauma

> Crush injury
> Compartment syndrome

Exertional

> Heat stroke
> Prolonged seizure activity

Infections

> Necrotizing fasciitis
> Inflammatory myositis

Drugs

> Malignant hyperthermia secondary to nondepolarising muscle relaxants and volatile anaesthetics in susceptible individuals
> Neuroleptic malignant syndrome secondary to antipsychotics
> Myositis secondary to statin therapy

Electrolyte abnormalities

> Profound hypokalaemia
> Profound hypophosphataemia

Features

> Relevant history of exposure to drugs, seizures, trauma, family history or history of previous episodes
> Presenting complaints of weakness, pain
> Tachycardia/hypotension/hyperthermia
> Dark urine
> Examination
> Investigations
> Elevated CK
> Hyperkalaemia/hyperphosphataemia/hypocalcaemia
> Metabolic acidosis

Principles of management

> Resuscitate with adequate fluids
> Replace electrolytes
> Actively cool if significant hyperthermia
> Alkaline diuresis
> Surgical fasciotomy/debridement as necessary
> Stop offending drugs
> Treat underlying cause Eg dantrolene for MH
> Antibiotics for treatment of likely causative agent
> Correction of hypokalaemia and hypophosphataemia if that is believed to be cause

Urinanalysis

Created question Discuss how the various components of bedside urinalysis can assist in the diagnosis of renal injury

Specific Gravity

> Normal: 1.003 – 1.030
> Measures the amount of solutes disolved in urine when compared with water (1.000)
> Elevated in decreased water (dehydration, SIADH) or increased solute (glucose, protein, radiocontrast)
> Decreased in diabetes insipidus, glomerulonephritis

pH

> Normal 4.5 - 8.0
> < 6.0: acidosis, pre-renal failure
> > 7.0: systemic alkalosis, alkalinising agents, RTA, urease producing bacteria

Glucose

> Increased glucose load presenting to nephron - diabetes mellitus
> Normal glucose load + altered glucose transport handling in nephron - Familial renal glycosuria, Fanconi syndrome

Blood

> Normal - negative
> Positive in:
  - Haematuria - trauma, infection, inflammation, calculi, neoplasia, clotting disorders
  - Haemoglobinuria - intravascular hemolysis, burns, eclampia, sickle cell crisis, multiple myeloma, transfusion reactions

Protien

> Normal - negative
> Positive in glomerulonephritis, pyelonephritis, nephritic syndrome, urinary tract malignancies

White cells

> Normal - negative
> Positive in UTI, renal calculi, interstitial nephritis, glomerulonephritis, vasculitis, infarction

Nitrites

> Normal - negative
> Positive test strongly suggests infection BUT negative test does not exclude it (PPV 95%, NPV 25-70%)

Ketones

> Normal - negative
> Positive in starvation, alcoholic and diabetic ketoacidosis, carbohydrate free and high fat or high protein diets

Bilirubin

> Normal - negative
> Increased in hepatocellular disease, cirrhosis, viral and drug induced hepatitis, biliary tract obstruction, pancreatic causes of obstructive jaundice

Urobilinogen

- Normal - negative
- Increased in cirrhosis, infective hepatitis, extravascular haemolysis, haemolytic anaemia, pernicious anaemia, malaria

Pharmacology and Toxicology

Activated charcoal

2010/2 A 16 year old female is admitted to the ICU following a multiple drug overdose. a)Outline the role of activated charcoal in the management of drug overdose. b) What are the complications of activated charcoal therapy? c) When is dialysis utilised in toxic syndromes? d) In the context of an overdose, list 3 drugs for which charcoal haemoperfusion may be useful

Role of activated charcoal in drug overdose.

> Single dose activated charcoal is generally preferred method of decontamination but does not improve outcome when applied to unselected patients and should not be regarded as routine.

> The amount of drug absorbed is dependent on

- Time since ingestion
- Dose of charcoal (usually 1g/kg)
- Type of charcoal

> Charcoal does not work well on small ionised molecules (lithium, alcohol, metals,

What are the complications of activated charcoal therapy?

> Vomiting

> Pulmonary aspiration

> Direct administration to lung via misplaced NG tube (potentially fatal)

> Impaired absorption of oral medications / antidotes

> Corneal abrasions

> Constipation / bowel obstruction (MDAC)

When is dialysis utilised in toxic syndromes?

> Best if drug is:

- Water soluble
- MW <500
- Not highly protein bound
- Eg Lithium, Ethylene glycol, Salicylates, Na Valproate
- Also good for correcting fluid and electrolyte abnormalities

Drugs for which charcoal haemoperfusion may be useful.

> Common drugs

- carbamazepine
- theophylline
- paraquat

Drug antidotes

2010/2 List the antidotes to the following drugs

Benzodiazepines	`Flumazenil
Beta blockers	Glucagon, adrenaline
Cyanide	Na thiosulfate, hydroxocobalamin;
Digoxin	Fab,
Heparin	Protamine
Iron	Desferrioxamine
Methanol, ethylene glycol	ethanol
Methaemoglobinemia	Ascorbic acid, methylene blue
Organophosphate	Atropine, pralidoxime
Opiates	Naloxone
Lead	Dimercaprol
Paracetamol	N-Acetylcysteine

Drug withdrawal

2001/2 What drug withdrawal states are relevant to ICU practice? Outline the principles of their management

Drug withdrawal states in ICU patients

- Alcohol
- Tobacco (nicotine)
- Narcotic (heroin, morphine)
- Benzodiazepines
- Caffeine
- Other street drugs (cocaine etc)

Principles of their management include –

- prevention (avoid prolonged high dose narcotics, benzodiazepines
- detection/diagnosis (be alert for signs eg agitation, tachycardia, fever)
- sedation (may be necessary to control systemic effects)
- replacement/substitution (eg nicotine patch)
- support (airway and respiration, fluid replacement)
- simple measures such as but firm communication, reality orientation, visible clock and presence of a relative contribute to reassurance of the patient.

Corrosive fluid ingestion

2001/2 List the potential complications associated with the management of a patient after intentional corrosive ingestion

Airway:

Airway burns, leading to airway compromise

Potential acute tracheo-oesophageal fistula due to corrosive effect on oesophagus

Assessment and immediate airway control is a priority

Breathing:

Potential aspiration of caustic gastric/oesophageal contents, thus acute lung injury

Hypoxia may be present; supplemental oxygen may be required. NIV may be contraindicated in case of full-thickness oesophageal injury

Circulation:

Potential hypovolemic shock due to fluid loss into the corroded gut, or haemorrhage though ulcers

Need for rapid fluid replacement or surgical haemostasis

CVC access, as this patient is likely to require long-term TPN

Neurological state:

Potential for disorganised behaviour due to psychiatric condition, or obtundation due to shock

Analgesia issues need to be addressed

Electrolyte disturbance

Absorption of corrosive agent may result in electrolyte and acid-base disturbance

Fluid balance

Likely, hypovolemia will exist and need correction

renal impairment may be present, with implications on drug dosing

Gastrointestinal problems:

Extent of corrosive damage will need to be assessed by CT and/or direct endoscopy (earlier is better, before significant tissue softenting makes endoscopy risky)

Perforation of hollow organs must be ruled out with CXR and/or CT

Specific issues

Decontamination by NG aspiration may be possible if it is safe to pass an NGT

Snake bite

2010/2 Discuss the clinical features, identification, laboratory abnormailities and management of snake bite in Australia

Clinical features

> Local pain, swelling and bruising. This may be absent

> Sudden collapse – associated with hypotension and loss of consciousness, rarely cardiac arrest and seizure (5%)

> Non –specific systemic symptoms – nausea, vomiting, diarrhoea, headache, sweating.

> Neurotoxicity – descending flaccid paralysis – starting with ptosis, diplopia, blurred vision, and then progressing to bulbar weakness, respiratory and limb muscle paralysis.

> Myotoxicity – local and generalised myalgia and muscle tenderness. Haemorrhage – rare – intracranial, gastrointestinal or from cannula sites

Laboratory abnormalities

> Venom induced consumptive coagulopathy – characteristic of Australian snake bite – INR >3, APPT >100, fibrinogen < 1, raised D-dimers – can be 100 times assay cut off, Thrombocytopenia <100

> CK – 1000 to over 100,000 u/L associated with myotoxicity

> Acute renal failure – raised potassium, urea and creatinine.

> Fragmented red cells in blood film – microangiopathic haemolytic anaemia.

> Deranged LFTs

Identification

- By geographical location
- Patient description
- Venom detection kit (VDK)
  - Swab wound
  - Blood immunoassays
  - Urine immunoassays

Management

- First aid – Pressure bandage with immobilisation of the limb
- Monitor the patient in critical care area with resuscitation facilities
- Resuscitation as appropriate with two large bore cannulas and collect blood for laboratory tests
- Administer anti-snake venom (ASV) only if clinical symptoms or signs or lab abnormalities such prolonged INR. Current guidelines are for one vial ASV only and then correct subsequent coagulopathy with FFP
- Polyvalent if there is uncertainty, monovalent if the snake ID is clear (polyvalent causes more anaphylaxis)
- Release pressure bandage only after administration of ASV.
- Monitor closely for anaphylactic reaction. Treat with adrenaline. Premedication with adrenaline, steroids or antihistamines not recommended.
- Repeat lab investigations at 6, 12 and 24 hours to monitor response such as improvement in coagulopathy (INR).
- Supportive treatment such ventilation for muscle paralysis and respiratory failure, dialysis for acute renal failure, inotropes for cardiovascular collapse and FFP for severe coagulopathy and bleeding complications

Calcium channel versus Beta Blocker overdose

2006/2 Compare and contrast the clinical features and management of a patient following beta blocker overdose with those of a patient following calcium-channel blocker overdose.

Calcium channel blocker overdose

Clinical features

Bradycardia

Hypotension

Heart block

Hyperglycaemia

Constipation/ileus

Management:

Antidote

Ionised calcium (eg. calcium chloride)

Glucagon

Insulin-dextrose

Inotropes and vasopressors

Removal

Activated charcoal

Hemoperfusion for verapimil

Beta-blocker overdose

Bradycardia

Hypotension

Heart block

Hypoglycaemia

Bronchospasm

Glucagon

Insulin-dextrose

Inotropes and vasopressors

Activated charcoal

Hemoperfusion for metoprolol

Iron poisioning

2013/2 A two-year-old boy is suspected of ingesting iron tablets. a)List the clinical features, and the underlying pathophysiology, of iron poisoning. b) Briefly outline your management of this child.

Clinical Features

> Shock and circulatory collapse - fluid shifts, GI bleeding and associated hypovolaemia
> RUQ tenderness - acute hepatic necrosis due to hepatotoxic effects of iron
> Coma and hypoglycaemia and lactactaemia - hepatic insult
> HAGMA - anaerobic lactic acidosis, ketosis, iron reduction
> Renal failure - pre renal due to shock and intra-renal due to ATN
> Gastric ulceration - corrosive effects of the iron tablets

Management

Resuscitation:

> ABCs
> Priority is early restoration of circulating volume
> Boluses of 10-20 ml/kg crystalloid and assess response

Risk assessment:

> History of ingestion – type, quantity of tablets and time of ingestion
> Iron preparations differ in the amount of elemental iron contained.
  - < 20 mg/kg elemental iron is asymptomatic
  - 20 – 60 mg/kg causes GI symptoms
  - > 60 mg/kg causes systemic toxicity
  - > 120 mg/kg is potentially lethal
> Children rarely ingest more than 60 mg/kg.

Specific investigations

> BSL
> Serum iron level
> ABG
> AXR – useful in confirming ingestion

Disposition

> Asymptomatic at 6hr and negative AXR may be discharged home
> Monitoring and treatment in paediatric centre (ward, HDU, ICU depending on severity)
> Ongoing assessment of response to resuscitation and antidotes.

Antidotes

> Desferrioxamine chelation therapy in cases of systemic toxicity (high serum iron level or metabolic acidosis on ABG)

Decontamination

> Iron not absorbed to activated charcoal
> Whole bowel irrigation indicated for confirmed ingestions > 60 mg/kg – difficult and potentially hazardous in 2-year-old
> Surgical or endoscopic removal of tablets if lethal ingestion or WBI not feasible

Malignant hyperthermia

2003/2 Outline the diagnostic features, complications and treatment of patients with an overdose of sodium valproate (valproic acid)

General features

- Follows suxamethonium or volatile agent administration
- Develops during anaesthesia
- Body temperature rises by 1 degree every 10 minutes

Clinical features

- Hyperthermia
- Jaw rigidity persists after sux has worn off
- Tachycardia and tachypnoea
- Increased EtCO2
- Increased O2 consumption
- Profuse sweating
- Hyperkalemia
- Cyanosis
- Generalised rigidity, increased muscle tone
- Prolonged bleeding

Complications

- DIC
- Rhabdomyolysis
- Hypotension
- Lactic and respiratory acidosis

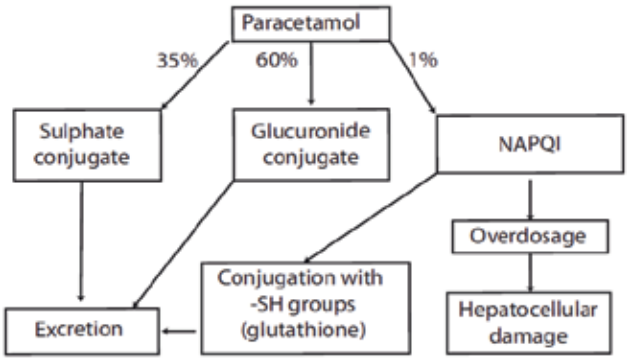
Management

- Abort the procedure
- Stop the anaesthetic
- Give 100% FiO2 and hyperventilate
- Start active cooling
- Administer dantrolene: 20mg as a rapid infusion
- Keep giving dantrolene until features of resolution begin to manifest
- Give steroids; eg. 2g of methylprednisolone
- Maintain high urine output to avoid renal damage from rhabodomyolysis
- Correct coagulopathy

Paracetamol overdose

Created Question With respect to the management of a 35-year-old female presenting with toxicity secondary to deliberate self-harm with paracetamol: a) Outline how paracetamol causes liver dysfunction and how N-acetylcysteine (NAC) works as an antidote in this setting. b) List the criteria for liver transplantation in this patient. c) Outline your management of the patient in the event of clinical deterioration, pending transfer to the regional centre for liver transplantation.

Mechanism of paracetamol toxicity



In overdosage the glutathione stores are depleted and more paracetamol is metabolised via the NAPQI pathway resulting in increase toxic metabolites and subsequent hepatocellular damage

Criteria for liver transplantation

The King's College criteria

> pH < 7.3

or

> In a 24h period, all 3 of:
  - INR > 6 (PT > 100s) +
  - Cr > 300mmol/L +
  - grade III or IV encephalopathy

> Lactate > 3 may improve sensitivity is added

Management

> ABCs

> Assess
  - preliminary investigations (history, examination, bloods, ECG)
  - plot paracetamol level on a nomogram to assess intervention strategy

> Prevent
  - further absorption with activated charcoal
  - avoid fever, hypoglycaemia, excessive fluids, hypercarbia

> Supportive management
  - replenish glutathione N-acetylcystiene infusions which most toxicologists agree replaces glutathione
  - Thiamine 300mg, Lactulose 30ml TDS, regular vitamin K, PPI, feeds

> Monitor
  - ALT is generally to most sensitive marker of liver damage.
  - Monitor phosphate, calcium, potassium and sodium

Propofol infusion sydnrome

2010/2 Discuss the pathophysiology, risk factors, clinical and lab features and management of PIS

Pathophysiology of propofol infusion syndrome

> Usually after 48 hours of infusion, at over 4mg/kg/hr.
> Mechanism is likely the inhibition by propofol of coenzyme Q and Cytochrome C.
  - This results in a failure of the electron transport chain, and thus the failure of ATP production.
  - Leading to anaerobic metabolism and high lactate
> Fatty acids are not utilised by lipolysis reducing ATP and break down in the blood contributing the the acidosis

Risk factors for propofol infusion syndrome

> Propofol infusion dose of >4mg/kg/hr for over 48 hrs
> Traumatic brain injury
> Catecholamine infusion
> Corticosteroid infusion
> Carnitine deficiency
> Low carbohydrate intake: because energy demand is met by lipolysis if carbohydate intake is low, thus leading to the accumulation of free fatty acids.
> Children more susceptible than adults - probably because their glycogen store is lower, and they depend on fat metabolism.

Clinical features and laboratory findings in propofol infusion syndrome

> Acute bradycardia leading to asystole.
> A prelude to the bradycardia is a sudden onset RBBB with ST elevation in V1-V3
> Arrhythmias
> Heart failure, cardiogenic shock
> Metabolic acidosis (HAGMA) with raised lactate (and also due to fatty acids)
> Rhabdomyolysis, raised CK and myoglobin
> Hyperlipidaemia
> Fatty liver and hepatomegaly
> Coagulpathy

Management of propofol infusion syndrome

> Stop the propofol infusion!
> Haemodialysis
> Nutrition with carbohydrates to reduce fat utilisation in energy production
> Carnitine based on case reports only
> Pacing, inotropes, atropine and chronotropes are often ineffective
> ECMO is a last resort option

Salicylate overdose

Created Question Discuss the complications, coagulation derangement and management of salicylate overdose

Complicatons of salicylate overdose:

> Serum level 30-50mg/dL: : :
  - Tachypnoea
  - Respiratory alkalosis
  - Nausea
  - Vomiting
  - Tinnitus
  - Dizziness
> Serum level 50-75mg/dL
  - Tachypnoea
  - Respiratory alkalosis
  - Fever
  - Sweating
  - Dehydration
  - Agitation
> Serum level >75mg/dL
  - Coma
  - Hallucinations
  - Seizures
  - Cardiogenic shock
  - Coagulopathy, with raised INR.
  - Oliguria
  - Renal failure.
  - Lactic acidosis and ketoacidosis

Coagulopathy of aspirin overdose

> Platelet inhibition
> Hepatotoxicity causing impaired synthetic function (Vitamin K dependent factors)
  - 2, 7, 9, 10 (especially 2 (prothrombin))

Management

Decontamination

- Activated charcoal 25g x3 over 2 hours

Alkalinise the urine

- This is vital.
- An alkaline blood environment also prevents the movement of salicylate into the CSF.
- Raising the urine pH from 5 to 8 can increase total salicylate excretion by twenty times.

Haemodialysis

- Aspirin is protien bound and has a small Vd and is easily dialysed

Supportive ICU therapies

Sodium valproate overdose

2003/2 Outline the diagnostic features, complications and treatment of patients with an overdose of sodium valproate (valproic acid)

Sodium valproate

The mechanism of action is via sodium channels blockade and its GABAergic effect

Overdose

Overdose is seen when blood levels exceed 100mg/L

Overdose results in a progressive onset of lethargy and CNS depression

Associated features include hypotension, hypothermia, vomiting, diarrhoea, agitation and tremors

Complications of overdose

Cerebral oedema (with prolonged coma)

Encephalopathy (elevated ammonia)

Hepatotoxicity (rarely fulminant)

Electrolyte disorders (with hypernatraemia, hypocalcaemia, increased osmolality and elevated anion gap metabolic acidosis).

Management

Activated charcoal if recent ingestion or a sustained release preparation

Carnitine supplementation may reduce the production of toxic metabolites

Valproate is poorly dialysed due to protien binding however in overdose protien sites are saturated and therefore there is excess free valproate. Being a small molecule with small Vd and water soluble this excess is quickly dialysed and is recommended when plasma levels exceed 100mg/L

Tricyclic overdose

Created question What is the mechanism, clinical manifestations and treatment options for tricyclic overdose?

Mechanism

> Beneficial effects
  - GABA blockade
  - SSRNI actions
> Toxic effects
  - Sodium channel blockade (which mediates the cardiotoxic effects)
  - Muscarinic receptor blockade

Clinical manifestations

Central nervous system

- sedation and coma tend to precede cardiotoxicity
- seizures
- delirium (anticholinergic)

Cardiovascular

- sinus tachycardia and possible mild hypertension initially
- hypotension (alpha-blocking effects and myocardial depression)
- broad complex tachydysrrhythmia
- broad complex bradycardia occurs pre-arrest

Anticholinergic effects (due to muscarinic blockade)

- may occur on presentation or may be delayed and prolonged
- agitation, restlessness, delirium
- mydriasis
- dry, warm flushed skin
- urinary retention
- ileus
- myoclonic jerks

Management

Initial resuscitation

> Airway assessment
> Supplemental oxygen
> Cardiac monitoring, ECG, Venous access, fluid resuscitation

Sepcific therapies

> Sodium bicarbonate should be instituted when the QRS is wider than 100ms
  - 100ml of 8.4% as a bolus then titrate to pH aim for a pH of 7.5 to 7.55
  - This results in less ionised drug (therefore less active) and higher ECF sodium mediating the sodium channel block
> Benzodiazepienes for agitation and increasing seizure threshold
> Intralipid is sometimes considered

Supportive care

Lithium overdose

Created question How do you differentiate between acute and chronic lithium toxicity. Discuss your management of acute lithium toxicity.

Chronic lithium toxicity

> Diagnosed on clinical history and serum lithium level
> Nephrogenic diabetes insipidis due to impaired concentrating mechanism of the kidneys and subesequent polyuria and polydipsia
> Is more likely to present with neurological symptoms such as sluggishness, ataxia, confusion or agitation.
> May present with seizures and NCSE
> Less issues with cardiac complications

Acute lithium toxicity

> Diagnosis based on history and examinations findings (lithium level to confirm diagnosis but not stratify risk)
> Nausea, vomitting and diarrhoea
> It may cause a prolonged QTc and bradycardia although this is rare
> Neurological symptoms develop late in acute toxicity

Lithium levels

> Serum lithium concentrations often do not correlate with clinical signs of acute toxicity
> They are more useful in chronic toxicity as the drug has reached steady state
  - 0.8 - 1.2 is the therapuetic range
  - 1.5 - 2.5 may manifest as tremor, slurred speech, lethargy
  - 2.5 to 3.5 demonstrates worsening lethargy, coarse tremors and clonus
  - > 3.5 indicates severe toxicity

Management

Initial management

> Airway assessment
> Supplemental oxygen
> Venous access, bloods, ECG monitoring, fluid resuscitation
> Benzodiazepienes for seizures

Specific management

> There is NO role for activated charcoal (small metal anion)
> Haemodialysis is particularly effective
> Symptomatic and a level of 2.5 - 4.0 or in all patients with a level >4

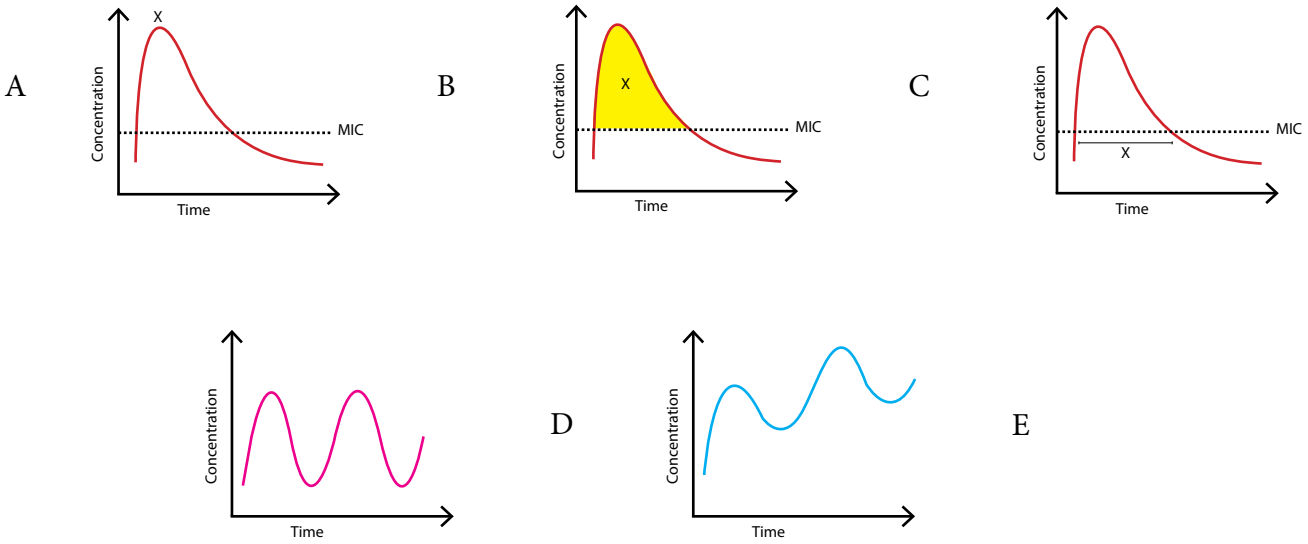
Supportive care

> Monitor in a HDU environment
> Feeding, analgesia, sedation with benzodiazepienes, thromboprophylaxis, PPI, BSL 6-10

Sepsis and Infection

Antibiotic pharmacodynamics and pharmacokinetics

2014/2 With regards to antibiotic dosing: Look at the diagram below, representing antibiotic drug concentration versus time, and answer the questions below: i- What do A - C represent in terms of antibiotic pharmacodynamics. Identify an antibiotic where this is important for eachii - Look at the diagram below, representing antibiotic drug concentration against time. Curves D and E represent concentrations after regular bolus administration of the same dose of an antibiotic to the same patient at different points of time. a) What pharmacokinetic changes are demonstrated in D and E? b) List the clinical conditions that could explain the difference between E and D iii - List the factors that result in failed resolution of sepsis despite antibiotic therapy.



Pharmacodynamics

MIC The MIC is the lowest concentration of an antibiotic that completely inhibits the growth of a microorganism in vitro

Peak concentration A represents peak concentration and can be characterised as the peak/MIC ratio. This is important with drugs such as aminoglycosides as the higher the concentration the faster and greater the bacterial killing

Area under the Curve Is another concentration dependent characteristic but refers to the total concentration of antibiotic above the MIC. antibiotics such as vancomycin, quinolones and tetracyclines

The time above MIC Is important when with time dependent antibiotics such as the penicllins and carbapenems.

Pharmacokinetics

> a) PK changes – Increased plasma concentrations with E relative to D for the same dose indicating reduced clearance and increased half-life.
> b) Hepatic dysfunction Renal dysfunction

Failed therapy

> Wrong antibiotic choice
> Delayed administration of antibiotics
> Inadequate source control
> Inadequate antimicrobial blood levels
> Inadequate penetration of the antimicrobial to the target site, Antimicrobial neutralization or antagonism,
> Superinfection or unsuspected secondary bacterial infection, Non-bacterial infection
> Non-infectious source of illness

Antibiotic choice in severe sepsis

2015/1 Discuss the factors that may affect your choice of antimicrobial agent in a critically ill septic patient, giving examples where relevant.

Introduction

Antibiotic selection is dependent on patient factors, environmental and resource factors, the disease process and the organism implicated (or presumed).

Patient Factors

> Allergies - may require desensitisation in some instances eg penicillin
> Renal function and liver function - may result in dosing adjustment or avoidance of certain antibiotics (eg aminoglycosides or vancomycin in renal impairment)
  - The ability to monitor drug levels in these patients may be influential especially in CVVHDF
> Previous antibiotic exposure - chronic antibiotic use increases the risk of resistance and infections such as C.Diff
> Immunodeficiency - primary or secondary such as immunosuppression, low CD4 count in HIV, malignancy
  - Requires coverage of opportunistic infections - would cover fungal and PCJ with -azole and bactrim
> Other comorbidities - DMII, vasculopathy, patients with prosthesis may require longer term antibiotics, CF
> Current medications - increased risk of QT prolongation with macrolides, CYP metabolised drugs
> Asplenism - increases the risk with encapsulated organisms
> Previous colonisation with a drug resistant organism would increase my likelihood of using vancomycin
> Delivery options if NBM (increase duration of IV medications) or no vascular access

Environmental and resource factors

> Local disease patterns and hospital/state guidelines, Antibiotic stewardship policies
> Duration of hospital admission and residential care (NH)- increases likelyhood of a resistant organism
> Occupational history may suggest rarer causes such as Cyptococcus Gatti in landscaper or Q-fever in farm worker
> Contact with birds/animals
> Overseas travel increases suspicion of water bourne disease, parasite or disease such as dengue, malaria etc
> Cost of antibiotics

Disease process and site of infection

> Speed of onset
> Primary infection site will guide empirical and choices
  - Lung disease - e.g. daptomycin inactivated by surfactant, vancomycin poor penetration
  - BBB and immunoprotected (brain and eyes) poor penetration of non lipid-soluble drugs
  - Biliary and urinary sepsis – select drugs with hepatic (e.g. ceftriaxone) and urinary excretion (cefotaxime) respectively
> Severity - especially degree of organ support - more likely to have a more aggressive approach in a more unwell patient

Organism

> Sensitivity profile will be one of the most influential characteristics
> Inducible beta-lactamase producers (e.g. ESCAPPM) more likely to choose a carbapenum
> Tendency to develop resistance to antimicrobial during treatment course e.g. Pseudomonas aeruginosa
> Intracellular (e.g. aminoglycosides poorly active against strictly intracellular bacteria e.g. Rickettsia, Chlamydia, Coxiella burnetti)
> Inhibition of toxin synthesis in toxic-shock syndrome by clindamycin and linezolid

Antibiotic selection

2013/2 For each of the microbes listed below, list the most appropriate antibiotic(s) for treatment of infection resulting from these organisms:

a) Candida glabrata b) Clostridum perfringens c) Listeria monocytogenes d) Neisseria meningitides e) Multi-resistant Acinetobacter f) Nocardia g) Penicillin-intermediate pneumococcus h) Vancomycin-resistant enterococcus

Briefly outline the dosing adjustment and the monitoring necessary for each of the following drug groups in patients with established septic shock and moderate to severe renal dysfunction (without dialysis):

a) Aminoglycosides b) Fluoroquinolones c) Beta-Lactamsmd) Carbapenems e) Glycopeptides

Antibiotics for specific bugs

> Candida glabrata - is generally resistant to -azoles therefore use an echinocandin such as caspofungin or anidulafungin

> Clostridium perfingens - is a gram positive baccili which causes necrotising fasc and gangrene. Penicillin G and clindamicin (inhibits toxin production) as combination

> Listeria monoctogenes - is a gram positive bacilli - causes gastroenteritis - usually self limited, can be severe in neonates and pregnancy - treatment is with ampicillin

> Neisseria meningitides - is a gram negative diplococci - causing menigitis - treatment with high dose ceftriaxone 2g BD or cefotaxime 2g QID

> Multi-resistant acinetobacter - gram negative bacilli - opportunistic infections and VAP - Colistin and Meropenum in combination

> Nocardia - Gram positive filamentous that causes abscesses - Bactrin and imipenum

> Penicillin-intermediate pneumococcus implies that a higher MIC is required - use 2g ceftriaxone or cefotaxime or vancomycin

> Vancomycin-resistant enterococcus is a gram positive cocci in pairs - Linezolid 600mg BD

Dosing adjustments in moderate to severe renal disease and septic shock

a) Aminoglycosides

High initial dose and monitor trough concentrations. Extend interval. May be necessary to decrease dose and monitor with MIC data

b) Fluoroqinolones

Reduce frequency but maintain dose. Monitor QT interval

c) Beta Lactams

Can reduce dose OR frequency Monitoring unnecessary

d) Carbapenems

As for Beta Lactams

e) Glycopeptides

High dosing on day one dose adjustments according to Cmin and dependent on degree of renal dysfunction

Antibiotics III

2010/1 Apart from vancomycin, list three antibiotics that have activity against hospital acquired methicillin resistant staphylococcus aureus (MRSA) List an example of each of the three main classes of systemic antifungal agents Briefly outline the dosing adjustment and the monitoring necessary in patients with septic shock for each of the following drug groups in patients with moderate to severe renal dysfunction (without dialysis) a) Aminoglycosides b) Fluoroquinolones c) BetaLactams d) Carbapenems e) Glycopeptides

Alternative treatments for MRSA

- Tigecycline
- Linezolid
- Daptomycin
- Ceftaroline

Drug classes of antifungals

- Azoles Fluconazole
- Echinocandins Casofungin, Andiluofungin
- Polyenes Amphoteracin

Antibiotic dose adjustment

a) Aminoglycosides

High initial dose and monitor trough concentrations. Extend interval. May be necessary to decrease dose and monitor with MIC data

b) Fluoroqinolones

Reduce frequency but maintain dose. Monitor QT interval

c) Beta Lactams

Can reduce dose OR frequency Monitoring unnecessary

d) Carbapenems

As for Beta Lactams

e) Glycopeptides

High dosing on day one dose adjustments according to Cmin and dependent on degree of renal dysfunction

Haemodynamic management of early SIRS/Sepsis

2014/1 47 year old in ED with hypotension post 2000ml IVF. Temp is 40°C, RR 24, Sats 98 on RA, HR 140, BP 80/40, lactate 6. Describe the steps for the initial haemodynamic management of this patient, including a brief discussion of the underlying evidence for each step.

Step 1: Fluid resuscitation and antibiotics

> Two sets of blood cultures
> Antibiotic therapy without delay
> 30ml/kg of balanced crystalloid (SSG) or Albumin (SAFE, ALBIOS)
> Do not use hydroxyethyl starch (CHEST)
> Transfuse blood if Hb < 70g/L (TRISS)

Step 2: Assess need for further fluid resuscitation

> Arterial line and central line (SSG)
> ScvO2 monitoring: recommended by the SSG, but may be pointless (ProCESS and ARISE)
> Use dynamic manoeuvres to assess fluid responsiveness (SSG)
> Options for assessment of fluid responsiveness:
  - Pulse pressure variation, Stroke volume variation
  - Passive leg raise autotransfusion
  - Clinical signs (capillary refill)
  - IVC ultrasonography
  - CVP, PAOP, GEDV, GEDVI
> End-point of resuscitation:
  - MAP > 65mmHg (SSG); ~75-80mmHg if chronically hypertensive (SEPSISPAM)
  - CVP ~ 8-12mmHg (SSG, but based heavily on Rivers; an approach ridiculed by Marik)
  - ScvO2 > 70% (SSG) - not supported by the more recent evidence (ProCESS and ARISE)
  - Lactate clearance is better than 10% over 2 hours
  - Arteriovenous CO2 difference under 6mmHg
  - Urine output over 1.0ml/kg (SSG)

Step 3: Vasopressors

> Noradrenaline is the first choice (SSG), Adrenaline is the second choice (CATS, SSG)

Step 4: Assess adequacy of cardiac output

> ECHO, PiCCO or other transpulmonary method
> Inotrope options:
  - Dobutamine: recommended by SSG; routine use may be pointless (ProCESS and ARISE)
  - Milrinone: evidence for its use in sepsis is of poor quality.
  - Levosimendan: again the quality of the evidence is non-reassuring. Wait for LeoPARDS.
  - Adrenaline: recommended by the SSG

Step 5: Refractory hypotension

> Vasopressin 0.03 U/min (VASST)
> 200mg hydrocortisone per day for severe septic shock (SSG; CORTICUS)
> Consider toxic shock syndrome - may require IV immunoglobulin and clindamycin

Steroids in spetic shock

2013/2 Critically evaluate the role of steroids in septic shock.

Introduction

A certain group of sepsis patients may benefit from the administration of steroids, with improvement in mortality.

Rationale

> Steroids may produce the following beneficial actions in severe shock:
  - Reversal of relative adrenal insufficiency
  - Reversal of inflammatory overactivity
  - Reprogramming of the immune response
  - Improved responsiveness of α-1 receptors (thus, decreased catecholamine requirements)
  - Correction of vasoplegia by deactivation of nitric oxide synthase
  - Improved cardiac tolerance of bacterial endotoxin
  - Improved retention of resuscitation fluid

Evidence

> 2008 CORTICUS trial
  - No mortality difference associated with the use of steroids.
  - Moderately shocked patients, only 0.5µg/kg/min (35ml/hr) of noradrenaline.

> 2009 meta-analysis
  - 17 trials; conclusion: there is a small mortality benefit.
  - The same analysis, excluding all but 6 well-designed trials:
  - Conclusion: steroids did not improve survival

> 2013 Surviving Sepsis Guidelines:
  - Grade 2B recommendation in favour of steroids, provided they are reserved for those patients who are refractory to fluids and vasopressors.
  - Rationale: survival only seems to be improved in patients whose mortality from sepsis is likely to be over 60%.

> ADRENAL currently recruiting

Advantages

> Cardiovascular improvement (decreased vasopressor dose)

> Decreased organ system dysfunction

> Earlier withdrawal of vasopressor support

> Possibly, decreased mortality in selected patients

Disadvantages

> Hyperglycaemia

> Fluid retention

> Possibly, increased risk of nosocomial infection

> Steroid myopathy and delayed ventilator weaning

> Increased risk of gastric ulceration

Own practice

I will consider steroids in severe sepsis that is refractory as per surviving spesis guidelines however await the ADRENAL trial results eagerly.

Surviving Sepsis Campaign

2015/1 Outline the strengths and limitations of the current Surviving Sepsis Campaign Guidelines, using examples to illustrate your points

Surviving sepsis campaign

- Is a consensus based guideling developed by the North American and European critical care communities. It has not been endorsed by ANZICS/CICM however Australians have been involved in its development (incl Prof Webb)
- It is a detailed document (over 60 pages) which covers the diagnostic criteria of sepsis and severe sepsis multiple aspects of sepsis management (and general ICU management)
- It uses the well regarded GRADE system to guide assessment of methodological quality of evidence for an intervention from A (high quality) to D (poor quality) and the strength of the recommendation which looks at the certainty, benefits and costs of the intervention from 1 (strong) to 2 (weak).
- It encourages uniform management of sepsis and may be particularly beneficial in low volume settings with reduced experience in managing sepsis
- Each recommendation has associated text with current references

Criticisms of the SSC

- The GRADE system is still remains subjective
- A narrower guideline may be more advantageous as it focuses on the specifics of sepsis
- It has been criticised for being slow to adapt to changed evidence
- There are concerns that there was too much influence of a single centre trial (Rivers) with unreplicated mortality benefit

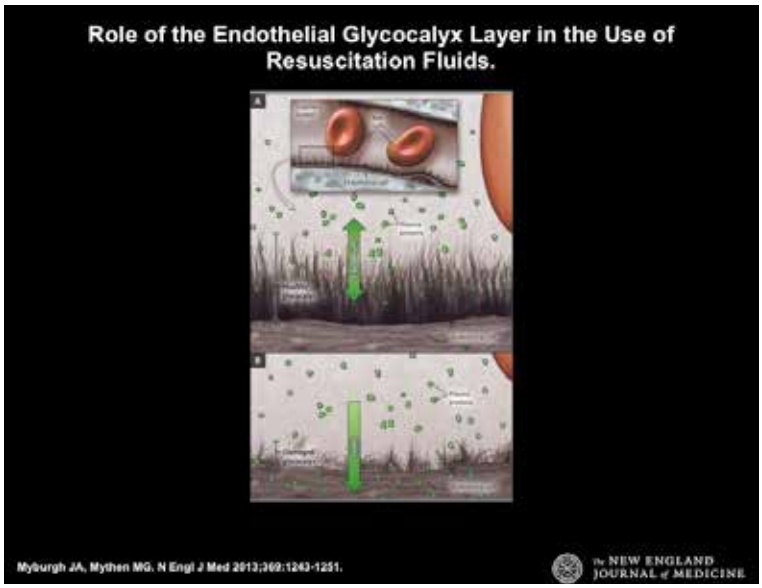
Response to ARISE and PROCESS

- These large EGDT trials demonstrated that we can manage protocolised care.
- The parameters for the intervention (based on many of the SSC dictums) did not demonstrate a mortality benefit and led to more aggresive treatments (more CVCs, more fluids and blood products)
- As a response the SSC authors removed the requirement for measuring ScVO2 and CVP at 6 hours if the lactate remains elevated (although they are still an alternative to clinical examination)
- The also added dynamic assessment of fluid responsiveness and bedside ECHO as options

The glycocalyx

2014/2 a) What is the endothelial glycocalyx? Outline its potential importance in sepsis. b) Name factors that can disrupt the endothelial surface layer (ESL). c) What are the effects of glycocalyx disruption?

The glycocalyx



- The glycocalyx is a web of membrane-bound glycoproteins and proteoglycans on endothelial cells
- The glycocalyx interacts with plasma constituents (including albumin) to form the endothelial surface layer
- The ESL comprises approximately 25% of the vascular space

In sepsis

- The glycocalyx has been demonstrated to be damaged in sepsis but multiple processes
- A loss of integrity is associated with increased membrane permiability
- This has been used as a model to describe organ dysfunction in sepsis

Causes of disruption

- Vascular damage due to: hyperglycaemia, hyperlipidaemia, smoking
- Inflammation, mediated by TNFα (this is prevented by hydrocortisone)
- Ischaemia-reperfusion injury (which halts the endothelial synthesis of glycosaminoglycan
- Hypervolemia (mediated by actions of the ANP)
- Hydroxyethyl starch (in same study that investigated the effects of hypervolemia)
- Major vascular surgery (seems like a consequence of bypass and ischaemia/reperfusion)

Effects of glycocalyx disruption

- Local hypercoagulability
- Global autoheparinisation (especially during trauma)
- Increased capillary permeability
- Tissue and organ oedema
- Impaired microcirculatory oxygen distribution
- Loss of vascular responsiveness
- Increased platelet aggregation, leading to microvascular thrombosis and DIC
- Increased leucocyte-endothelium interaction, leading to inflammation

Vasoactives in septic shock

Created Question Compare and contrast the pharmacology of noradrenaline, adrenaline and vasopressin in the management of septic shock

Adrenaline

Class

Endogenous catecholamine

Presentation

Clear glass vials 1:1000 (1mg/ml)

PK

Absorption - IV only

Metabolism - MAO and COMT

Elimination - half life 2 minutes

PD

> Non selective adrengeric agonist.
> At moderate doses beta1 agonism leads to increased inotropy and chronotropy.
> At the highest doses it is primarily a vasoconstrictor.
> It also stabilses mast cells which is why it is used in acute anaphlyaxis.

Side effects

> May cause deranged metabolic states with increased gluconeolysis, lypolysis and gluconeogenesis (increased BSL)
> Associated with increased lactate which may confound
> Arrythmogenic

Noradrenaline

Class

Endogenous catecholamine

Presentation

Glass vials 1:1000 (4mg/4ml)

PK

Absorption - IV only

Metabolism - MAO and COMT

Elimination - half life 2 minutes

PD

> Acts mainly via alpha 1 receptors
> As such is primarily a potent vasoconstrictor

Side effects

> Vasoconstriction leading to impaired organ perfusion

Vasopressin

Class

Endogenous endocrine peptide

Presentation

Glass vials with 20 units in 1ml

PK

Absorption - Delivered IV in sepsis although may be delivered IM of IN.

Metabolism - hepatic and renal

Elimination - half life 20 minutes (IV)

PD

> V1a receptors are found in multiple places including vascular smooth muscle and platelets are responsible for the vasopressor actions
> May also reduce urine output via ADP receptors in the kidney and affect platelet aggregation

Side effects

> May cause severe vasoconstriction and limb or gut necrosis
> Can lead to water retention and hyponatraemia
> May affect platelet function

Summary

> Noradrenaline is accepted as the first line agent in septic shock.
> Myburgh et al demonstrated that adrenaline is equally efficacious in supporting the blood pressure but may lead to increased arrythmias and a higher lactate
> The VASST study showed that vasopressin is useful for catecholamine sparing.
> The shorter half lifes of norad and adrenaline make them more useful to titrate against the blood pressure

Clinical: acute resp failure in fit pt

2012/1 A 33-year-old abattoir worker presented to the Emergency Department with a 2 week history of increasing shortness of breath and haemoptysis. He had previously been fit and well. On examination he is alert, normotensive but tachypnoeic (35 breaths per minute), centrally cyanosed (SaO2 85% on 10L/min O2) and tachycardic (120 beats per minute). Auscultation reveals a systolic murmur at the lower left sternal edge and coarse inspiratory crackles bibasally. The remainder of the examination was unremarkable. His chest radiograph demonstrates bibasal consolidation. List the most likely differential diagnoses, and for each diagnosis, list the specific investigations needed to confirm the diagnosis and the specific treatment required

Community Acquired Pneumonia

Bacterial (strep pneumonia, H. influenza, or atypical such as mycoplasma)

Ix Blood culture, Sputum M,C&S, PCR

Tx Tazocin and Azithromycin for atypical

Viral illness

Viruses: RSV, Influenza, Human parainfluenza, Coronavirus, Adenovirus,

Ix NPA for viral PCR and direct antigen

Tx Supportive / not oseltamivir given symptoms present for >72 hours

Uncommon infective agent

Q-Fever (although very rare most features in this presentation are consistent with Q Fever infection)

Ix Serology for C.Burnetti

Tx Treatment is with doxycycline or ciprofloxacin

Tuberculosis

Ix Acid fast bacilli then PCR

Tx DOTS: Rifampicin / Isoniazid / Ethambutol

Primary cardiac issue

Endocarditis or non infective valvular pathology

Ix TOE and BC sets x3

Tx Ceftriaxone / Gentamicin / Surgical excision & valve repair

Inflammatory disease

Wegners / other vasculitis

Ix Vasculitic screen - cANCA

Tx Pulsed methylprednisolone / plasmapharesis

Bilateral infiltrates in AIDS

2003/1 List the potential causes of diffuse pulmonary infiltrates in a patient with AIDS, and outline how they would influence your management

AIDS is defined as a CD4 count of <200 or an AIDS defining illness in the setting of HIV positive status.

Bilateral pulmonary infiltrates

May be infectious or non infectious.

Infectious

Infectious aetiologies broaden as the CD4 count declines. Antibiotic choices should reflect potential pathogens

> Pathogens
- CD4 > 200
  - Myobacterium species
  - Community acquired pneumonias (Strep pneumonia, H.Influenza, Legionella)
  - Respiratory viral infections (RSV, influenza, para-influenza, adenoviruses)
- CD4 < 200
  - PCP becomes an important consideration
  - Cryptococcus neoformans
- CD4 < 100
  - Staph aureus
  - Pseudomonas aeruginosa
  - Toxoplasma
- CD4 < 50
  - Histoplasma
  - Coccidiodes
  - CMV
  - MAC
  - Aspergillous

Non infectious

> SIRS/ARDS - ARDSnet protocols
- Pancreatitis
- Non lung sepsis
- TRALI

> Pulmonary oedema - treat with diuresis, PPV, nitrates etc.
- Fluid overload
- TACO
- Acute LV dysfunction

> Vasculitis - steroids etc
- Inflammatory screen - pANCA etc

> Malignancy
- Kaposi sarcoma with lung involvement
- Non Hogkins lymphoma

Invasive aspergillosis

2014/2 A 65-year-old male with a background history of chronic obstructive pulmonary disease has been ventilated for ten days for respiratory failure related to community-acquired pneumonia. He develops a new fever and a sputum sample is positive for Aspergillus spp. a) Discuss the difficulties in confirming a diagnosis of invasive pulmonary aspergillosis (IPA) in this patient. b) What findings on history and examination are associated with increased risk of IPA? c) What investigations are used to confirm a diagnosis of IPA?

Aspergillosis

> Aspergillosis refers to illness due to allergy, airway or lung invasion, cutaneous infection, or extrapulmonary dissemination caused by species of Aspergillus

Diagnostic difficulties

> Aspergillus species are ubiquitous in nature, and inhalation of infectious conidia is a frequent event, therefore colonisation with aspergillus species does not necessarily indicate IPA
> Obtaining tissue samples showing invasion of tissues can be problematic
> Radiological signs may be difficult to identify in intubated patients
> In the setting of immunosuppression other fungi and pseudomonas can cause similar radiological findings such as 'halo' signs confusing the diagnosis
> Classic triad of pleuritic chest pain, fever and haemoptysis may be difficult to elict or be confounded

Risk factors

> Severe and prolonged neutropenia
> Receipt of high doses of glucocorticoids
> Other drugs or conditions that lead to chronically impaired cellular immune responses (eg, immunosuppressive regimens administered to treat autoimmune diseases and to prevent organ rejection, AIDS)
> Chronic COPD patients in ICU settings especially on steroids
> Transplant patients especially lung, renal and liver with CMV exposure

Diagnosis

> Suggested on CT or XRay by characteristic halo sign
> Culture of Aspergillus spp in combination with the histopathologic demonstration of tissue invasion by hyphae provides definitive evidence of invasive aspergillosis
> Glactomannan assay is relatively specific for IPA although has low sensitivity and may be difficult to interpret when tx with tazocin
> BAL and blood samples can be tested via PCR

Splenectomy and infection risk

2013/1 A 56-year-old male, with a previous splenectomy, presents with an altered mental state but a stable cardiorespiratory status. He is pyrexial with a temperature of 38.4oC.?Blood cultures taken on admission show gram-positive cocci in both bottles. a) What is the likely diagnosis and what other specific investigations would you order? b) Outline your specific treatment for this condition. c) List five factors that predispose to this condition. ? d) What follow-up treatment will you recommend for this man on hospital discharge?

Introduction

Asplenic individuals are at increased risk for overwhelming sepsis, a fulminant and rapidly fatal illness that complicates bacteremic infections due to encapsulated pathogens (including Streptococcus pneumoniae, Haemophilus influenzae, and Neisseria meningitidis), which are normally cleared from the circulation by the spleen. Strep pneumoniae is the most important and accounts for 60% of septic deaths in asplenism.

Diagnosis

As the culture shows gram positive cocci the most likely diagnosis is Strep pneumoniae

Investigations

CTB, lumbar puncture, chase cultures and sensitivities, urine pneumoncoccal antigen (+legionella), PCR for pneumococcus

Treatment

Start empirical antibiotics immediately (don't delay for a LP etc).

Ceftriaxone 2g BD or Cefotaxime 2g TDS + vancomycin 1.5g BD

Dexamethasone has been shown to reduce mortality in patients with strep pneumoniae meningitis and is therefore recommended (0.15 mg/kg every six hours for four days) - it should probably be discontinued if the CSF iolate is a different bug however.

Risk factors

- Age <2 or ≥65 years
- Chronic cardiovascular disease (eg, heart failure, cardiomyopathy)
- Chronic pulmonary disease (eg, chronic obstructive pulmonary disease, emphysema, asthma)
- Chronic liver disease (eg, cirrhosis) or Chronic renal failure or nephrotic syndrome
- Diabetes mellitus
- Alcohol abuse and Smoking
- Functional or anatomic asplenia (eg, sickle cell disease, splenectomy)
- Immunosuppressive conditions (eg, HIV infection, congenital immunodeficiency, malignancy, B cell defects, multiple myeloma)
- Solid organ or hematopoietic cell transplant recipients
- Patients undergoing treatment with alkylating agents, antimetabolites, or systemic glucocorticoids
- Patients with cerebrospinal fluid leaks
- Cochlear implant recipients

Prevention

- Vaccination and re-vaccinate at 5 year intervals
- Empiric antibiotics if develops temperature
- Consider life long antibiotic therapy in this patient.

Bacterial meningitis

2015/1 With respect to community-acquired bacterial meningitis in Australia and New Zealand: a) List two common pathogens encountered AND the empirical antimicrobial therapy of choice in EACH the following contexts: Neonate aged < 1month, Immunocompetent adult aged 35 years, Adult aged 48years on steroids, Immunocompetent adult aged 85 years (70% marks) b) Briefly discuss the role of adjunctive corticosteroids in the management of meningitis. (30% marks)

Neonate aged < 1 month

> Bugs
  - Gp B Strep (agalactiae)
  - E. coli
  - Listeria
> Empirical antibiotics
  - Ampicillin + Ceftriaxone

Immunocompetent adult aged 35 years

> Bugs
  - Strep. pneumoniae
  - N. meningitidis
> Empirical antibiotics
  - Vancomycin + Ceftriaxone

Adult aged 48 years on steroids

> Bugs
  - Listeria
  - Gram negative bacilli
  - [TB]
> Empirical antibiotics
  - Vancomycin + Ampicillin + Meropenem

Immunocompetent adult aged 85 years

> Bugs
  - Strep pneumoniae
  - N meningitides
  - Listeria
  - Aerobic GNB
> Empirical antibiotics
  - Ampicillin + Ceftriaxone + Vancomycin

Role of steroids

> Rationale is that it reduces swelling and may improve outcomes
> Evidence
  - Often conflicting evidence - based on subgroup analysis may improve mortality in strep pneumonia, reduce hearing loss in paeds with haemophilus
> Issues
  - May reduce penetrance of antibiotics (Vanc) into the BBB, can worsen infection
  - Other issues with steroids - hyperglycaemia, osteoporosis etc
> Practice -Give if suspect strep pneumoniae (stop of cultures do not prove) and give in kids with haemophilus

Cytomegalovirus - CMV

2013/2 Discuss the diagnosis, risk factors in immunocompetent patients, the adverse outcomes in the patient group and the treatment of CMV.

Diagnosis

> Positive CMV antibodies (IgM) - sensitive for recent or acute infection
> Qualitative PCR - very sensitive for the presence of CMV, but they do not distingusih between active and latent infection.
> Quantitative PCR - ideal test, as it provides a quantitative assessment of viral load, and allows the monitoring of therapy.

Risk factors for the immunocompetent host (among the ICU population)

> Critical illness in general seems to be a risk factor.
> Trauma
> Burns
> Severe critical illness (high APACHE score, over 27)
> Blood transfusion
> Mechanical ventilation
> Severe sepsis
> Prolonged ICU stay
> Pregnancy

Consequences of CMV reactivation

> Colitis
> Hepatitis
> Encephalitis
> Guillain-Barre syndrome
> Pneumonitis (rare)
> Pericarditis and myocarditis
> Uveitis and retinitis

Management of CMV

> Ganciclovir or valganciclovir
> Foscarnet (if resistant)

Contamination, Nec Fasc and Gram neg baccilus

2013/1 23.1 A 55-year-old obese male with dysuria and hypotension was admitted to the ICU 12 hours previously. He had a femoral central venous catheter inserted in the Emergency Department on admission. Your registrar has reported that blood cultures collected through the CVC at the time of insertion growing Staphylococcus epidermidis. a) What advice will you give the registrar regarding the blood culture result? b) List two groups of patients in whom this result would be a concern.

A 61-year-old male fisherman presented to the Emergency Department with hypotension, three days after falling on a coastal slipway and suffering extensive abrasions to both lower limbs. These abrasions are now progressing and transforming into haemorrhagic bullae. The patient is now admitted to the ICU for organ support. a) What is the most likely causative organism? b) What is the specific treatment required in this case?

A 56-year-old patient who has been on Meropenem and Fluconazole for six days for intra-abdominal sepsis has developed new fevers and blood cultures have shown a Gram negative organism. The sensitivities are given below: a) List three likely causative organisms for the new episode of sepsis. b) For each organism listed give an appropriate antibiotic.

> Resistant to: Gentamicin, Tobramycin, Ampicillin, Imipenem, Ciprofloxacin, Ticarcillin
> Gram stain: Gram negative bacillus

Staph epidermis in blood cultures

a) Not to give additional antibiotics. Consider removing / re-siting the femoral CVC depending on the patient's condition

> Immunocompromised patients with intravascular devices
> Patients with surgical implants?Patients high risk for endocarditis
> Low weight neonates and elderly

Vibrio infection

a) Vibrio vulnificus or V parahaemolyticus

b) Surgical debridement of necrotic tissue including amputation if indicated.

Antibiotic therapy – 3rd generation cephalosporin + a tetracycline OR

Ciprofloxacin OR Meropenem OR any reasonable antibiotic choice

Gram negative bacillus

> i) Stenotrophomonas maltophilia · Co-trimoxazole
> ii) Multi-resistant Acinetobacter · Amikacin / Colistin
> iii) Multi-resistant pseudomonas spp · Amikacin
> iv) Enterobacter spp · Amikacin
> v) Proteusspp · Amikacin

Community acquired pneumonia

2012/2 A 67 year old male, having presented with a presumptive diagnosis of Community Acquired Pneumonia (CAP) remains intubated and in need of mechanical ventilation at Day 5 of his admission to hospital. a) Outline the factors that may affect the expected rate of resolution of their CAP b) Outline your approach, and indication for, the diagnostic evaluation of non-resolving pneumonia

Rate of CAP resolution

Host factors

> Alcoholism, older age, and the presence of comorbid diseases such as diabetes and chronic obstructive lung disease. In addition, disorders of immune function, particularly AIDS and syndromes associated with deficient humoral immunity, can be associated with delayed resolution of pneumonia.

> Approximately 90 percent of patients younger than 50 years of age show radiographic resolution by four weeks, compared with only 30 percent of patients older than 50, even in the absence of concurrent disease

Severity of CAP

> In particular shock, severe hypoxemia, acute renal failure, bacteremia, and acute respiratory distress syndrome have all been shown to worsen the course of CAP.

> Radiographic resolution of severe pneumonia is estimated at 10 weeks, compared with three to four weeks for mild to moderate pneumonia

Pathogenic factors

> The virulence of the infecting organism and the infections response to antibiotics are important to determine the speed of resolution.

> Antibiotic resistance may not be initially detected delaying appropriate therapy, and make eventual treatment more difficult

> In general, resolution is more rapid with Mycoplasma pneumoniae, non-bacteremic Streptococcus pneumoniae, Chlamydophila (formerly Chlamydia) species, and Moraxella catarrhalis than with other organisms

> Resolution is generally prolonged with unusual pathogens such as; Mycobacterium tuberculosis, Nocardia, Actinomyces israelii, Aspergillus, Coxiella burnetii (Q fever), Chlamydia psittaci (psittacosis), Leptospira interrogans (leptospirosis), Pseudomonas pseudomallei (melioidosis)

Development of complications from initial CAP

The two main forms of sequestered focus preventing adequate resolution of pneumonia are empyema and lung abscess.

Non-infectious aetiology to initial CAP and/or underlying lung disease

Respiratory Malignancy, lymphoma, Granulomatosis with polyangiitis (Wegener's), Diffuse alveolar hemorrhage, Bronchiolitis obliterans-organizing pneumonia (BOOP), Acute or Chronic eosinophilic pneumonia, Acute interstitial pneumonia, Pulmonary alveolar proteinosis, Sarcoidosis, Systemic lupus erythematosus, Heart failure, Pulmonary embolism

Evaluating non resolving pneumonia

> Chest CT to look for sequestered areas of infection or for findings that suggest an alternative diagnosis.

> Look for more difficult to detect species such as TB, Nocardia and mycobacteria

> Check inflammatory markers ?vasculitis

> Fiberoptic bronchoscopy patients – lesions, mechanicals respiratory lesion, unusual pathogen

> Thoracoscopic or open lung biopsy

> Consider a drug induced pneumonia (rare) or PE (rare)

Community aquired pneumonia II

2012/1 a) List the clinical features that indicate a poor prognosis in a patient with community-acquired pneumonia? b) List 5 common organisms causing severe community acquired pneumonia in immunocompetent adults. c) What are the possible reasons for non-response to empiric treatment for patients treated for severe community acquired pneumonia? d) Briefly outline your approach to stopping antibiotics given for CAP responding to empiric treatment in ICU?

Prognosis in CAP

CAP prognosis predicted by a range of scoring systems including

- CURB 65 (confusion, urea > 7, RR >30, SBP < 90 and/or DSP < 60, and age >65)
- Pneumonia Severity Index which includes elements of CURB plus other characteristics such as sodium < 130, pH < 7.35, paO2 < 60, extremes of temperature, tachycardia, comorbidites such as renal or liver disease and malignancy, CCF and cerebrovascular disease. Gender is also included in the PSI.
- PIRO is a specific scoring system for ICU and includes Comorbidities (chronic obstructive pulmonary disease, immunocompromise); age >70 years; multilobar opacities in chest radiograph; shock, severe hypoxemia; acute renal failure; bacteremia and acute respiratory distress syndrome.

5 common organisms in immunocompetent with severe CAP

- Staphylococcus Aureus
- Streptococcus Pneumonia
- Haemophilus Influenza
- Klebsiella Pnuemonia
- Mycoplasma Pneumonia
- Consider also virus pathology

Reasons for non response?

- Atypical organism – eg meleoidosis (geographical predisposition for certain pathogens hence need to follow local empiric therapy guide)
- Resistant organism – eg MRSA
- Non-complicance with antibiotic medication
- Inadequate dosing either under dose or issue with drug interval
- Secondary infections with another pathogen
- Complication of CAP – empyema / abscess
- Patient comorbidities – malignancy / lung disease
- Wrong diagnosis – cardiac failure / PE

Stopping plan for antibiotics

- Once commenced for clinically apparent CAP I would generally compete a full course of 7-10 days IV antibiotics assuming demonstrable clinical improvement observed
- Consider narrow antibiotics cover once pathogen and sensitivities known
- In discussion with my infectious diseases team consider change to oral regime, or lengthen course for some infections such as legionella

Selective decontamination of the digestive tract (SDD)

Created question Critically evaluate the role of selective decontamination of the digestive tract (SDD) in the ICU

Definition

Selective decontamination of the digestive tract indicates a method designed to prevent infection by eradicating and preventing carriage of aerobic, potentially pathogenic micro-organisms from the oropharynx, stomach and gut. It involves the prophylactic application of topical nonabsorbable antibiotics to the oropharynx and stomach with or without a short course of intravenous antibiotics.

Selective oropharyngeal decontamination (SOD) is the main alternative treatment and most studies have shown that there is benefit but this benefit is less than SDD.

Topical chlorhexidine gel application to the orophayrnx is more widespread although may cause harm.

Rationale

> Hospital acquired infections are associated with significant mortality, morbidity and cost
> The incidence of pneumonia in critically ill patients may be as high as 40%, with mortality from VAP up to 50% in some populations
> SDD has been extensively researched as a method of reducing the risk of VAP and other hospital acquired infections

Supporting evidence

> Multiple RCTs primarily in European settings have demonstrated benefit or trend to benefit with SDD
> A 2013 Cochrane review of 36 RCTs (~7000 patients) has demonstrated that there is a significant and likely clinically worthwhile reduction in mortality associated with SDD
> A 2014 Meta-analysis in BMJ demonstrated similar results
> Detailed cost-benefit analysis in a Dutch setting has demonstrated that SDD and SOD were cost saving

Controversial aspects

The Cochrane and BMJ reviews

> Had significant heterogeneity
> Compared several different regimes creating uncertainty regarding the optimal strategy
> Involved studies which had very different flora to Australian ICUs

Antibiotic stewardship

> There is significant concern from clinicians regarding the development of antibiotic resistance
> The main evidence however from Holland counter-intuitively indicates reduced resistance with SDD
> The Holland evidence may have limited external validity due to very low existing rates of resistance

Cost-benefit analysis

> There is increased nursing requirements with SDD and other resource issues
> Uncertain applicability of the Dutch cost-benefit analysis

Adverse drug reactions and anaphylaxis

> May increase with increased usage of antibiotics and topical antiseptics

Summary

> There remain significant attitudinal barriers to adoption of SDD in Australian ICUs (SuDDICU Delphi study)
> Despite considerable evidence most intensivists feel there remains equipoise
> There is unlikely to be widespread adoption of SDD until further research is conducted in an Australian cohort

H1N1 in pregnancy

2011/1 You are called to assess a 38 year old female with respiratory failure in the Emergency Department. This is her first pregnancy and she is 28 weeks pregnant after several attempts at IVF. She is positive for Swine-Origin Influenza Virus (H1N1). Evaluation of the foetal heart reveals significant bradycardia.

Arterial blood gas on a FiO2 of 0.8 shows:

- pH 7.31
- pCO2 48 mm Hg
- pO2 55 mm Hg
- Bicarbonate 18 mmol/L

Outline the specific challenges in this case that distinguish it from a similar illness in a previously healthy 38 year old male.

- Precious pregnancy in older, primiparous patient.
- Known high incidence of morbidity and mortality in mother and foetus with H1N1 Influenza infection with severe CAP.
- Requirement to work closely with specialist obstetric team and rationalising potentially conflicting priorities eg. timing of delivery of foetus.
- Evidence of increased level of severity based on the blood gas results given altered normal ranges in pregnancy (3rd trimester pCO2 30-32)- this gas indicates a more severe hypercapnea when compared with a 38 yr old male, although the associated metabolic acidosis is not as severe (normal HCO3 in third trimester is low 20s)
- Anatomical and Physiological considerations during pregnancy- elevated diaphragm and decreased FRC, decreased chest wall compliance, increased risk of aspiration during intubation, pressure of gravid uterus on IVC (and aorta) decreasing venous return (and increasing afterload) in the supine position.
- Maintaining effective foeto-placental circulation while optimising maternal outcome.
- Safety of various drugs in pregnancy eg. anti-virals, sedatives.
- History of severe asthma complicating current episode of severe CAP likely to make ventilatory strategy more complex.
- Importance of keeping family members well informed of considerations and likelihood of poor foetal outcome as priority will be given to mother's survival.

Outline your specific approach to the management of this case.

- Immediate
- Clinical scenario described requires rapid resuscitation.
- Airway- Secure early, rapid sequence induction. Anticipate difficult airway (ensure help and difficult airway equipment available.
- Breathing- Ventilate with protective lung strategy. Example of Settings – SIMV/PC,
- FiO2-1.0 PC to achieve Tidal Volumes of 6-8ml/kg, Low rate- 6-8/min I:E ratio 1:3-4 to allow adequate expiratory time, PEEP 10-15cm titrated to oxygenation. Close monitoring with regular blood gas evaluation. Tolerate hypercapnia (although not ideal for foetus) if poorly compliant lungs. Position at least 30 degrees head-up to optimise respiratory mechanics. Sedate heavily to minimise oxygen consumption. Neuromuscular blockade if required to facilitate ventilation.
- Circulation-. Fluid resuscitate (likely to be volume depleted) to clinical endpoints, vasoconstrictors to maintain perfusion pressure (eg MAP>60mmHg). Assessment of cardiac output if unstable haemodynamics with these measures (eg. echocardiogram, PiCCO, PA catheter, ScVO2)- High cardiac output expected due to pregnancy and infection. Inotropes if cardiac output low. Position slightly left lateral to relieve IVC compression.
- Early specialist obstetric evaluation to determine foetal condition, position of placenta and risk versus benefit of delivery of foetus may need to be considered carefully taking into consideration maternal and foetal factors.

Infective endocarditis

Clinical manifestations

> Osler's nodes and Janeway lesions
> Splinter haemorrhages
> Roth spots
> Focal neurological signs suggestive of embolic phenomena
> A new murmur or a worsening of an old murmur
> Splenomegaly
> Glomerulonephritis
> Arthralgia and arthritis
> Elevated ESR, CRP or rheumatoid factor

Duke's Criteria

> 2 Major OR 1 Major + 3 minor OR 5 minor = Endocarditis
> Major criteria
  - 2 seperate blood cultures of a typical organisms
  - ECHO evidence of endocardial involvement
> Minor criteria
  - Predisposing factor: known cardiac lesion, recreational drug injection
  - Fever >38 °C
  - Embolism evidence: arterial emboli, pulmonary infarcts, Janeway lesions, conjunctival hemorrhage
  - Immunological problems: glomerulonephritis, Osler's nodes, Roth's spots, Rheumatoid factor
  - Microbiologic evidence: Positive blood culture of atypical bug

Common implicated organisms

> S.epidermidis and other coagulase-negative staphylococci
> Streptococcus viridans (includes milleri group)
> S.aureus (MSSA and MRSA)
> Enterococcus
> Coxiella burnetii (Q fever)
> HACEK organisms are mentioned, even though they are responsible for only about 3% of native valve endocarditis.
  - Haemophilus species: H.aphrophilus, H.parainfluenzae and H.paraphrophilus
  - Actinobacillus and Aggregatobacter species
  - Cardiobacterium hominis
  - Eikenella corrodens
  - Kingella kingae

Antibiotic management

> Empiric therapy native valve = Vancomycin + ceftriaxone (or gentamicin)
> Prosthetic valves = Vancomycin, gentamicin and rifampicin "triple therapy"

Indications for urgent surgery

> Haemodynamic instability
> Aortic root abscess
> Ongoing embolic phenomena

Leptospirosis

2014/2 Returned traveller, fevers and myalgias after 12 days back, improved initially then worsened. Now; unwell, respiratory rate 24 breaths per minute; bibasal crackles on auscultation, heart rate 102 beats per minute, blood pressure 92/45 mmHg, cool peripheries, conjunctival suffusion, and mild meningism. Acute kidney injury, boderline platelets, low Hb, raised INR, deranged LFTs with high bilirubin and CK. WCC 20.

> a) List the features on the history, examination and results of investigations, given above, that are in keeping with a diagnosis of leptospirosis in this patient.

> b) Briefly describe the natural course of this disease.

> c) Discuss the specific treatment of this patient for this condition.

Leptospirosis

Leptospirosis is a zoonotic disease endemic in tropical regions. It results in protean clinical manifestations caused by pathogenic spirochetes of the genus Leptospira.

Features consistent with diagnosis

> Recent overseas travel to tropical region

> Conjuctival suffusion occurs in ~50% of patients and is a useful differentiator

> Biphasic disease process with initial illness that improved and now second phase consistent with Weil's disease incl;

- Haemorrhagic diathesis
- Renal impairment
- Acute hepatitis and jaundice
- Rhabdomyolysis
- Aseptic meningitis

Natural course of the disease

> Most cases are mild and self-limited or subclinical.

> The illness generally presents with the abrupt onset of fever, rigors, myalgias, and headache in 75 to 100 percent of patients, following an incubation period of 2 to 26 days (average 10 days).

> A second phase may occur called Weil's disease, is characterised by multi-organ dysfunction and may be potentially fatal

Treatment options

> Limited evidence for antibiotic treatment as per Cochrane review, although may shorten the disease process

> Options include

- Penicillin (1.5 million units IV every 6 hours) OR
- Doxycycline (100 mg IV twice daily) OR
- Ceftriaxone (1 to 2 g IV once daily), OR
- Cefotaxime (1 g IV every 6 hours).

> The duration of treatment in severe disease is usually seven days.

> There may be a inflammatory reaction to spirochete lysis at the initiation of antibiotics

Malaria

2011/2 With respect to malaria: a) Describe the laboratory confirmation of this condition b) List 2 first line drugs from different classes given parenterally in the treatment of the severe form of this disease c) List the acute complications of this disease

Lab diagnosis of malaria

Light microscopy of thick and thin blood smears (give diagnosis and parasite load)

Rapid diagnostic tests utilising malarial antigens (dependents on specific test)

First line treatment options

> Cinchona alkaloids (quinine and quinidine)
> Artemisinin derivatives (artesunate, artemether).

List the acute complications of this disease

> Cerebral Involvement with or without convulsions
> Respiratory Failure - acute respiratory distress syndrome (ARDS)
> Circulatory collapse
> Renal failure, hemoglobinuria (“black water fever”
> Hepatic failure
> Haematological
> Disseminated intravascular coagulation
> Severe anemia secondary to Haemaolysis
> Thrombocytopenia
> Metabolic
> Hypoglycemia
> Severe Acidosis
> Hyponatraemia
> Splenic Rupture

Pregnancy, necrotising infections and pyelonephritis

2014/2 a) Outline briefly the difficulties associated with the diagnosis of sepsis during late pregnancy and labour. b) List the leading causes of sepsis in pregnant patients.? c) What are the common pathogens encountered in pregnancy-related sepsis? d) List two antibiotics contra-indicated during pregnancy.

A 74-year-old female presents with perforated colonic cancer and widespread peritoneal contamination. She has a laparotomy, peritoneal washout, colonic resection and formation of a defunctioning ileostomy. On day 6, she is noted to have abdominal wall cellulitis, abdominal wall oedema and a positive blood culture growing Gram positive bacilli. a) What is the likely diagnosis?? b) What is the likely organism isolated in the blood culture?

A 56-year-old male presents with pyelonephritis. Ultrasound reveals an obstructed right kidney. Percutaneous nephrostomy is performed. Blood cultures show 2/2 bottles growing Enterobacter cloacae, sensitive to ceftriaxone. What antibiotic will you choose and why?

Pregnancy

a) Applying SIRS criteria to pregnancy may be problematic as there is:

> Leukocytosis
> Body temperature is raised during pregnancy and labour
> Tachycardia and tachypnoea are seen during normal labour

b) Common infections include;

> Pyelonephritis
> Chorioamnionits
> Septicabortion
> Episiotomyinfections
> Necrotisingfasciitis
> Septic thrombophlebitis
> Aspirationpneumonia

c) Gram negative more common than Gram positive agents - E.Coli, Group B Streptococcus, Klebsiella

d) Tetracyclines, Chloramphenicol, Aminoglycosides, Metronidazole, Sulphonamides

Necrotising infetions

> a) Necrotising fasciitis.
> b) Clostridial species.

ESCAPPM

Organisms with resistance to cephalosporins include Enterobacter, Serratia, Citrobacter, Aeromonas, Proteus, Providencia, Morganella Morganii

Therefore in this setting I would choose a stat dose of gentamicin 4-6 mg/kg plus meropenum

Tetanus

2014/1 A 67-year-old female has presented acutely with a diagnosis of tetanus. She sustained a laceration one week earlier while gardening and has now developed generalised spasms and respiratory distress. Outline your specific management of this patient including management of the anticipated complications of tetanus.

Tetanus

Tetanus is a nervous system disorder characterized by muscle spasms that is caused by the toxin-producing anaerobe Clostridium tetani, which is found in the soil.

Goals of treatment

Airway management

> Consider intubation as ventilation early as tetany of the muscle of respiration can cause a crisis. Early tracheostomy is also warranted

Halting the toxin production

> This is achieved by wound debridement and removal of necrotic tissue
> Antimicrobials have limited evidence by their use is widespread. Metronidazole is first line treatment however penicillin as an alternative

Neutralization of the unbound toxin

> Tetanus toxins bind irreversibly to muscle receptors however unbound toxin can be mopped up with human tetanus globulin

Immunisation

> Since tetanus is one of the few bacterial diseases that does not confer immunity following recovery from acute illness, all patients with tetanus should receive active immunization with a total of three doses of tetanus and diphtheria toxoid spaced at least two weeks apart, commencing immediately upon diagnosis

Control of muscle spasms

> Benzodiazepienes are recommended
> NMB such as a long acting agent such as pancuronium are another option

Management of dysautonomia

> There is some evidence for magnesium
> Labetalol is useful for it's alpha and beta effects
> Clonidine may also be an option

General supportive management

> Feeding
> Analgesia
> Sedation
> Thromboprophylaxis
> Head up 30 degrees whilst intubated
> Ulcer prophylaxis
> Glycaemic control 6-10

Vancomycin Resistant Enterococci

2012/2 Outline the predisposing factors, consequences and management of the critically ill patient with Vancomycin Resistant Enterococcus (VRE).

Predisposing factors

> Previous treatment with anti-microbials (especially vancomycin, cephalosporins and broad-spectrum antibiotics)
> Advanced age
> Increased length of stay
> Renal impairment and dialysis
> Haematological malignancies
> Long-term IV access especially with CVCs
> Enteral tube feeding
> Prevalence of VRE colonized patients in the ICU
> Contact with a patient with VRE
> Resident of long-term care facility
> Decreased staff : patient ratios

Consequences

> Potential transmission of resistance to Staph aureus
> Determined by site of infection if present (eg UTI, bloodstream including endocarditis and rarely respiratory infection)
> Need for isolation

Management

> Specific antibiotics if infected rather than colonized depending on sensitivities (Van A resistant to vancomycin and teicoplanin; Van B sensitive to teicoplanin) – options include linezolid, daptomycin, quinupristin-dalfopristin, tigecycline.
> Probiotics may have a role.
> Infection control including isolation, contact precautions and PPE, and general infection control measures including surface and environmental cleaning, antibiotic stewardship, screening of contacts and patient surveillance until swabs are negative. Precautions should continue on discharge from ICU

VRE II

2012/1 You are looking after a 54 year old man post cadaveric liver transplantation with impaired graft function and failure to progress. A large subhepatic bile collection was drained percutaneously on day 7 when he was started on piperacillin-tazobactam. Culture of the drain fluid reveals heavy growth of Enterococcus spp. a) What activity does piperacillin have against Enterococcus spp? b) The Provisional report is that the Enterococcus is resistant to Vancomycin. List 3 antibiotics you would consider in this situation. c) What are the main toxicities of each of the antibiotics you have listed in your answer to b)? d) Which antibiotic would you select, and why?

Tazocin activity versus enterococcus

There should be activity. However the possibility of development of VRE exists (especially in a hospital setting). In this instance VRE tends to be resistant to B-lactams.

Treatment options for VRE

- Tecioplanin
- Linezolid
- Tigecycline
- Daptomycin

Toxicities of VRE antibiotics

- Tecioplanin: Well tolerated. Some renal and hepatic dysfunction
- Linezolid: thrombocytopenia, anaemia, serotonin syndrome
- Tigecycline: Poor action against VAN-A VRE. GI disturbance, catabolic
- Daptomycin: Myopathy
- Ceftaroline: well tolerated

Choice of antibiotics

Select Linezolid

- has activity as VAN-A & B (Teicoplanin does not work well against VAN-A).
- Van A resistance is common in Australia, so many VRE are teicoplanin resistant.
- Linezolid also has a high degree of tissue penetration – important given the area of collection.
- No dosage reduction is necessary in renal or hepatic failure.

Ceftaroline is also a good option

Clostridium difficile extended

2012/1 a) List the patient-related risk factors associated with the development of Clostridium difficile enterocolitis b) List two tests that can be used for diagnosis of Clostridium difficile enterocolitis. c) List four markers of severity of disease in Clostridium difficile enterocolitis d) What are other possible causes of infective diarrhoea in the critically ill?

C.Diff risk factors

> Extremes of age
> Exposure to antibiotics
  - Clindamycin
  - Cephalosproins
  - Fluoroquinolones
  - Extended spectrum penicillins
> Immunosuppression
> Proton pump inhibitors and H2 antagonists
> Nursing home or group care home

C Diff diagnosis

> Lab testing
  - C.Diff antigen as a screening tool in patients in clinical setting
  - C.Diff toxin testing if antigen positive (75% specific, 99% sensitive)
  - Progress to PCR if antigen positive and ongoing high index of suspicion

Markers of severity of disease

> Blood markers
  - WCC greater than 15
  - Albumin level less than 30
  - Creatinine 150% baseline
> Radiological markers
  - Thickened colon wall suggestive of toxic megacolon
  - Ascities, stranding consistent with inflammation
> Clinical markers
  - Fever and rigors
  - Haemodynamic instability
  - Features consistent with toxic megacolon

Other infective causes of diarrhoea

> Viruses
  - Adenovirus, Norovirus, CMV, Rotovirus (paeds)
> Bacterial pathogens –
  - Campylobacter
  - E.Coli
  - Cholera
  - Salmonella
> Protozoa – Cryptosporidium, Giardia
> Parasitic -Strongyloides

Clostridium difficile

2014/1 With regards to Clostridium difficile (C. difficile) infection in critically ill patients: a) What are the risk factors for development of this condition? b) What complications can occur as a result of this infection? c) How is the diagnosis of C. difficile and its complications established? d) Briefly outline the options for prevention and treatment

C.Diff risk factors

- Extremes of age
- Exposure to antibiotics
  - Clindamycin
  - Cephalosproins
  - Fluoroquinolones
  - Extended spectrum penicillins
- Immunosuppression
- Proton pump inhibitors and H2 antagonists
- Nursing home or group care home

Associated complications

- Related to the diarrhoea
  - Hypovolaemia
  - Electrolyte disturbance; hypokalaemia, hypomagnesaemia
- Related to the intestinal infection
  - Sepsis and septic shock
  - Perforation
  - Toxic megacolon
  - Bleeding

C.Diff diagnosis

- Clinical setting
  - clinically significant diarrhea (≥3 loose stools in 24 hours) or ileus,
  - relevant risk factors (including recent antibiotic use, hospitalization, advanced age and severe illness)
- Lab testing
  - C.Diff antigen as a screening tool in patients in clinical setting
  - C.Diff toxin testing if antigen positive (75% specific, 99% sensitive)
  - Progress to PCR if antigen positive and ongoing high index of suspicion
- Radiological - CT may be useful in severe disease to look for toxic megacolon or pseudomembranous colitis
- Colonscopy - May be useful in severe disease with illeus to identify fulminant collitis

C.Diff treatment

- Stop current antibiotics if potentiating the disease
- Oral vancomycin or metronidazole
- Consider adding in IV metro in severe disease
- Probiotics may be of benefitFaecal transplant is another option in recurrent disease

C.Diff prevention

- Good antibiotic stewardship
- Contact precautions, barrier nursing, screening

Multi-resistant organisms

2011/1 The organisms below were isolated and demonstrated antimicrobial sensitivities as listed. a) What is the significance of these results? b) List 1 appropriate antimicrobial in each case. c) List the strategies available to reduce the development of these organisms in ICUs.

a) What is the significance of these results?

The organisms are multi-resistant which results in more problematic and usually prolong treatment regimes with associated increased health care costs

b) List 1 appropriate antimicrobial in each case.

Van A VRE: Linezolid, Daptomycin, (Tigecycline, Quinupristin-dalfopristin)

ESBL: Carbapenem (imipenem, meropenem, and perhaps ertapenem), Colistin, Aminoglycosides, Ciprofloxacin

c) List the strategies available to reduce the development of these organisms in ICUs.

> Strategies to improve the efficacy and utilization of antimicrobial therapy
  - Antibiotic evaluation committees
  - Protocols and guidelines to promote appropriate antimicrobial utilization
  - Hospital formulary restrictions of broad-spectrum agents
  - Substitution of narrow-spectrum antibiotics (such as first generation cephalosporins and aminoglycosides)
  - Mandatory consultations with infectious diseases specialists
  - Antibiotic cycling by regularly cycling different antimicrobial classes

> Infection control measures
  - Handwashing compliance: Alcohol-based hand wash is more effective than traditional soap and water in cleansing hands of bacteria
  - Barrier precautions with gloves and gowns
  - Isolation
  - Surveillance for multidrug-resistant bacteria for the early identification and control
  - Monitoring and disseminating the incidence and prevalence of isolation of multidrug-resistant bacteria
  - Limiting LOS and invasive devices (idc / ett/ vascular)

Pandemic management

2013/2 Outline how you would plan the ICU response to an influenza epidemic, including in your answer how you would increase resources

Definitions

> Epidemic An event where at a particular time, new cases of an infectious disease far exceed the expected rate

> Pandemic An epidemic that is geographically widespread (across countries/continents)

Planning phase

Firstly access the available resources to assist with planning

> Hospital and/or ICU pandemic plan

> Government action plans via NSW Health and Australian Federal Government

> Others; CICM, NHMRC, CTC (USA)

Identify and engage key stakeholders

> Departmental heads, especially emergency, anaesthetics/surgery, Nursing unit managers - to assist with staffing

> Pathology and microbiology department to assist with rapid diagnosis and infection control

> Hospital board/executive to ensure adequate funding availability

Execution phase

> Infection control
  - Set up a surveillance program to ensure early detection of patients at risk
  - Infection control measures to reduce the spread to other patients and ICU staff
  - Provision of antiviral prophylaxis / virus vaccine (if becomes available) for the staff

> Anticipated need for ICU equipment – identify where additional equipment can be resourced (ED, OR etc.)

> Increase ICU bed capacity
  - Opening additional beds in existing non-commissioned physical critical care bed spaces
  - Defer elective surgery requiring post-operative ICU/HDU care
  - Identify potential additional capacity for ICU ventilated beds in alternative clinical areas such as recovery, CCU, peri-operative units and respiratory units, convert HDU
  - Discharge of suitable patients to other ward areas (with appropriate upgrade in medical/nursing support)
  - Maximise the use of non-ventilatory strategies in care of ICU patients freeing up devices and equipment for patients for whom mechanical ventilation is essential
  - Facilitate end-of-life discussions and decisions in those appropriate ICU patients assessed as not reaching a meaningful recovery
  - Increase threshold for referral of patients for ICU from other hospitals
  - Consider using available private hospital ICU capacity

> Increase ICU healthcare staffing levels
  - Increase nursing staff shift length (e.g. 8 to 12 hour shifts)
  - Expansion of nursing capacity by increasing casual, agency or bank staff support
  - Cancellation of leave for medical and nursing staff
  - Train staff from other non-ICU monitored areas to provide intensive care
  - Secondment of additional medical staff from elective duties (e.g. anaesthesia)
  - Change in nurse:patient ratio to provide intensive care

> Allocation of pregnant / immuno-compromised staff to" non-flu" patients

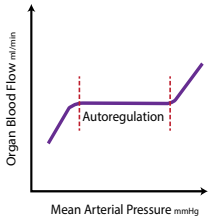
Review phase (post-pandemic)

Blood pressure targets in septic shock

Created Question A 72 yo male with a history of poorly controlled hypertension is admitted to your ICU with septic shock secondary to severe lower limb cellulitis. What haemodynamic parameters will you set for his resuscitation and provide evidence to support your plan.

Rationale (pros)

Auto-regulation is the ability of the organs to maintain constant blood flow within a range of different blood pressures



The kidneys, brain and heart demonstrate auto-regulation

Patients with poorly controlled hypertension may reset their auto-regulation curve (right shift) and as a result be less tolerant to low blood pressure

Higher targeted MAP during hypotensive episodes have been advocated in this group

Issues (cons)

Aiming for higher MAPs is likely to result in more aggressive management

> Increased invasive procedures (with associated issues of secondary infection, bleeding, perforation)
  - Arterial lines
  - Venous lines; IVC, CVC and pulmonary catheters

> Use of fluid resuscitation
  - Increased risk of pulmonary oedema, tissue oedema
  - Metabolic derangement due to sodium and chloride loads

> Use of vasoactive drugs
  - Increased risk of arrhythmias
  - Potential for increased SVR and BP but decreased tissue perfusion in specific vascular beds

Higher MAP targets are likely to result in increased costs

> Monitoring, medications, during of intubation, length of ICU stay

Evidence

The best quality evidence comes from the SEPSISPAM investigators from France (NEJM 2014)

> Parallel superiority RCT with stratification for hypertension on MAP targets in shock (65-70 v 80-85mmHg)

> Hypertensive subgroup demonstrated
  - No difference in primary outcome (28 day mortality)
  - Increased rate of renal replacement therapy (p=0.04) and increase in baseline creatinine in lower MAP threshold
  - Increased rate of AF in the higher MAP threshold group (3% versus 7%)

My practice

I would carefully evaluate the patients cardiac, neurological and renal status however my preference would attempt to target a MAP of >80mmHg in this patient to reduce his risk of renal injury. I would constantly reappraise the patient.

Haematology

Haematology cheat sheet

Interpretation of Abnormal Iron Studies

Condition	MCV	MCHC	Serum iron	Ferritin	Transferrin	Transferrin Saturations	TIBC
Iron deficiency anaemia	low	low	low	low	high	<20%	high
Anaemia of chronic disease	low	low	low	normal	low	normal	low/ norm
Acute phase response	normal	normal	low	high	low	normal	low
Iron overload	normal	normal	high	high	normal	high	high

Body iron content

3.7 grams of iron. 2.5g in haemoglobin, 1g in ferritin, 0.1g in myoglobin and the rest in protiens

Ferritin

> The gold standard for the assessment of iron stores as the small amount in plasma is proportional to total amount
> It consists of about 20% iron.
> It is found in all cells, but especially in hepatocytes and reticuloendothelial cells.
> Hepatic synthesis of ferritin is stimulated by increased iron, and depressed by decreased iron. It is therefore a good marker of iron overload.
> There is no clinical situation other than iron deficiency in which extremely low values of serum ferritin are seen.
> Very high ferritin is seen in numerous conditions, esp haemophagocytic syndrome, pregnancy and inflammation
> Ferritin level discriminates between iron deficiency anaemia (low ferritin) and anaemia of chronic disease (high or normal ferritin)

Serum iron

> This test measures all serum iron: both the small amount of soluble ionised ferric iron (Fe3+) and the transferrin-associated ferric ion.
> A patient's serum iron values may vary 10-40% within a single day
> There is a predictable diurnal variation
> Serum iron is decreased in genuine iron deficiency
> Serum iron is increased in haemolysis, iron overdose, lead toxicity, hepatic necrosis, and haemochromatosis

Transferrin

> Transferrin is the binding protein which carries iron from the liver into the bone marrow.
> It is also a part of the innate immune system, and transferrin molecules are seen in mucosa, where they bind free elemental iron, reducing its availability to invading microorganisms.
> Transferrin decreases in inflammatory states.
> Its level can also diminish in liver disease, nephrotic syndrome, and due to malnutrition.
> A raised transferrin may be a reaction to an iron deficiency state.

Transferrin saturation

> Each molecule is able to carry 2 atoms of iron and 20-45% saturation is normal
> Transferrin saturation less than 20% usually means there is too little iron (i.e. an iron deficiency state).
> A high (>45%) transferrin saturation suggests there may be an iron overload state such as haemochromatosis (or, that a patient has recently had an iron infusion).

Total iron-binding capacity (TIBC) and unsaturated iron-binding capacity (UIBC)

UIBC is the amount of "free" transferrin, unassociated with iron.

TIBC is the sum of serum iron and UIBC

The TIBC is therefore a surrogate for a transferrin level and these two laboratory tests can be used interchangeably (usually the lab will only report one or the other).

UIBC represents the capacity to bind "extra" iron; a raised UIBC is associated with iron deficiency anaemia (and a low UIBC represents a state of iron overload, as all the transferrin molecules are saturated)

Blood films characteristic findings

Red blood cell morphology

Shape

- Large oval shaped RBCs suggest a megaloblastic process (B12 or folate deficiency)
- Fragmented RBCs (or schistocytes) suggest mechanical destruction - prosthetic valve, TTP/MAHA or DIC
- Teardrops are found in patients with extramedullary hematopoiesis (myleofibrosis) and thalassaemia
- Bite like deformity due to phagocytes eating RBCs with denatured haemoglobin (Heinz bodies). Increased risk of oxidative sensitivity and haemolytic anaemia as seen in G6PD deficiency
- Sickle cells
- Target cells have an extra drop of Hb, and suggest liver disease, post splenectomy and thalassaemia
- Spiculated RBCs (burr cells) due to uraemia, spurs cells are due to liver disease

Colour

- Blueish tinge is seen in reticulocytes (increased RNA)
- Pale RBCs in thalassaemia and iron deficiency
- Hyperchromia in dark spherocytes due to hereditary spherocytosis or autoimmune haemolytic anaemia

Size

- Small - iron deficiency, thalassaemia, sideroblastic anaemia, anaemia of chronic disease
- Large - increased reticulocyte count, B12 and folate deficiency, liver disease and primary bone marrow failure

Inclusions

- Nucleated blood cells - are immature RBCs suggesting a haemolytic crisis, stress or hypoxaemia (rushed release)
- Howell Jolly bodies - are bits of RBCs usually removed by the spleen - and are seen therefore post splenectomy
- Heinz bodies - denatured haemoglobin common in G6PD deficiency
- Basophilic staining - thalassaemia, alchohol abuse and heavy metal poisoning
- Pappenheimer bodies - sideroblastic anaemia

White blood cells

Lymphocytes

- Atypical lymphocytes - following viral infections such as infectious mononucleosis
- Lymphocytosis - post Bordatella pertussis
- Smudge cells are squashed lymphocytes seen in CLL

Neutrophils

- Maturation process is from myeloblast - promyelocyte - myelocyte - metamyelocyte - band form - mature neutrophil
- Band form and mature neutrophil are normally present in the smear and an increased number suggests infection
- Metamyelocytes and myelocytes suggest haematolic malignancy although pregnancy, infection, leukemoid rxns
- Dohle bodies in neutrophils suggest infection but have also been seen in pregnancy, burns and myelodysplasia

Plasma cells, rouleux formation and nucleated RBCS

2013/1 With respect to the peripheral blood film of an adult: List four conditions in which plasma cells may appear. List four conditions in which nucleated red blood cells may appear. Explain the significance of rouleaux formation.

Plasma cells

> Are a subset of b-cells which are activated in lymph nodes and then migrate to the bone marrow. Identifying plasma cells on a peripheral blood smear is generally representative of pathology.

> Causes of plasma cells on a peripheral smear include

- Multiple myeloma (most common)
- B-Cell lymphoma
- Plasmacytoma
- MGUS

Nucleated red blood cells

> if NRBCs are seen on an adult's peripheral blood smear, it suggests that there is a very high demand for the bone marrow to produce RBCs, and immature RBCs are being released into circulation

> Causes include

- Compensatory erythropoeisis with anaemia
- Hypoxia
- Hyposplenism
- Marrow replacement/ invasion
- Extramedullary haematopoeisis
- Other – uraemia, sepsis, liver disease, renal transplant, thermal injury, chemotherapy.

Rouleux formations

> Rouleaux are stacked/clumped groups of red cells caused by the presence of high levels of circulating acute-phase proteins which increase red cell 'stickiness'.

> They are often an indicator that a patient has a high ESR

> Causes include

- Infections, autoimmune conditions, chronic inflammation, paraproteinaemia and myeloma

Blood products

2013/1

Blood Product Crossmatch

- Packed red blood cells Yes
- Granulocyte concentrate Yes
- Platelets No
  - ABO matching has been found to improve the increment achieved
  - HLA matching may be required in patient with refractory platelet response (increment less than 10)
- Fresh Frozen Plasma No
- Cryoprecipitate No
- Prothrombin concentrate No
- Intravenous immunoglobulin No

The PROPPR trial

- Parallel group RCT looking at almost 700 severe trauma patients requiring MTP
- Intervention was RBC:FFP:Platelet ratios of 1:1:1 versus 1:1:2
- No difference in 24 hour mortality (primary outcome)
- Improved haemostasis and less death from exsanguination in the 1:1:1 group

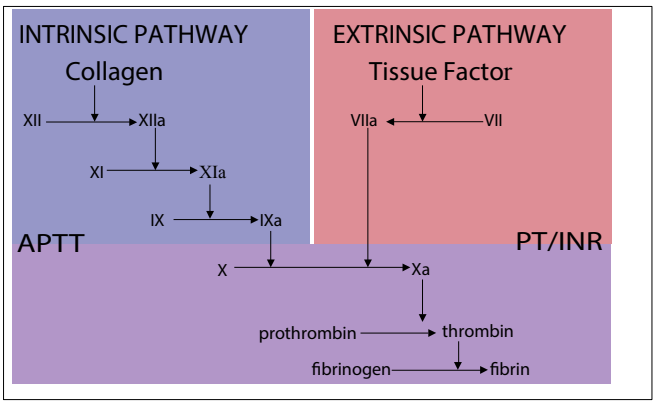
Red blood cell storage lesion

- The storage lesion refers to the changes that occur to red blood cells (RBCs) during storage
- Storage lesions include;
  - Depletion of ATP
  - Decreased RBC deformability
  - Depletion of 2.3 DPG
  - Haemolysis
  - Reduced NO availablity affecting microvascular tissue perfusion
  - Accumulation of inflammatory and immunomodulatory byproducts
- Evidence
  - TRANSFUSE is still recruiting
  - ABLE and RECESS trials were published in NEJM in April 2015
    - Both were parallel group RCT ~1100 patients in each
    - ABLE - critically ill adults, RECESS - cardiac surgery
    - No difference in any of the primary or secondary outcomes

Coagulation cascade

Traditional

The coagulation cascade is traditionally conceived in terms of the intrinsic and extrinsic pathways. Whilst this is a useful method for describing what happen in vitro (and therefore clotting tests such as APTT and the PT/INR) it does not adequately describe what happens in vivo. A unified method of describing the coagulation process is in three major phases; initiation, amplification and propogation.

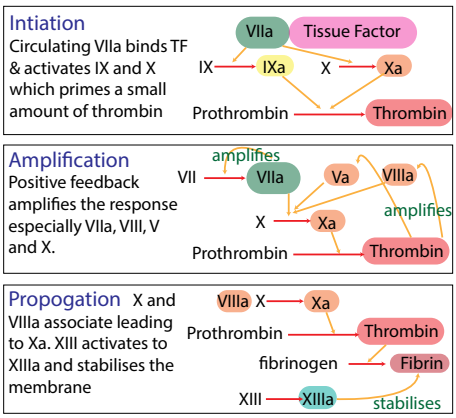


Unified theory

Initiation: clotting is initiated through a sequence of events broadly analogous to the extrinsic pathway. Tissue factor, which is not found in the circulation but is found in the subendothelium and other surfaces reacts with circulating coagulation protiens, in particular VII, which is activated to VIIa and then activates small quantities of X and IX to Xa and IXa respectively. These basically 'prime' as small amount of prothrombin (II) to thrombin (IIa). The thrombin activates platelets and encourages coagulation factor attachment.

Amplification: Is characterised by positive feedback mechanisms which ramp up the process, in particular by increasing VIIa production, by activating VIII and V to increase prothombin activation to thrombin, and enhancement of Xa and IXa production.

Propogation: During propogation large amounts of X associate with VIIIa on the surface of platelets, activating X to Xa and further increasing thrombin formation and therefore fibrin formation. Stabilisation of the the fibrin clot then occurs via activation of XIII to XIIIa which crosslinks the fibrin monomers into a stable fibrin matrix.



Transfusion thresholds in critical care

Created Question Critically evaluate low versus high blood transfusion thresholds in the critically ill patient

Statement

There is a paucity of evidence to support transfusion thresholds of greater than 70g/L however there may be some specific patients where higher thresholds are reasonable although this is not based on robust clinical trials.

Rationale

> The delivery of oxygen to end organs is one of the fundamental goals of critical care medicine.
> The formula for O2 delivery is Hb(Saturation)1.36 x Cardiac Output
> It has therefore can be argued that increasing Hb will improve O2 delivery (assuming unchanged temp, CO2, 2,3 DPG, pH)
> Hb transfusions however are usually allogenic and therefore represent a transplant and therefore have associated risk

Evidence

The Titre2 investigators

> Hb threshold 75g/L versus 90g/L
> Used a composite outcome measure and showed no difference
> Demonstrated a mortality benefit however in liberal transfusion (2%) versus restrictive (4%) ? multiple comparisons

The TRICC trial remains one of the most influential in this area

> Hb thresholds were 70g/L versus 100g/L
> The trial used non leucodepleted blood
> 840 general ICU patients expected to be admitted for greater than 24 hours and not actively bleeding
> The 30 day mortality was 18% on the lower threshold group and 23% in the higher group which was significant

The FOCUS trial (elderly pts with CVS disease)

> Hb threshold was 100g/L versus 80g/L
> 2100 high risk geriatric patients were enrolled
> The 60 day mortality was not significantly different 7.6 (low) versus 6.6 (high)\

The TRISS trial was published in a Scandinavian population and looked at transfusion thresholds in sepsis

> 1000 patients with septic shock
> Hb threshold was 70g/L versus 90g/L
> Actually was powered to identify an increase in mortality associated with the intervention (power from TRICC results)
> Used leucodepleted blood
> Demonstrated that there was no difference in 90 day mortality 43% (low) versus 45% (high)

The TITRE study was published in NEJM 2015 and looked at post cardiac surgery transfusion thresholds, comparing 75g/L versus 90 g/L.

> It did not show a difference in primary outcome which was a composite of major infection, infarction (brain, gut and heart) or AKI.
> Interestingly it did show a reduction in mortaolity in the 90 g/L group although the relative risk reduction seems unrealistic (2.6% versus 4.2% all cause mortality)

My practice

I would act within local institutional guidelines however my instinct would be to target a lower Hb threshold of 70g/L in most patients with the exception of perioperative patients and those with ongoing bleeding. There is some very limited evidence to suggest that higher thresholds in aneurysmal SAH may reduce the risk of delayed cerebral ischaemia and in this instance I would accept a higher threshold of 80-90g/L

Massive transfusion

Definition

- Massive transfusion (eg. replacement of more than 50% of blood volume in 12 to 24 hours, or one circulation blood volume in 24 hrs [T Oh]) is associated with many potential problems which are related to a number of factors including the volume of resuscitation, factors related to the storage blood, and many other related issues. Problems include:

Complications

- TACO - Volume overload (careful monitoring of filling pressure, response to volume, diuresis)
- Over-transfusion (monitor Hb regularly, titrate according to needs)
- Hypothermia (use of fluid warmers and general measures to minimise heat loss)
- Dilutional coagulopathy of both clotting factors and platelets (regular and early monitoring of coagulation, and involvement of haematology for replacement therapy [better than according to protocol])
- TRALI Transfusion related lung injury (consider use of filters, leukodepletion)
- Excessive citrate causing metabolic alkalosis and hypocalcemia (monitor pH and ionised calcium, replace calcium as necessary)
- Hyperkalaemia (use of "younger" blood, monitor regularly, may require specific therapy)
- Disease transmission (use of products on as needed basis only, standard blood banking precautions)
- Distractions resulting in not controlling source of haemorrhage, and risks of hurried cross-checking and incompatibility (allocation of sufficient resources and personnel, standard programs in place to facilitate process and anticipate needs)
- Other problems include loss of identity (cross matching issues, loss of baseline haematological information etc.)

Transfusion associated cardiac overload and lung injury

TACO

- Transfusion associated circulatory is characterised by dyspnea, orthopnea, tachycardia and a wide pulse pressure, often with hypertension and hypoxemia, all the way through to seizures.
- It may begin near the end of the transfusion, or within six hours
- Risk factors are pre-existing impaired cardiac function, the extremes of age, the volume and rate of transfusion
- Many characteristics overlap however TACO is differentiated from TRALI by the presence of
  - An increased BNP
  - Increased right sided pressures (CVP, PA and wedge)
- Management
  - Standard acute heart failure management is employed; diuretics, sit up, CPAP and oxygen

TRALI

- Defnition is
  - Acute onset (during or within six hours of transfusion)
  - Hypoxemia (P:F <300)
  - Bilateral infiltrates on frontal chest radiograph
  - No evidence of circulatory overload/left atrial hypertension
  - No pre-existing ALI/ARDS before transfusion
- Mechanism
  - Neutrophils are sequestered in the pulmonary vasculature
  - Neutrophils are then activated causing an acute inflammatory response
- Risk factors include
  - Liver transplantation surgery
  - Chronic alcohol abuse
  - Shock
  - Higher peak airway pressure while being mechanically ventilated
  - Current smoking
  - Higher interleukin (IL)-8 levels
  - Positive fluid balance
- In contrast to TACO
  - More likely to have fever
  - Hypotension
  - Pulmonary exudates
- As this is a subset of ARDS the management is similar
  - Stop transfusion
  - Low tidal volumes
  - Permissive hypercapnoea and lower range oxygenation (paO2>60mmHg)
  - Mixed evidence on steroids, no evidence of statins
  - Haemodynamic support with pressors
  - Diuresis not unreasonable but may be limited utlity
  - Anti-biotics if secondary infection

Blood conservation strategies in ICU

Created Question Describe how you will implement a blood conservation strategy in your ICU

Process analysis to establish a baseline, identify specific issues and look for solutions

Equipment
Availability of blood conserving devices, peadiatric blood tubes, haemostatic devices

Resources
Funding for implementation
Staffing requirements
Medication availability

Benchmark
Retrospective analysis of blood use
Point prevalence of blood use
? Prospective data collection

Existing guidelines
Find current guidelines
Indentification of possible substitutes (Jehovah Witness policies)

Assess current practice and attitudes
Nursing practices
JMO and registrar understanding
Consultant opinions

Non ICU Involvement
Engage haemoatology, anaesthetics, surgery and emergency to find joint solutions

Blood conservation options various strategies that may be implemented

Achieve Haemostasis
Identify bleeding early
Point of bleeding control; compression, surgery
Use of TEG/ROTEM technology
Employ use of haemostatic agents
- Tranexamic acid
- Desmopressin
- Blood products - FFP, Cryo, Factors,Plts

Reduce blood testing
Identify unneccesary testing
Use ETCO2/SaO2 to decrease freq of ABG
Employ paediatric tubes
Use point of care testing rather than lab (smaller samples)
Remove arterial/CVC lines - (increases likelihood of testing by up to x3)

Improve erythropoesis
Baseline iron studies in patients with significant anaemia
Iron replacement when appropriate
Erythropetin if indicated
Optimise nutrition
Avoid bone marrow suppresion if possible

Restrictive transfusion thresholds
Multiple large RCTs have now demonstrated that restrictive transfusion policies do not worsen outcome (TRISS, FOCUS) and may decrease adverse events (TRICC).
Ensure strict transfusion policies are employed

Blood return options
Closed loop arterial line systems to return blood during blood sampling
Cell saver technologies in surgical patients with large blood loss (issues with lysis/fibrinogen depletion noted)

Implementation process executing the strategy in ICU

Equipment
Provide adequate paediatric tubes, closed loop systems, consider TEG/ROTEM

Resources
Assign CNC/CNS/Registrars to implement the guidelines
Provide funding for medications

Re-evaluation
Reassess blood usage after implementation via benchmarking
Identify shortfalls and barriers then correct these

Guideline development
Establish clear guidelines based on the best available evidence and display prominently

Changing practice
Education days for RN/Regs and SS
Advertise guideline within the unit
Incentivise blood conservation

Promotion
Find methods of involving other relevant specialities
Consider publication in scientific journals

Anaemia in the critically ill

Dilution of RBC concentration

- dilutuonal anaemia with fluid replacement
- Artifactual anaemia due to sampling of a vessel with diluted content (i.e. the vein that has the fluids running through it).

Increased loss of RBCs

> Extravascular loss
- Bleeding:
  - Traumatic blood loss
  - Upper or lower GI blood loss, eg. gastric erosion/ulceration
  - Iatrogenic loss through samling and surgery

> Intravascular loss
- Intravascular haemolysis, eg. autoimmune hemolytic anaemia
- DIC
- Mechanical haemolysis, eg. due to extravascular perfusion circuits, dialysis filters, or mechanical heart valves
- Appropriate reticuloendothelial sequestration of abnormal haemoglobin
- Thalassaemias
  - Methaemoglobinaemia
  - Sickle cell anaemia

Decreased production of RBCs

- Decreased hematinics
- B12/folate deficiency
- Drugs which interfere with B12/folate metabolism
- Iron deficiency
- Decreased proliferation signals
- Decreased EPO in renal failure
- Anaemia of chronic inflammatory states

Investigation

- History of fluid resusictation or trauma
- Resampling to confirm the diagnosis
- Imaging to look for obvious blood loss
- Faecal occult blood test and/or endoscopy to exclude GI blood loss
- Direct Coombs test, formal blood film, conjugated/unconjugated bilirubin, LDH, haptoglobin and reticulocyte count to investigate haemolysis
- RBC folate and B12 levels
- Iron studies
- Coagulation screen (looking for DIC and MAHA)
- Renal function tests and/or EPO levels

Thrombocytopaenia

2015/2

Causes of thrombocytopenia:

Pseudothrombocytopenia

> The sample was improperly anticoagulated, and there is platelet clumping on the blood film.
  - Send a citrated tube instead- often EDTA is to blame

> Abciximab can cause this, as it is an antibody to the GP IIb/IIIa receptor

Dilution of platelets

> Massive transfusion

> Massive fluid resuscitation

Decreased platelet production

> Bone marrow suppression
  - Viral infection, eg. HIV, EBV, Hep C, parvovirus, mumps, rubella, varicella...
  - Neoplasm, eg. leukaemia or lymphoma
  - Myelofibrosis or aplastic anaemia
  - Congential causes, eg. Fanconi anaemia
  - Chemotherapy
  - Alcohol toxicity

> Nutritional deficiency
  - B12 and folate deficiency

Increased platelet destruction

> SLE

> ITP

> DIC

> Drugs:
  - Quinine
  - Heparin
  - Valproate

> Post-transfusion thrombocytopenia

> Microangiopathic haemolytic anaemia

> Thrombotic thrombocytopenic purpura-hemolytic uremic syndrome (TTP-HUS)

> Antiphospholipid syndrome

> HELLP syndrome in pregnancy

> Physical destruction in the cardiopulmonary bypass apparatus

Sequestration

> Hypersplenism
  -

Anticoagulants

May 2015 Q4 (77%) The following list refers to classes of oral anticoagulation regimens for use in chronic atrial fibrillation,

> i. Antiplatelet agents
> ii. Vitamin K antagonists
> iii. Antithrombin agents
> iv. Anti Xa agents

Antiplatelet agents	Vitamin K antagonists	Antithombin agents	Anti Xa agents

a) Give an example of a drug for each class of drug listed. (10% marks)

Aspirin Clopidogrel Ticagrelor	Warfarin	Dabigatran	Rivaroxaban

b) Compare and contrast these regimens specifically with respect to: (90% marks) (%)

> The relative advantages

Simple option No monitoring required. Useful in patients post stenting.	Well understood drug Reversible Easily measured	Improved outcomes compared to warfarin No monitoring required Reversible (soon)	Simpler dosing regime Improved outcomes compared to warfarin No monitoring required

> and disadvantages

Not recommended as single agent Worse outcomes when compared to warfarin	Unpredictable, many influences on effectiveness Requires frequent testing Initially causes increased risk of thrombosis	Less well understood BD Dosing	Less well understood No simple reversal option

> The appropriate laboratory tests to assess coagulation status

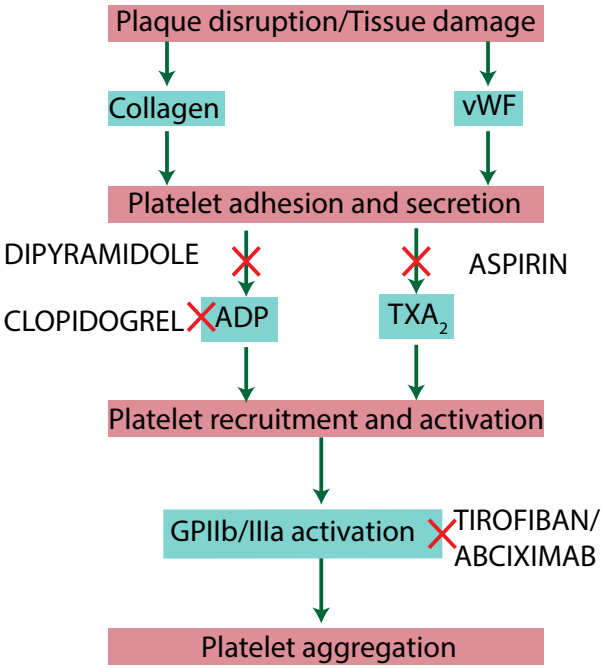
Plt count (nb does not distingiush dysfunctional plts) TEG/ROTEM (max amplitude) Bleeding time	INR/PT	Haemoclot thrombin inhibitor (gold standard) INR/APTT (unreliable) TEG/ROTEM (prolonged R)	Anti Xa levels INR/APTT (interpatient variability)

> Management of life-threatening bleeding

Platelet transfusion	Vitamin K Prothrombinex FFP	Idarucizumab when available Consider dialysis	Prothrombinex at 50 units/kg

Antiplatelet drugs

Drug	Chemical properties	Mechanism	Clearance	Half-life	Duration of effect
Aspirin	Salycilate; Weak acid	Irreversible COX-1 inhibition, thus decreased production of the prothrombotic thromboxane A2	Renal	1-2 hrs	7-10 days
Clopidogrel	Thienopyridine	Irreversible inhibition of P2Y12 ADP receptor, thus inhibition of cAMP-dependent platelet activation	50% renal, 50% biliary	0.5-1 hrs	7-10 days
Prasugrel	Thienopyridine	Irreversible inhibition of P2Y12 ADP receptor, thus inhibition of cAMP-dependent platelet activation	Renal	7 hrs	7-10 days
Ticagrelor	Nucleoside (adenosine) analogue	Reversible inhibition of P2Y12 ADP receptor, thus inhibition of cAMP-dependent platelet activation	Biliary	7-8 hrs	3-5 days
Abciximab	Fab fragment of a human monoclonal antibody	Glycoprotein IIb/IIIa inhibition, thus inhibition of platelet binding to fibrinogen and von Willebrand factor.	Reticulo-endothelial system	0.5 hr	18-24 hours
Tirofiban	Small molecule non-peptide	Glycoprotein IIb/IIIa inhibition, thus inhibition of platelet binding to fibrinogen and von Willebrand factor.	Renal	2 hrs	4-8 hours



New generation anticoagulants

Created Question Discuss the pharmacokinetics and pharmacodynamics of prasugrel, dabigatran and rivaroxaban

Prasugrel

Summary is a platelet aggregation inhibitor which is currently approved in Australia for prevention of thrombotic events in the setting of acute coronary syndrome.

Pharmaceutical is presented as yellow tablets 5-10mg

Pharmacodynamics Prasugrel is a prodrug that is metabolized to both active and inactive metabolites. The active metabolite irreversibly blocks the P2Y12 component of ADP receptors on the platelet, which prevents activation of the GPIIb/IIIa receptor complex, thereby reducing platelet activation and aggregation. Inhibition of platelet aggregation (IPA): Dose dependent: 60 mg loading dose: <30 minutes

Pharmacokinetics

Absorption Rapid; ≥79%

Distribution Active metabolite: Vd: 44-68 L

Metabolism Rapid intestinal and serum metabolism via esterase-mediated hydrolysis to a thiolactone intermediate (inactive), which is then converted, via CYP450-mediated (primarily CYP3A4 and CYP2B6) oxidation, to an active metabolite

Platelet aggregation gradually returns to baseline values over 5-9 days after discontinuation; reflective of new platelet production

Elimination Urine (~68% inactive metabolites); feces (27% inactive metabolites)

Dabigatran

Summary Is a direct thrombin inhibitor approved in Australia for prevention of DVT/PE following hip replacement and prevention of stroke in patients with non valvular AF.

Pharmaceutical is presented as a blue and white capsule 75-150mg.

Pharmacodynamics Dabigatran is a prodrug lacking anticoagulant activity that is converted in vivo to the active dabigatran, a specific, reversible, direct thrombin inhibitor that inhibits both free and fibrin-bound thrombin. It inhibits coagulation by preventing thrombin-mediated effects, including cleavage of fibrinogen to fibrin monomers, activation of factors V, VIII, XI, and XIII, and inhibition of thrombin-induced platelet aggregation.

Pharmacokinetics

Absorption rapidly absorbed but with a poor bioavailability of 3-5%

Distribution the volume of distrubution is approximately 50-70L. Minimal protien binding

Metabolism Hepatic; dabigatran etexilate is rapidly and completely hydrolyzed to dabigatran (active form) by plasma and hepatic esterases; dabigatran undergoes hepatic glucuronidation to active acylglucuronide isomers.

Half life is 12-17 hours

Elimination More than 80% is excreted in the urine

Rivaroxaban

Summary is a factor Xa inhibitor that is approved in Australia for DVT/PE prevention post hip or knee replacement, and in the setting of recurrent DVT/PE. It is also approved for the prevention of stroke in patients with non valvular AF.

Pharmaceutical is presented as light red tablets 10-20mg.

Pharmacodynamics Inhibits platelet activation and fibrin clot formation via direct, selective and reversible inhibition of factor Xa (FXa) in both the intrinsic and extrinsic coagulation pathways. FXa, as part of the prothrombinase complex consisting also of factor Va, calcium ions, factor II and phospholipid, catalyzes the conversion of prothrombin to thrombin. Thrombin both activates platelets and catalyzes the conversion of fibrinogen to fibrin.

Pharmacokinetics

Absorption rapidly absorbed with a bioavailability of 80-100%

Distribution the volume of distrubution at steady state is approximately 50L. Highly protien bound

Metabolism via CYP3A4, CYP2J2 and CYP-independent mechanisms

half life of approximately 5-10hrs

Elimination 2/3 undergoes metabolic degradation, with half then being eliminated renally and the other half eliminated by the faecal route. The final 1/3 of the administered dose undergoes direct renal excretion as unchanged active substance in the urine, mainly via active renal secretion

Monitoring, TEGs and reversal of three anticoagulants

Created Question Compare the optimal monitoring of anticoagulants dabigatran, rivaroxaban, LMWH and heparin, their effect on standard tests such as APTT, PT/INR and TEG as well and the methods of reversal in severe acute bleeding.

Heparin and LMWH

Summary Unfractionated heparin binds to antithrombin, a naturally occuring anticoagulant which neutralises most of the enzymes in the clotting cascade, including thrombin and Xa. When bound heparin induces a conformational change that accelerates the rate at which antithrombin inactivates clotting factors. LMWH have less thrombin activity because they are too short to bind to both antithrombin and thrombin therefore they act primarily on Xa.

Monitoring Heparin is associated with a dose dependent increase in aPTT and this is considered the standard method of monitoring. Anti Xa levels are used to measure LMWH activity.

Thrombelastograph (TEG)will be chacterised by a prolonged R (time to clot initiation), K (speed of clot formation), α (the slope of the R-K curve) and MA (clot strength).

Reversal/Antidote Heparin is reversed with protamine and the maximum dosage is usually 1mg per 100 units of heparin given as a slow bolus if the heparin was given IV or as an infusion if the heparin was subcut. Although not as effective protamine is also advocated for use in LMWH overdosage and severe bleeding.

Dabigatran

Summary Is a direct thrombin inhibitor and as the name suggests binds directly to thrombin. Unlike heparin which must be bound to both antithrombin and thrombin (making it unable to neutralise already bound thrombin) dabigatran is able to inhibit both soluble thrombin and clot-bound thrombin.

Monitoring Dabigatran causes an increase in both PT/INR, TT and aPTT however this is non-linear and importantly the increase in aPTT will plateau meaning that supratherapeutic concentrations may not be recognised. A normal aPTT however provides reasonable confidence that dabigatran is not causing a major anticoagulant effect. Hemoclot thrombin inhibitor (a diluted TT) is now the accepted standard for monitoring and has good reproducibility, linear dose response and high sensitivity.

Thrombelastograph (TEG)will be chacterised by a prolonged R (time to clot initiation), K (speed of clot formation), α (the slope of the R-K curve) and MA (clot strength).

Reversal/Antidote Prothrombinex or Factor VIIa is an option. Praxbind is currently being licenced by BD. As there is only approximately 35% of the drug plasma bound however it is a reasonable candidate for dialysis.

Rivaroxaban

Summary is a factor Xa inhibitor that like the direct thrombin inhibitors has the advantage of acting both on soluble Xa and clot bound Xa. Factor Xa catalyses the conversion of of prothrombin to thrombin.

Monitoring Rivaroxaban causes prolongation of PT/INR and aPTT which occurs in a dose dependent fashion in individual subjects however there is significant inter-assay variability. Anti-factor Xa levels are generally reliable however and are available at most major teaching hospitals in Australia.

Thrombelastograph (TEG)will be chacterised by a prolonged R (time to clot initiation), K (speed of clot formation), α (the slope of the R-K curve) and MA (clot strength).

Reversal/Antidote Prothrombinex at a dose of 50 IU/kg has been shown to normalise PT in healthy volunteers given a therapeutic dose of rivaroxaban and this treatment is a reasonable option in severe bleeding. Rivaroxaban is not a candidate for dialysis due to its high protien binding.

Heparin resistance and antithrombin deficiency

2014/2 A 44-year-old male presents with dyspnoea and is diagnosed as having multiple pulmonary emboli on a computerised tomography pulmonary angiogram (CTPA). He is commenced on 1000 units of heparin per hour IVI after a 5000 unit intravenous bolus. During the night his heparin infusion has steadily increased to 1500 units per hour. His APTT remains <40 and other indices of coagulation are normal.

a) Give two reasons for the relatively low APTT despite heparin therapy.

b) List four causes for an increased predisposition to venous thromboembolic disease.

Definition

> The phenomenon of heparin resistance refers to a requirement for unusually large doses of heparin in order to achieve an aPTT in the therapeutic range (eg, >35,000 units of heparin per 24 hours, excluding initial bolus doses)

> This may occur in up to a quarter of patients based on case series evidence

Causes of heparin resistance

> A reduction in Anti-thrombin III levels (<60%) is the most common cause of low aPTT despite adequate treatment
  - Using anti Xa levels will result in a reduced heparin dose but similar DVT prophylaxis

> Increased heparin binding protiens

> Increased fibrinogen and factor VIII

> High heparin clearance by the liver

Antithombin deficiency

> AT inhibits thrombin (factor IIa), factor Xa, and other serine proteases in the coagulation cascade such as factor IXa

> Inherited deficiency
  - Is a rare autosomal dominant condition present in 1-2 per 1000

> Acquired deficiency
  - Production is reduced in liver disease
  - Consumption is increased in DIC, MAHA, trauma and surgery (especially bypass)
  - Loss may be increased in nephrotic syndromes
  - Heparin causes a measurement artefact resulting in an inaccurate low reading

Management of AT deficiency

> Use anti-Xa levels to measure heparin action

> Change to low molecular heparin, instead of unfractionated heparin

> Give cryoprecipitate and/or fresh frozen plasma (if there is confirmed ATIII deficiency)

> Give antithrombin III concentrate

>

TTP-HUS

2013/1 With respect to thrombotic thrombocytopaenic purpura (TTP): List the classical clinical features of TTP. Describe the underlying pathophysiological process. Plasma exchange has been used to treat TTP and Guillain Barre syndrome. Outline the important differences between the plasma exchange treatment regimens used for each condition. Explain the difference between plasmafiltration and plasmapheresis. Steroids and rituximab are two drug therapies commonly recommended as adjunctive therapy in TTP. Outline the mechanism of action for each in treating TTP Anaemia

Clinical features of TTP

> Thrombocytopenia
> Microangiopathic haemolytic anaemia
> Schistocytosis
> Neuorological symptoms
> Fever and renal failure are actually uncommon

Underlying pathological process

> Trigger causes endothelial activation
> ADAMT 13 levels (which cleaves vWF) are low
> vWF accumulates and causes microvascular thrombosis and haemolysis

Difference in plasma exchange for TTP and Guillain Barre Syndrome

> In TTP
  - Treatment continues until remission
  - The treatment is more frequent (1.5 volumes processed daily)
  - Replacement is sometimes with cyrodepleted plasma or FFP
> In GBS
  - Treatment is for five treatments total
  - Treatment is less frequent (1.5 volumes second daily)
  - Replacement is with 4% albumin usually

Plasmafiltration versus plasmapheresis

> As the name suggests PF is similar to CVHF - blood is pushed through a filter and the plasma is removed and replaced with colloid
> In PP the blood is centrofuged and the plasma is then removed from the cells and replaced with colloid

Mechanism of steroids versus rituximab

> Steroids
  - Act on intracellular receptors and modify gene transcription resulting in a suppressed immune response
> Rituxamab
  - Acts on the B20 surface protien of B-Cells causing apotosis and reducing the immune response

Tumour Lysis Syndrome

2014/2 a) Define tumour lysis syndrome (TLS). b) List the risk factors associated with the development of TLS.c) List the strategies used for the prevention and/or treatment of TLS and provide a rationale for the use of each strategy.

Definition

> The tumor lysis syndrome occurs when tumor cells release their contents into the bloodstream, either spontaneously or in response to therapy

> When cancer cells lyse, they release potassium, phosphorus, and nucleic acids, which are metabolized into hypoxanthine, then xanthine, and finally uric acid, an end product in humans

> Laboratory tumor lysis syndrome requires that two or more of the following metabolic abnormalities occur within 3 days before or up to 7 days after the initiation of therapy: hyperuricemia, hyperkalemia, hyperphosphatemia, and hypocalcemia.

> Clinical tumor lysis syndrome is present when laboratory tumor lysis syndrome is accompanied by an increased creatinine level, seizures, cardiac dysrhythmia, or death.

Risk Factors

> Tumour-related factors:
  - High tumour cell proliferation rate or large tumour burden
  - Chemo sensitivity of the malignancy
  - Transformation to acute leukemia

> Patient factors:
  - Pre-treatment hyperuricemia or hyperphosphatemia
  - A pre-existing reduction in renal function
  - Volume depletion
  - Surgery/Stress
  - Steroid treatment

Management

> Preventative measures:
  - Adequate hydration - reduce uric acid precipitation in the tubules
  - Electrolyte monitoring - manage high K, PO4
  - Allopurinol - reduce xanthine converting to uric acid
  - Rasburicase - converts uric acid to allotonin which is more soluble than uric acid
  - Alkalinisation of urine - uncommon - used to reduce uric acid preciptiation

> Management strategies:
  - Rasburicase
  - Forced diuresis
  - Electrolyte correction
  - Hemodialysis

Gastro and Nutrition

Acute Liver Failure

Created Question List the causes and clinical manifestations of acute hepatic failure?

Acute Liver Failure Acute liver failure refers to the development of severe acute liver injury with encephalopathy and impaired synthetic function (INR of ≥1.5) in a patient without cirrhosis or preexisting liver disease (<26 weeks).

Causes

- Drug causes
  - Paracetamol (dose related) accounts for up to 50% of acute liver failure in developed countries
  - Other drugs (idiosyncratic)
    - anti-infectives, anticonvulsants and anti-inflammatories are the most commonly implicated
    - New generation monoclonal antibody drugs are an emerging cause
- Infectious causes
  - Hepatitis A, B and E are the most common causes of ALF in less developed countries
  - Hepatitis C is an uncommon cause, Hepatitis D may cause ALF in association with Hep B
  - Rarely EBV, Herpes viruses, adenovirus and CMV may cause ALF
- Toxins
  - Mushroom poisoning and Chinese herbal medications
  - Alcohol
- Ischaemia - Usually secondary to a low output state in sepsis or heart failure
- Other
  - Neoplastic infiltration, Budd Chiari Syndrome or Wilson's disease

Clinical Manifestations

- Liver
  - Cholestatic manifestations including jaundice, RUQ tenderness, pruritis, nausea and vomiting and anorexia
  - Coagulopathy due to impaired synthesis of factors (and anticoagulants) - bruising, petechaie, bleeding
  - Hypoglycaemia related to impaired gluconeogenesis - lethargy and fatigue
  - Lactate acidosis due to impaired cori cycle and increased respiratory rate
  - Hyperammonaemia due to impaired clearance
- Neurological
  - Hepatic encephalopathy - hepatic flap, hyper-reflexia, clonus, extensor posturing, delerium
  - Cerebral oedema and raised intracranial pressure - papiloedema, false localising CN signs, seizures, coma
- Cardiac
  - High output state - tachycardia
  - Subclinical myocardial injury
- Systemic inflammatory response
  - Hypotension secondary to vasodilation
  - High energy use and development of catabolism/cachexia/ascites and oedema
- Immunological - impaired leucocyte function increasing risk of sepsis
- Respiratory - may be assoc. with ALI through to ARDS but usually later in the course secondary to infection/SIRS
- Renal - may have acute kidney injuries
- Pancreas - may develop pancreatitis
- Adrenal - may have inadequate glucocorticoid production
- Bone marrow - suppression may occur more commonly in pts with viral disease

TIPS, acute and chronic liver scoring systems

2011/1 Q2 Answer the following questions about transjugular intrahepatic portosystemic shunts (TIPS): a) What is a TIPS procedure and why is it used in patients with portal hypertension? b) What are 2 recognised indications for this procedure? c) Excluding mortality list 5 COMMON complications of TIPS procedure d) Describe one classification system used in assessing severity of chronic liver disease and outline its utility.

TIPS Procedure

The hepatic vein is accessed via the internal jugular vein and IVC. A needle is then passed to connect the hepatic vein with the large portal vein near the centre of the liver, the needle tract dilated and a stent inserted to maintain the tract and form the shunt between the higher pressure portal vein and the lower pressure hepatic vein. Reduces portal HTN.

Indications

> Refractory variceal bleeding OR Refractory ascites

5 COMMON complications of TIPS procedure

> thrombosis
> occlusion of the stent
> capsular puncture
> bleeding
> encephalopathy
> stent migration

Classification of chronic liver disease

Childs-Pugh score

> Classified A,B or C by a composite of Total bilirubin, albumin, INR, ascites and hepatic encephalopathy

MELD score severity scoring system (Model for End stage Liver Disease)

> Uses serum bilirubin, creatinine and INR

Classification in acute liver disease

King's College Criteria

> Associated with paracetamol overdose:
  - pH < 7.3 OR
  - All 3 of the following
    - INR > 6.5
    - Creatinine > 300
    - Encephalopathy

> Non paracetamol related:
> INR > 6.5 OR
  - 3 out of 5 of
    - Age <11 or >40
    - Bilirubin > 300
    - Coma development in < 7 days
    - INR >3.5
    - Drug toxicity

Liver transplant patient management

2012/2 Q11 A 42-year-old male is admitted to ICU following a cadaveric orthotopic liver transplant for end-stage liver disease secondary to alcohol-induced cirrhosis. List the important management principles for the first 24 hours specific to this patient.

Airway

> Will return from OT intubated, review CXR for position of ETT

Breathing:

> Aim for paO2 > 70
> Aim for a lower PEEP to ensure that the anastomosis is not stretched.
> Early weaning from invasive ventilation is one of the major goals however hypoxia post extubation is associated with poorer outcomes therefore caution should be employed

Circulation

> Maintain MAP > 70
> Avoid excessive fluid resuscitation as this may increased risk of APO and cause graft congestion
  - Plasmalyte or normal saline (not lactate containing hartmanns)
> Use vasopressors early if required
> Monitor for increased SVR as the body shifts from vasodilated preop to potentially vasoconstricted post op.
> GTN infusion if the patient get high afterload

Neurology and sedation

Remifentanyl and propofol ideally for pain managment and sedation

Gastrointestinal

> Monitoring of the graft consist of several sequential assessments:
  - Hepatic arterial Doppler
  - BSL
  - Lactate
  - Bilirubin
  - INR after 4-5 days
> Typically, 1-9% of liver transplants fail within hours of surgery.
> Surveillance for abdominal compartment syndrome
> Abdominal girth values are required as sequential measurements.

Nutritional support

> NG feeds when surgeons happy

Hematological support

> Optimise coagulation profile, transfuse to Hb > 80, avoid acidosis, aim for normothermia

Immune and ID

> Tacrolimus
> Antibiotics and sepsis surveillance - The Sanford Guide recommends linezolid, ciprofloxacin and fluconazole.

Renal

> Monitor renal function - poorer outcomes are associated with renal impairment

Hepatorenal syndrome, ammonia and BNP

Hepatorenal Sydnrome (HRS)

Diagnostic criteria

> Cirrhosis
> Ascites
> Creatinine level over 150mmol/L
> failure of this to improve after 2 days of fluid replacement
> Absence of other causes of renal failure, such as nephrotoxic drugs or some sort of serious parenchymal renal disease (eg. glomerulonephritis)

Management

> Albumin and fluid resuscitation
> Terlipressin
> Noradrenaline
> Octreotide

2012/2 Q14 Critically evaluate the role of the following investigations in the critically ill patient:

Serum ammonia

> B-type natriuretic peptide (BNP)
> Serum Ammonia
> Used as an indicator of hepatic encephalopathy
> Normal values do not rule out encephalopathy – therefore of limited utility in patients with known chronic liver disease
> Not useful as a monitor during therapy
> Very high levels may indicate cerebral herniation
> May be useful to indicate undiagnosed cirrhosis in patients presenting with altered mental status
> May also be elevated in: TPN, GI Bleed and steroid use, portosytemic shunts and inborn errors of metabolism.

B-type natriuretic peptide (BNP)

> Released from cardiac cells in response to ventricular wall distension
> Elevated in heart failure
> Can be used as a diagnostic marker in patients presenting with dyspnoea to emergency department, and can be useful prognostically and to guide therapy in heart failure
> May be elevated in many other conditions in critical care, including sepsis, acute lung injury, PE and intracranial bleed
> Interpretation of BNP in ICU patients is therefore complex and while it may have a role in prognosis and response to therapy in future its current place is unclear.

Prokinetics

Created question Critically evaluate the use of prokinetics for gastric emptying in Intensive Care patients

Definition

> Prokinetics are agents that increase gastrointestinal motility

Rationale

> Gastroparesis common -> increased gastric residual volumes -> GORD, aspiration risk and inability to meet nutrition targets

> Theoretically, an increase in gastric motility helps in establishing target enteral feeds early in critically ill patients, which improves outcome

Agents

Metoclopramide

> prokinetic and antiemetic

> prokinetic action: antagonism of D2 receptors in gut, and weak agonist at 5HT4 receptors

> actions: increased tone of the lower oesophageal sphincter, accelerated gastric contractions, increased small bowel transit time (increased peristalsis in duodenum and jejunum)

> adverse effects: sedation, dystonic reactions, dysrhythmias (methemoglobinemia in overdose)

> not effective in patients with brain injury and may contribute to raised ICP

> tachyphylaxis occurs

Erythromycin

> macrolide antibiotic

> prokinetic action due to agonism at motilin receptors

> metabolised hepatically

> drug interactions due to CYP450 3A4 inhibition

> adverse effects: prolonged QT, hepatic dysfunction, overgrowth of non-susceptible organisms and clostridium difficile, possibly antibiotic resistance

> most effective single agent, but is limited by tachyphylaxis (over 2-7 days)

> combination with metoclopramide is more effective than either alone

Methylnaltrexone

> Useful in opoid associated reduction in gasgtric motility

> Antaogonises mu-receptors

Neostigmine

> acetylcholinesterase inhibitor

> increase intestinal contractility and transit

My practice

> In the setting of reduced GIT kinetics I will generally start metoclopramide and erythromicin together to optimise the synergistic effects.

> I will monitor all patients and will generally stop the erythromicin if the QTc exceeds 440ms.

Assessing nutritional status in critical illness

2010/2 Outline your approach to the assessment of nutritional status in a critically ill patient, including the use of appropriate laboratory tests.

History

- Premorbid weight and the pattern of its change
- Premorbid diet
- Diseases affecting gastrointestinal function (eg. coeliac disease, bowel surgery, pancreatic disease)
- Disease affecting satiety control (eg. Prader-Willi syndrome)
- Metabolic substrate utilisation (thyroid dysfunction, hypoadrenalism, Cushings disease or corticosteroid therapy)
- Chronic inflammatory states which predispose to cachexia (malignancy, CCF, HIV, COPD)

Examination

- Subjective global assessment - may be better than objective measures
- Observed quality of nails and hair (an indicator of chronic protein intake)
- Subcutaneous fat measurements (triceps)
- Muscle bulk and muscle tone of quadriceps and deltoids
- Presence of oedema and ascites
- Oropharaynx - angular stomatitis, glossitis, poor dentition, gingevitis
- Evidence of any specific micronutrient deficiency

Anthropometry

- BMI
- Ideal body weight
- Lean body mass

Biochemistry and physiology

- Cholesterol and triglycerides
- Random BSL
- HbA1C
- Serum cortisol
- TFTs
- FBC for lymphocyte count
- Albumin and prealbumin
- Transferrin
- Calculation of nitrogen balance
- Micronutrient levels:
  - Fat-soluble vitamins - A, D, E and K (coagulation profile)
  - Water-soluble vitamins - Thiamine, Folate, Vitamin B12
  - Minerals and antioxidants - Zinc, Selenium
- Delayed hypersensitivity skin-testing

Physiological assessment of metabolic requirements

- Indirect calorimetry
- Predictive equations for energy expenditure
- Using the reverse Fick method to calculate energy expenditure

Cachexia and critical illness

2011/1 Define cachexia. List the factors that may predispose to cachexia AND the consequences of cachexia in a ventilated patient with sepsis and multi-organ dysfunction syndrome.

Definitions

Cachexia is a form of malnutrition that is characterised by accelerated loss of skeletal muscle in the context of a chronic inflammatory condition. It is distinguished from starvation by the presence of increased protien synthesis and degradation, as well as increased serum insulin and cortisol.

Starvation is due to a pure caloric deficiency and forms the other main paradigm of malnutrition

Predisposing factors

- Persistent inflammatory state
- Inadequate nutritional state
  - Pre-exisiting malnutrition
  - Malabsorptive conditions
  - Anorexia
- Catabolic medication use (steroids)
- Chronic illness state
- Multiple comorbidities
- Advanced age

Causes of cachexia

- Malignancy
- Infection
  - HIV and AIDS
  - Tuberculosis
- Rheumatological disease
- Congestive cardiac disease
- Chronic obstructive pulmonary disease

Pathophysiological consequences of cachexia

- Muscle - skeletal muscle wasting
- Heart - myocyte atrophy, increased energy consumption
- Gut - gut-barrier dysfunction, inflammatory mediator release, altered ghrelin production
- Brain - altered pattern of hypothalamic mediators, loss of appetite/anorexia
- Liver - releases acute phase reactants, reduced albumin synthesis
- Adipose Tissues - Brown adipose tissue - increased thermogenesis - White adipose tissue - increased lipolysis

Consequences of cachexia in critical illness

- Increased risk of death
- Prolonged time on ventilator
- Increased ICU and hospital length of stay
- Increased risk of nosocomial infections
- Poor wound healing
- Malnutrition and nutritional deficiency syndromes

Anorexia, malnutrition and ethics

Created Question You are asked to admit a 21 year old female with a BMI of 10 to ICU for forced feeding. She has a history of anorexia nervosa and is refusing all nutrition. a)What are the effects of extreme malnutrition? b) What are the risks of feeding such a patient and what are the risks of sedating her in ICU to do so? c) What are the ethical issues?

Malnutrition

Malnutrition is a broad clinical state characterised by inadequate delivery of macronutrient and micronutrients to achieve the metabolic needs of the patient. It may be due to reduced intake such as starvation or unbalanced diets, impaired uptake of nutrients or increased metabolic demands such as those seen in cachexic states.

The effects of extreme malnutrition (BMI < 15) may be characterised by the deficiencies that result

> Macronutrients
  - Caloreic deficiency - markedly reduced BMI, muscle wasting, sunken eyes, prominent bony landmarks
  - Protien - results in the features of kwashiorkor (or marasmas if there is no oedema) apathy, irritibility, ulcerating dermatoses, increased infections, peripheral oedema
  - Carbohydrates - may lead to a starvation ketoacidosis
  - Fat - (linoleic and linoiec) rarely may cause thrombocytopaenia

> Micronutrients
  - Fat soluble
    - Vitamin A - impairs immunity, Vitamin D - deficiency causes impaired calcium homoeostasis and secondary hyperparathyroidism, Vitamin E - haemolysis, neuromuscular disorders, ataxia, and peripheral neuropathy., Vitamin K - high INR echymosis, bleeding diathesis, features of anaemia
  - Water soluble vitamins
    - Thiamine (B1) Wernicke Encephalopathy , Riboflavin (B2) deficiency is characteristed dmage to oropharynx, Niacin (B3) pellagra. Pyridoxine (B6) deficiency may occur in TB treatment and leads to stomatitis, glossitis, cheilosis, irritability, confusion, and depression. Cobalamin (B12) deficiency is characterised by megaloblastic anaemia and neurological symptoms.. Vitamin C deficiency may lead to scurvy with ecchymoses, bleeding gums, petechiae,. Folate Deficiency can lead to megaloblastic anaemia
  - Antioxidant vitamins and minerals
    - Iron deficiency leads to microcytic, hypochromic anaemia,. Zinc deficiency reduces growth, immunity, impairs taste and smell, and cause night blindness. Iodine deficiency is associated with goitre, hypothyroidism, mental retardation. Severe selenium deficiency is associated with skeletal muscle dysfunction and cardiomyopathy. Copper deficiency manifestations include anaemia, ataxia, and myeloneuropathy

Risks of feeding and sedation in ICU

The major risk of feeding in this patient is refeeding sydnrome. This can be monitored through frequent electrolyte checks and is characterised by hypophosphataemia, hypokalaemia, and may progress to peripheral oedema and heart failure. The reintroduction of nutrition should therefore be a staged process performed in consultation with dieticians. The other main risk with this patient is the mirconutrient deficiencies which should be investigated and replaced as required with complications managed appropriately.

Other associated conditions such as metabolic derangements secondary to vomitting should be addressed, awareness of the increased risks of potassium fluctuations.

In regards to sedation the patient will have significantly altered pharmacokinetics secondary to her profoundly abnormal body shape (BMI 10). Lipid soluble drugs such as propofol will have a greatly reduced volume of distribution and therefore more judicious dosing will be required. Drugs with high protien binding will also be more available. There may be hepatic and renal dysfunction which would also affect drug clearance.

Ethics of anorexia

Recourse to law should be seen as a last resort however where there is a clear and apparent risk to the patient (such as a BMI of 10) involvement of use of the Mental Health Act or involvement of the Guardianship Tribunal would be reasonable.

Micro and macro-nutrients

Created questions List the clinical features associated with macro- and micro-nutrient deficiencies

Macro-nutrients Provide the bulk of energy. Macro-nutrients are traditionally classified into three major classes; Carbohydrates (40-50% of energy requirements), Proteins (10-15%), and Fats (40-50%).

Protein deficiency

> Clinical features of protein deficiency are seen in Kwashiokor disease - Peripheral oedema and ascites due to reduced oncotic pressures, anorexia and irritability, ulcerating dermatoses

> Impaired immune responses to illness, muscle wasting and fatty infiltration of the liver

Carbohydrate deficiency

> The body can compensate for at least 48 hours by using glycogen stores, then occurs by protein breakdown producing a ketoacidosis

> A profound deficiency may cause an acidotic state with high RR, obtundation and coma

Fat deficiency

> Whilst the body can synthesise most fats from the diet there are two essential fatty acids (EFA) linolenic acid and linoeic acids. EFA deficiency is very rare although occasionally occurs in non breast fed infants and is characterised by scaly dermatitis, alopecia, and thrombocytopaenia

Micro-nutrients Only required in small volumes but deficiencies may have significant pathological consequences.

Fat soluble vitamins: ADEK

> Vitamin A deficiency impairs immunity and hematopoiesis and causes rashes and typical ocular effects

> Vitamin D deficiency causes impaired calcium homoeostasis and secondary hyperparathyroidism, in paeds it causes Rickett's disease. It manifests as bone pain and tenderness, muscle weakness, fracture, and difficulty walking

> Vitamin E deficiency causes haemolysis, neuromuscular disorders, ataxia, and peripheral neuropathy.

> Vitamin K required in coagulation factor synthesis 2, 7, 9, 10, echymosis, bleeding diathesis, features of anaemia

Water soluble vitamins

> Thiamine (B1) deficiency may occur in TPN treatment without supplementation or in alcoholism.
  - Wernicke Encephalopathy is a triad of nystagmus, ophthalmoplegia, and ataxia, along with confusion
  - Korsakoff's Syndrome is a chronic manifestation of WE with impaired short-term memory and confabulation
  - Wet and Dry Beriberi - Dry involves symetrical neuropathy, Wet involves neuropathy plus features of heart failure
  - Leigh's Syndrome may occur in infants and involves subacute necrotising encephalopathy

> Riboflavin (B2) deficiency is characteristed by sore throat, hyperemia of pharyngeal mucous membranes, edema of mucous membranes, cheilitis, stomatitis, glossitis , normocytic-normochromic anemia, and seborrheic dermatitis

> Niacin (B3) is common in plant and animal foods, it is important in enzymatic rxns and deficiency leads to pellagra

> Pyridoxine (B6) deficiency may occur in TB treatment and leads to stomatitis, glossitis, cheilosis, irritability, confusion, and depression

> Cobalamin (B12) deficiency is characterised by megaloblastic anaemia and neurological symptoms.

> Vitamin C deficiency may lead to scurvy with ecchymoses, bleeding gums, petechiae, coiled hairs, hyperkeratosis

> Folate (synthetic form: folic acid) Deficiency can lead to megaloblastic anaemia, neural tube defects in foetuses

Antioxidant vitamins and minerals

> Iron deficiency leads to microcytic, hypochromic anaemia, clinical features include fatigue, irritability, pale mucous membranes and palmar creases, koilonychia (spoon nails)

> Zinc deficiency affects growth and may depress immunity, impair taste and smell, and cause night blindness

> Iodine deficiency is associated with goitre, hypothyroidism, mental retardation

> Severe selenium deficiency is associated with skeletal muscle dysfunction and cardiomyopathy

> Copper deficiency manifestations include anaemia, ataxia, and myeloneuropathy

Nutritional support when EN fails

Created Question A 67 year old female with severe community acquired pneumonia has been ventilated in your ICU for 7 days. She has had high gastric aspirates, and enteral feeds have not been established. Outline your approach to her nutritional support. [Majority of answer provided by Rachel Choit 2015]

Definitions

Gastric Residual Volume (GRV) is the amount aspirated from the stomach following administration of enteral feeds. There is some controversy regarding high GRVs with different authors arguing for volumes >300, however most agree that >500ml represents a high GRV and may be indicative of feed intolerance.

Approach to nutritional support

Determine nutritional requirements

> Pre-morbid health status, weight at admission, biochemical data, involuntary weight loss, persistent inflammatory states (cancer, vasculitis, infection)

> Establish risk factors for malabsorption or malnutrition

> Determine caloric requirement

- Indirect calorimetry is the gold standard
- Predictive equations (Harris Benedict)
- Simplified weight based estimations (25-20 kcal/kg/day + 1.2-1.5g protein)
- Global assessment

Troubleshoot feed intolerance and maximise likelihood of establishing EN

> Identify causes

- Patient - GORD, hiatus hernia, gastroparesis/ileus, pseudo-obstruction, bowel injury, bowel ischaemia, shock, sepsis, pancreatitis, obstruction, hyperglycaemia, hypoxia, ischaemia, trauma, burns, hypothermia
- Mechanical - NGT not in stomach
- Drugs - Opiods, sedation, hyperosmolar function

> Use feeding protocol to maximise chance of achieving nutritional target rates

- Commencing at 30ml/hr and increasing as tolerated
- Delivered as a continuous infusion

> Consider use of pro-kinetics - metoclopramide, erythromycin, enteral naloxone

> Trial of post pyloric feeding

Parenteral nutrition

> If trouble shooting does not improve feeding then commence PN

> Establish appropriate access (PICC or CVC)

> Determine TPN composition based on nutritional requirements, titrate up to target

> Monitor glycaemic control, electrolytes (refeeding syndrome), LFTs, triglycerides

> Regularly attempt to re-establish EN

Prophylactic antibiotics in severe acute pancreatitis

Created question Discuss the role of prophylactic antibiotics for patients with acute severe pancreatitis?

Definitions

Pancreatitis is an inflammation of the pancreas, thought to be a result of unregulated activation of trypsin in pancreatic acinar cells. Almost three quarters of presentations are due to alcohol and gallstones, the remaining 25% are due to a range of rare causes such as electrolyte and lipid disturbances, instrumentation of the biliary tree, toxins, adverse drug reactions, infections and malignancy.

The diagnosis is made when at least two out the following criteria are present

> Epigastric or RUQ abdominal pain
> Elevated amylase or lipase
> Changes on CT abdomen consistent with pancreatitis

Severe acute pancreatitis (SAP) occurs in 20% of cases and confers a mortality of 15-20%. The diagnosis of SAP is made when there are features including

> Local and extrapancreatic complications
> Persistence of hypovolaemia
> Multiple organ dysfunction

Severity may be assessed by specific scoring systems such as RANSON criteria, CT Severity index or Atlana classification or general scoring systems such as SOFA and APACHE II

Infection

Infection of pancreatic necrosis is a very important issue in SAP. This complication usually develops during the second or third week in 40-70% of patients. Infection is believed to be due to translocation of gut pathogens. The benefit and timing of antibiotics remains contentious.

Early antibiotics

Early empirical antibiotic usage has been studied by multiple underpowered RCTs with variable results and a tendency to increased effect size with smaller studies. A Cochrane review of these studies did not demonstrate a mortality benefit in the commencement of early antibiotics in SAP. Despite this finding there was a consistent clinically worthwhile trend across both primary and secondary endopoints to benefit suggesting that further research into this question is warranted.

Late antibiotics

There appears to be a consensus view that late empirical antibiotic usage is reasonable when there exists clinical suspician of infection and that these should be commenced following an attempt to obtain a tissue culture via fine needle aspiriation.

Antibiotic choices

Broad spectrum antibiotics choices reflect the severity of illness and likely gut pathogens. Options include;

> Pipercillin and tazobactam 4.5g TDS or QID
> OR (if penicillin sensitivity) Ceftriaxone 1g Daily or Cefotaxime 1g TDS + Metronidazole 500mg BD
> With escalation in consultation with infectious diseases specialists to Meropenum 1g TDS

My practice

I would not start early empirical antibiotics in my patients with SAP unless further evidence supported this management strategy as it often creates uncertaintly in the ongoing management and diagnosis of complications, does not have obvious end points and represents issues with good antimicrobial stewardship.

Following a full septic work up including tissue culture I would commence tazocin if there was evidence of infection however I would cease antibiotics if the septic screen proved negative.

Feeding in severe acute pancreatitis

Created question Discuss main issues associated with feeding in patients with acute severe pancreatitis?

Definitions

Pancreatitis is an inflammation of the pancreas, thought to be a result of unregulated activation of trypsin in pancreatic acinar cells. Almost three quarters of presentations are due to alcohol and gallstones, the remaining 25% are due to a range of rare causes such as electrolyte and lipid disturbances, instrumentation of the biliary tree, toxins, adverse drug reactions, infections and malignancy.

The diagnosis is made when at least two out the following criteria are present

- Epigastric or RUQ abdominal pain
- Elevated amylase or lipase
- Changes on CT abdomen consistent with pancreatitis

Severe acute pancreatitis (SAP) occurs in 20% of cases and confers a mortality of 15-20%. The diagnosis of SAP is made when there are features including

- Local and extrapancreatic complications
- Persistence of hypovolaemia
- Multiple organ dysfunction

Severity may be assessed by specific scoring systems such as RANSON criteria, CT Severity index or Atlana classification or general scoring systems such as SOFA and APACHE II

Parenteral nutrition (PN) versus enteral nutrition (EN)

Rationale To supress the function of the exocrine pancreas bowel rest and parenteral nutrition has been advocated.

Issues Clinical and experimental models however have demonstrated that bowel rest is associated with mucosal atrophy and increased infectious complications due to bacterial translocation from the gut.

Evidence A Cochrane review of this question from 2010 found that in patients with acute pancreatitis, EN significantly reduced mortality, multiple organ failure, systemic infections and the need for operative interventions. It recommends that EN should be the standard of care

Early versus late EN

This question is currently under investigation by the PYTHON investigators

Nasogastric (NG) versus Nasojejunal (NJ) feeding

Rationale The rationale of placing nasojejunal tubes are that they may reduce gastric and pancreatic stimulation

Issues The main issue with NJ tubes is the difficulty in placement and the risk of migration. Insertion of an NJ tube is generally more invasive due to the need for endoscopy or fluroscopic methods ton confirm placement.

Evidence Equipoise for a large RCT to address this question. In essentially phase 2 trials with less than 100 patients NG tubes appear to be tolerated in up to 80% of patients and there does not appear to be an effect on mortality.

My practice

I would aim to commence standard EN within the first 72 hours in patients with SAP (until further evidence such as the PYTHON trial emerges). In the centre where I work we do not routinely place NJTs and therefore I would usually feed via a NGT in the first instance as the lack of experience with NJT may result in a higher complication rate. I would consider NJT feeding if NGT was not tolerated and would only consider TPN if EN is not possible and would do so in consultation with the surgeons

Total parenteral nutrition TPN

2006/2 Outline how you would initiate a regime for Total Parenteral Nutrition in a critically ill septic malnourished 60 kg man.

Total Parenteral Nutrition involves delivering a patients nutritional requirements solely through an intravenous route as opposed to partially or completely through the enteral route.

> It is generally only considered when there is a contraindication to enteral feeding or attempts to feed enterally have failed.

> It may increase the rate of infection either due to increased permeability of gut mucosa, decreased gastro-intestinal-lymphoid tissue (GALT) activation or because of the CVC access.

Initiating TPN

Central venous access

> Peripheral IV delivery results in an increased risk of thrombophlebitis therefore central CVC access is recommended

> Some centres recommend an antibiotic coated CVC to reduce infection rates

Calculate energy requirements

> Indirect methods are the gold standard

- Resting energy expenditure can be calculated by measuring VO2 (O2 consumption) and VCO2 (CO2 exhaled) and applying the Weir Equation REE = [3.9 (VO2) + 1.1 (VCO2)]1.44 -
- This method is however time-consuming and often not practical in most ICUs

> Predictive equations are more commonly used

- Harris-Benedict equation based on age, gender, height and weight is a simplified option however this has been shown to be inaccurate in critical illness
- The Faisy-Fagon equation for patients on mechanical ventilation offers a better estimate in this setting, adding MV and temp to height and weight

> Often a target intake of 25-30 kcal/kg is chosen irrespective of pathological process or other parameters

Determining TPN composition

> Carbohydrates (CHO)

- Usually provided in the form of dextrose aim to provide ~60% of calorie intake from dextrose
- Some argument for less CHO provision in patients with respiratory failure (to reduce CO2 production)

> Lipids

- Provided as a lipid emulsion ~ 40% of non-amino acid calorie intake
- Weak evidence for increased use of omega-3 fats (which reduce inflammation) rather than omega-6 fats (which are pro-inflammatory)

> Proteins

- Assuming normal renal function I would aim for a protein intake of 1.2-1.5g/kg
- I would avoid high dose glutamine (REDOX trial demonstrating potential harm)

> Micro-nutrients

- Trace elements - chromium, copper, manganese, selenium and zinc
- Vitamins - fat soluble; A, D, E and K - water soluble; thiamine, niacin, pyridoxine, C and folate

Commencement at usually 40ml/hr then titrating up to target rate according to calorie requirements

Monitoring

> QID - Glycaemic control BSL 6-10

> BD - EUC and CMP - especially K, PO4, Mg to identify and treat re-feeding syndrome early

> Daily - LFTs (likely mild transaminitis), coag profile, FBC

> Weekly - Triglycerides, some trace elements and vitamin levels as indicated

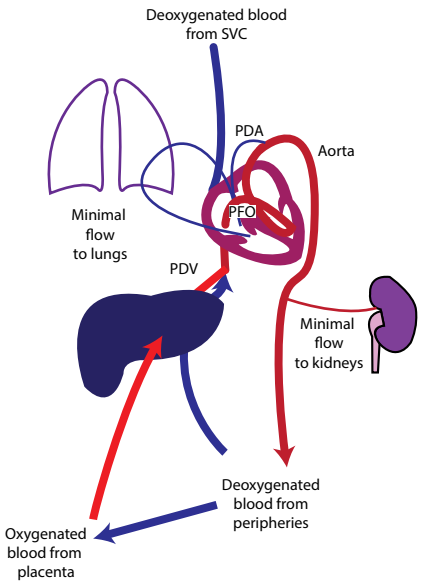
> Monitor for infection, and reassess for suitability for EN regularly

Paediatrics and Obstetrics

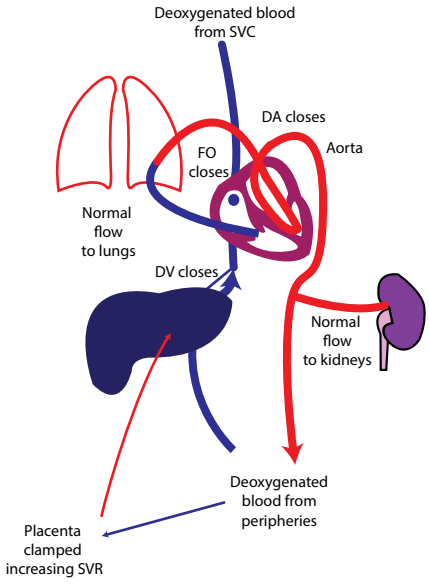
Circulatory changes after birth

2007/2 Outline the circulatory changes that occur immediately after birth

> 1. First breath
  - lungs expand ->
  - pulmonary blood flow increases markedly ->
  - drop in PVR ->
  - bolus of blood to LA + LV ->
  - reversing pressure & closure of foramen ovale.
> 2. Loss of umbilical circulation (clamping cord) -> increased SVR
> 3. Closure of ductus venosus
> 4. Closure of ductus arteriosus
  - functional not anatomical due to increased exposure to increased PO2, pH and decreased PCO2 -> inhibiton of prostaglandins E1 & E2 -> vasoconstriction
> 5. Large increase in pulmonary circulation.
  - inflation of lungs drawing blood into thorax
  - prostaglandin & NO action
> 6. Changes in skin blood flow from exposure.
> 7. Decrease renal vascular resistance -> increase in RBF & GFR.
> 8. Increased FiO2 shifting oxy-Hb curve to to right -> less fetal Hb & increased 2,3 DPG.



Before Birth



After birth

Dehydration in paeds

2012/2 A nine-month-old child is brought to your ED with a history of severe diarrhoea and vomiting over several days. On presentation the child is clearly dehydrated. a) Describe your approach to initial management in this situation b) How would you calculate the degree of dehydration in a child based on clinical assessment?

Initial managment

Standard assessment of unwell patient using normal parameters for 9 month old

- Airway and breathing assessment
  - Sepcifically looking for tachypnoea consistent with acidosis or critical illness
  - O2 therapy if indicated
- Circulation assessment
  - Heart rate and blood pressure
  - Ausculation
  - Peripheral perfusion, evidence of mottling, peripheral oedema, mucous membranes, sunken eyes, fontanelle likely fused at 9 months
  - Establish peripheral access
    - IV or IO
    - Fluid bolus commenced at 20ml/kg initially of 0.9 normal saline
    - Calculate fluid loss (see below) and replace with 0.45 normal saline
    - Antiemetics
- Disability
  - Assess for irritibility, agitation or obtundation as markers of severity
  - Evidence on harm or injuries
  - Quick developmental assessment/?syndromal
- History
  - Unwell contacts
  - Vaccinations, medications, previous admissions, milestones
- Investigations
  - VBG, EUC and CMP ?metabolic derangement
  - Septic work up is indicated - blood cultures, urine, CSF, sputum, stool

Calculating fluid loss

Degree of dehydration (deficit) + Maintenance fluid requirements + Ongoing losses

- Patients with mild (<4%) dehydration have no clinical signs.
  - They may have increased thirst.
- Moderate dehydration (4-6%)
  - Delayed CRT (Central Capillary Refill Time) > 2 secs
  - Increased respiratory rate
  - Mild decreased tissue turgor
- Severe dehydration >7 %
  - Very delayed CRT > 3 secs, mottled skin
  - Other signs of shock (tachycardia, irritable or reduced conscious level, hypotension)
  - Deep, acidotic breathing
  - Decreased tissue turgor

Acute anaphylaxis in paed

2006/2 A nine year old boy developed severe bronchospasm, with hypotension and a rash 30 minutes following induction of anaesthesia with propofol, cistracurium and fentanyl for facial reconstructive surgery. There was no known history of allergy, and prior anaesthetic procedures have been uneventful. the anaesthetist calls for help. Outline the advice you would give and your subsequent management of this patient.

Introduction

These features are consistent with a classic analphylaxis presentation which is a severe life threatening systemic hypersensitivity reaction.

Immediate management

> Identify agent and cease
  - Unclear which agent caused the reaction - cisatracurium probably more likely but tiny event rates noted
  - Talk to surgeons and clarify whether they have injected anything into the face
  - Non drug culprits include chlorhexidine (increasingly common in anaphylaxis during anaesthesia) and latex
  - Cease all potential offending agents
> Cease surgery as quickly as practicable
> Call the arrest code if patient remains hypotensive
> Increase FiO2 to 100%
> Stat adrenaline 1mcg per kg, repeat if necessary to maintain blood pressure, start infusion if necessary
> Fluid bolus 10-20ml/kg or isotonic cyrstalloid
> CPR if pressure unsupportable
> Consider salbutamol IV if bronchospasm resistant to adrenaline 5-15mcg/kg IV

Intermediate management

> Consider hydrocortisone dose 4mg/kg IV
> H1 and H2 receptor antagonists may be useful
> ABG - correct abnormalities
> Noradrenaline infusion for ongoing BP support
> Leave intubated post operatively if severe reaction
> Transfer to PICU

Longer term management

> Monitor for 12-24 hours, extubate when complete symptom resolution
> Perform mast cell tryptase at time event and in 6 hrs
> Referral to specialist paediatric immunologist for ongoing management and investigation
> Documentation/Education/NOK

Bronchiolitis in infants

2008/1 You have been asked to review a six week old infant in the emergency department with a presumptive diagnosis of bronchiolitis. (a) Outline your approach to the assessment and (b) management of this baby.

Assessment of bronciolitis

> Past medical history
  - Premature delivery, neonatal ventilation, any previous respiratory disease, congenital heart disease or other syndromes (eg trisomy 21). - All of these worsen the prognosis

> History of presenting illness
  - In the normal child, RSV bronchiolitis runs a course of 7 – 10 days.
  - A severe presentation in the first 3 days is more serious than the fifth or sixth day
  - Biphasic disease suggests possible secondary infection (Staphylococcus or Streptococcus)

> Current observations
  - In this cohort apnoeas are one of the most common triggers for invasive ventilation
  - Monitor Pulse and respiratory rate, severity of respiratory distress

> Examination
  - Airway assessment - stridor
  - Evidence of increased WOB
    - Grunting, nasoflaring, accessory muscle use, abdominal indrawing of breaths
    - Chest auscultation for wheeze or pneumonic signs
  - Circulation
    - Mottling, capillary refill, heart sounds for a murmur
  - Disability
    - Level of consciousness, lethargy, apathy, interaction with environment

> Diagnosis of bronchiolitis
  - must exclude undiagnosed congenital cardiac condition;
  - 60% of presentations in otherwise well patient is RSV
  - Other differentials include pertussis and influenza, both of which have the potential to be worse
  - Up to 20% are bacterial primary or secondary infection
  - NPA may be indicated if severe presention, check WCC, CXR, Blood and urine cultures (LP if obtunded)

Management

> Mx Is usually mostly supportive

> Airway - usually do not require invasive ventilation although apnoeas, respiratory failure, haemodynamic instability may necessitate

> Beathing - high flow nasal prong oxygenation or suitable O2 therapy to target sats >94%

> Circulation - monitor, aim for normal parameters, gentle IVF

> Medications -often antibiotics are prescribed until bacterial infection is excluded, Caffiene may be used if apnoeas present

> Disposition
  - If severe disease requiring HFNP or intubation or in high risk groups with pre-exisiting medical conditions then should be transported to appropriate PICU/ICU environment.
  - Most bronchiolitis can be managed in a paediatric ward

> Family
  - Reassurance and explanantion of the disease process and likely progress

> Documentation, Education

Burns and airway issues in toddlers

2011/1 You have been asked to review a three year old child who was trapped in a house fire and is now in the Paediatric Emergency Department. There is no history available from the child's carer and you observe that the child is drowsy and confused and has a persistent cough. His heart rate is 140 beats per minute, blood pressure 70/40 mmHg. Respiratory rate is 54 breaths per minute and oxygen saturations are 94 % on high flow oxygen via a non re- breather mask. a. Briefly outline the initial priorities in management. b. List the features from the history and your examination of this child which would suggest a significant airway injury. c. List 4 likely causes for his altered conscious state.

Initial management

Simultaneous assessment and management

Airway - high risk of comprimise, look for cabonaceous sputum, early oedema, evidence of stridor, may require intubation early, call for help, have a plan and back-up, rapid IV induction preferable

Breathing - increased respiratory rate and borderline saturations concerning, sats may be lower due to CO poisioning, review ABG for CO levels and paO2, continue to aim for near to 1.0 FiO2, listen to chest for wheeze/stridor

Circulation - current obs high normal ranges, establish IV access with largest bore cannulas available, commence fluids as per resus protocol (3ml x % burn x weight) hartmanns/albumex, consider central access

Disability - Assess burn extent by percentage of body area, consciousness level, contact plastics or specialist burn centre, commence pain relief - paracetamol, morphine

History - medications, admissions, vaccinations, developmental or syndromal issues

Investigations - send baseline bloods, X Ray if required

High risk features

Airway - Carbonaceous sputum, burns above the clavicles, burns to mouth, oropharynx, cough, stridor

Breathing - high RR, low saturations, high COHb, accessory muscle use, increased effort then fatigue

Circulation - Hypotension, tachycardia

Disability - reduced level of consciousness, circumfrential burns, burns to genitalia, axilla, hands and feet

Cause of obtundation

CO poisioning

Hypoxic brain injury

Traumatic brain injury

Other toxidrome - pain medications from ambulance officers, hypoglycaemia, metabolic derangement

Can't intubate or ventilate 6yr old post op

2006/2 A 6 year old girl develops respiratory distress post extubation following a neurosurgical procedure. She does not respond to nebulised adrenaline and itravenos dexamethasone. She deteriorates rapidly and a decision is made to secure her airway. It is diffcut to support her breathing with bag-mask ventilation. Larygocopy is performed and it is impossible to visualise her vocal cords and blind attempts at intbation are unsuccessful. Outline your approac to this problem.

Overview

- Can't intubate can't ventilate is very rare in paediatrics
- Urgent call for help – Anaesthetist and ENT surgeon
- Optimise management
- Ensure appropriate monitoring
- Equipment and Drugs
- Technique

Airway management

- reassess airway
- quick assessment while preparing for subglottic airway
- 100% oxygenation via BMV (adjuncts)
- consider LMA insertion
- surgical cricothyroidotomy with size 3/5 #
- tracheostomy, preferably with ENT surgeon
- if ENT surgeon not available: analgesia, sedation, aseptic technique, scalpel vertical incision over trachea, horizontal incision over trachea, insertion of tracheostomy over bougies or suction catheter
- transfer to operating theatre for further airway management if possible

Other issues

- treat circulation or shock
- prevention of secondary brain injury
- early treatment of negative pressure pulmonary oedema
- dexamethasone
- head up
- ENT review prior to extubation or decannulation for fibreoptic endoscopy

Croup

1995/2 Outline the assessment of severity and appropriate management of mild, moderate, and severe croup

Introduction

Croup (laryngotracheitis) is a respiratory illness characterized by inspiratory stridor, barking cough, and hoarseness. It typically occurs in children six months to three years of age and is chiefly caused by parainfluenza, RSV or influenza virus. The focus of management is supportive care and reduction of the airway obstruction.

Severity assessment

Mild: barking cough, inspiratory stridor on exertion, hoarse voice and cry

Moderate: inspiratory stridor at rest, mild intercostal retractions, some other signs of respiratory distress, minor agitation

Severe: severe respiratory distress, hypoxia, severe stridor, severe intercostal retractions, often pale, fatigued or highly anxious and agitated

Management

> Complete comprehensive history and examination - coryzal prodrome is strongly suggestive of the diagnosis
> Ensure the child remains calm working on concert with the parents as upsetting them may worsen the obstruction
> Consider alternative diagnoses such as epiglotittis, bacterial tracheitis and laryngeal foreign body

Mild cases

May often be managed at home with supportive care and a single dose of dexamethasone (0.6mg/kg)

Moderate to severe croup

> Initial treatment
  - Nebulised adrenaline (0.5ml of 1% solution in 3.5 normal saline)
  - Dexamethasone 0.6mg/kg
> Patients with moderate symptoms can be observed for several hours in the emergency department then discharged if stable.
> Patients with severe symptoms especially hypoxia require admission

Inpatient management

> Supportive measures
  - IVF is usually indicated the high RR leads to increased insensible losses
  - Antipyretics such as paracetamol are frequently prescribed
  - Reducing anxiety and distress is an important component of supportive care
  - Close monitoring and consideration of a secondary bacterial infection if suddenly worsens
> Respiratory support
  - PRN nebulised adrenaline
  - Oxygen supplementation should be provided in a HDU with appropriate nursing ratios. On a general ward O2 may mask impending respiratory failure and therefore it is not recommended on a general ward
  - Respiratory failure is rare however it requires prompt assessment and management, culminating in intubation.
> Infection control
  - Contact precautions should be employed due to the high risk of viral transmission

Acute pancytopaenia, liver and renal dysfunction in pregnancy

2013/2 A 20-year-old primigravida presents at 37 weeks gestation with jaundice, headache, blurred vision and hypertension (140/90 mmHg). The antenatal period was otherwise unremarkable. She is febrile, drowsy, pale, icteric and has pedal oedema. The uterus is palpated as for a full term pregnancy with a normal CTG trace. Examination is otherwise normal. Bloods show plts 50, Hb 80, INR and APTT prolonged, low fibrinogen, bilirubinaemia, renal impairment, transaminitis.

Pre-eclampsia management and investigations

> Deliver baby
> Control BP
> Hydralazine, labetalol
> SNP/GTN if intravenous agent required.
> Prevention of seizures
> Magnesium sulphate
> Urinalysis – protein, WBCs, RBCs, casts
> **Evidence of infection or proteinuria (pre-eclampsia)**
> Renal US

HELLP Syndrome

> Deliver baby
> Regular monitoring of platelet count and liver function
> Supportive measures whilst observing in HDU for dangerous complications
> hepatic haemorrhage/rupture, progressive renal failure, pulmonary oedema.
> Peripheral blood film smear
> Reticulocyte count, haptoglobins, conjugated/unconjugated bilirubin
> **Haemolysis screen**
> Full liver function tests

Sepsis with DIC

> Timely delivery of baby in consultation with obstetrician.
> Early broad-spectrum antibiotics.
> Cardiovascular support – adequate volume resuscitation and establish MAP > 65mmHg.
> **Blood, sputum, urine and vaginal swab for MC&S**
> Septic screen

HUS-TTP

> Deliver the baby.
> Fresh frozen plasma
> Therapeutic plasma exchange
> Corticosteroid therapy
> Monoclonal antibody therapy – Rituximab
> Evidence of haemolysis or MAHA
> Reticulocyte count, haptoglobins, conjugated/unconjugated bilirubin
> Haemolysis screen
> **ADAMTS 13**

Statistics

Bias and Confounding in Clincial trials

Exam heading character style With regards to clinical trials:

> What is bias?

> List 4 potential sources of bias that may affect the result of a clinical trial

> What is confounding?

Bias

Bias is a systematic deviation from the truth and is one of the two causes of error in clinical trials (the other is random chance)

Sources of bias

Selection bias refers to systematic differences between baseline characteristics of the groups that are compared. Reduction of selection bias in clinical trials is achieved through a robust randomisation process and allocation concealment

Performance bias refers to systematic differences between groups in the care that is provided, or in exposure to factors other than the interventions of interest. Recuction of performance bias in clinical trials is achieved through blinding of the patients, investigators and care providers to the intervention allocated.

Detection bias implies systematic differences between groups in how outcomes are determined, and is reduced by blinding the outcome assessors to intervention allocated

Attrition bias refers to systematic differences between groups in withdrawals from a study and is reduced by uniform reporting standards in clinical trials

Confounding

A confounding variable is a variable, other than the independent variable that you're interested in, that may affect the dependent variable.

From a trial design and method perspective it is reduced by ensuring minimal selection, performance, detection and attrition bias.

From a results perspective in is reduced by performing statistical regression techniques which attempt to control for confounding variables.

Critical appraisal of clinical trials

Created Question Critically appraise a recent article on a new vasopressor 'Wankopressin' (with thanks to Prof Fisher)

Trial Design

> What was the study hypothesis? - does the trial design address this question?
  - Wankopressin may be attractive for a different reason than the primary outcome - cost, mode of delivery, side effects
  - Using a non-inferiority or equivalence trial may be more appropriate in this setting than a superiority trial

> Population
  - Is the study population of sufficient similarity to my population that the results are applicable (external validity)
  - Check the calculations of the sample size been accurately calculated (no difference may be due to a lack of power)?
    - event rates (do these match the actual event rates)
    - expected absolute risk reduction and relative risk reduction (are these realistic?)
    - appropriate power (80 or 90% is generally accepted) and p value (0.05 or 0.01)

> Intervention
  - How was wankpressin given? (Is this realistic in current practice)

> Comparator
  - Was the comparator placebo (which would not be very helpful) or the accepted treatment standard (eg norad)

> Outcome
  - Was the outcome patient centered and relevant such as mortality
  - Are there secondary outcomes of interest?
    - Have the authors prespecified the secondary outcomes (which reduces the risk of selective reporting)
    - Are the number of secondary outcomes limited (which reduces the risks of multiplicity)

Trial Methods

> What was the process of randomisation?
  - Was there a robust method of randomisation (to reduce selection bias)
  - Was allocation concealed (could people predict which treatment the patient would be assigned to?)

> How was blinding managed? - were the investigators, patients and the outcome assessors unaware of treatment allocation (to reduce performance bias)

> Were the groups treated equally (with the exception of the intervention) throughout the trial (to reduce confounders)

> Were all patients accounted for throughout the study? (risk of attrition bias)

> Was there an independent data and safety management committee?

Trial Results and Analysis

> Does the reporting conform to CONSORT guidelines?

> Was the data analysis plan appropriate and prepublished? (to reduce the risk of selective reporting and data mining)
  - Was the data analysed as intention to treat? (+/- per protocol)
  - Were there interim analyses and what were the stopping rules? (early stopping may be inappropriate)
  - Have the researchers compensated for multiple comparisons? (a reduced p value may be required)

> Was there balance of the groups at baseline? (which reduces potential confounders)

> What is the treatment effect size? (is this of clinical significance?)

> What is the cost benefit and number needed to treat versus number needed to treat?

> How precise are the results? (which is a marker of internal validity)

> Were subgroups limited, prespecified, identified at baseline and biologically plausible?

External validity and bias

2014 - 2 With reference to clinical studies: a) Define the term "external validity". b) Define the term "bias". c) Briefly explain selection bias and measures to reduce it.

External Validity

Is the degree to which inferences made about a population in a specific study may be generalised to different populations.

Bias

Bias is a systematic deviation from the truth and is one of the two causes of error in clinical trials (the other is random chance)

Selection bias

Refers to systematic differences between the baseline characteristics of the groups that are compared.

This occurs when there is poor randomisation procedures in place

Reducing selection bias

Reduction of selection bias in clinical trials is achieved through a robust randomisation process and allocation concealment.

Randomisation

> Should be by 'truely' random process such as a computor generator process

> If the trial is small then blocks may be employed to ensure that there is less imbalance due to chance

- the blocks used should be of random sizes to reduce likelihood of guessing allocation

> If there are known confounders then randomisation should also be stratified

Allocation

> Should be concealed from the participants and the study personnel if feasible

Implementation

> The randomisation process should be assessed during the trial by the independent data safety monitoring committee or by the investigators at the conclusion of the study

> The baseline characteristics of the intervention and comparator groups should also be presented (as per ConSORT)

Systematic review designs

Created Question Describe the key features of a meta-analysis, meta-analysis with trial sequential analysis and a network meta-analysis?

Introduction

All of these analyses are systematic reviews and are characterised by the following features;

> a clearly stated set of objectives with pre-defined eligibility criteria for studies;
> an explicit, reproducible methodology;
> a systematic search that attempts to identify all studies that would meet the eligibility criteria;
> an assessment of the validity of the findings of the included studies, for example through the assessment of risk of bias;
> a systematic presentation, and synthesis, of the characteristics and findings of the included studies

Meta analysis

Meta-analyses are a subset of systematic reviews that are quantitative

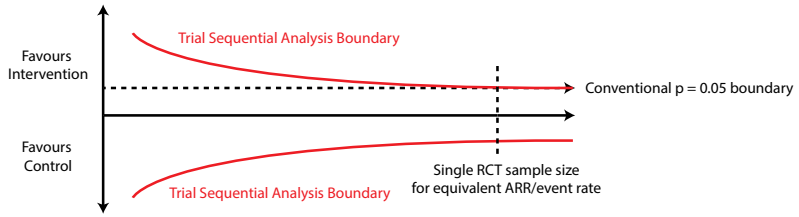
> MA use statistical methods to summarize the results of independent studies.
> Combining the results of mulitple smaller trials may improve the statistical precision of the outcome studied
> MA may use
  - aggregated data combining the overall results from each included trial
  - individual patient data extracted from each of the included trials and then re-analysed

Meta analysis with Trial Sequential Analysis (TSA)

MA with TSA is a subset of meta analyses which employs a strategy to reduce the risk of a false result due to a small number of events or a small overall patient number (information size).

Similar to interim analyses in single RCTs there is a sequential monitoring boundary

> this is more conservative if there are limited sample size and gradually becomes less conservative as trials are progressively added to the MA over time (increasing the information size)



Networked Meta-Analysis (NMA)

A NMA is a subset of MA which is employed when there are more than three trials with the similar populations and outcomes but different (although overlapping) interventions and comparators.

For example; there may be three interventions A, B, and C. Trial 1 compares A-B, Trial 2 B-C and Trial 3 A-C.

> In a standard pairwise MA this comparison would not be possible
> A NMA enables all three inventions to be compared in a meta analysis as each trial has a commonality.
  - this may increase the precision of the effect estimate
  - enables indirect comparisons of treatment efficacy.

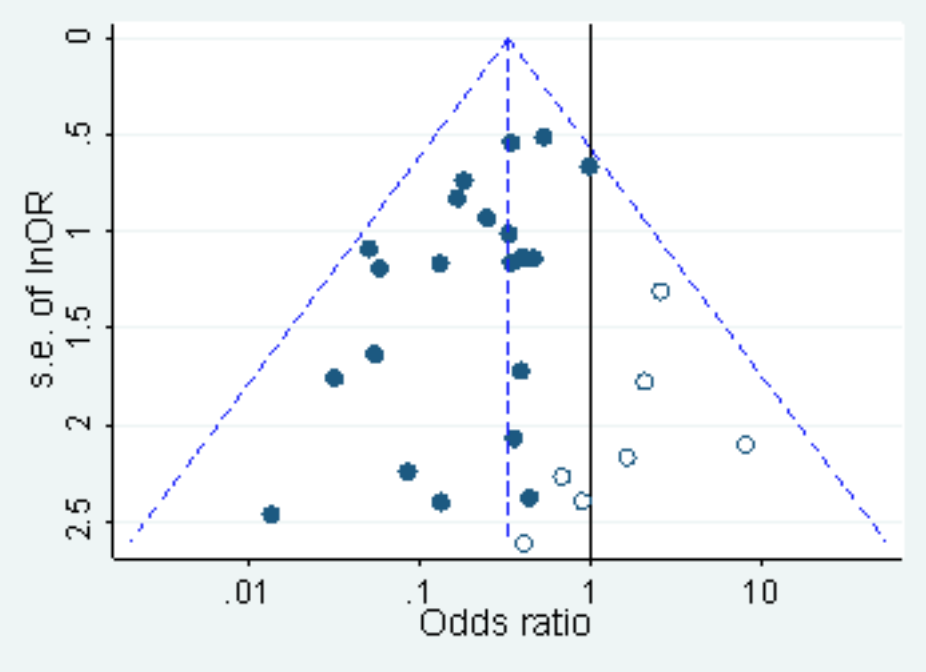
Funnel plots

> A funnel plot is a graph designed to check for the existence of publication bias;

> Funnel plots are commonly used in systematic reviews and meta-analyses.

> In the absence of publication bias, it assumes that the largest studies will be plotted near the average, and smaller studies will be spread evenly on both sides of the average, creating a roughly funnel-shaped distribution.

> Deviation from this shape can indicate publication bias



Dashed border

Outer dashed lines-triangular region where 95% of studies are expected to lie Solid vertical line- no intervention effect

Causes of asymmetry in funnel plots

> i) Heterogeneity
  - Size of effect differs according to study size
  - Clinical differences
  - Methodological differences

> ii) Systematic deviation
  - Publication bias- delayed publication, language, citation, multiple publication bias
  - Selective outcome reporting
  - Selective analysis/inadequate analysis reporting
  - Poor design
  - Fraud

> iii) Chance

Statistics definitions

Risk ratio

A risk ratio is simply a ratio of risk, for example, [risk of mortality in the intervention group] / [risk of mortality in the control group].

It indicates the relative likelihood or experiencing the outcome if the patient received the intervention compared with the outcome if they received the control therapy.

Odds ratio

Odds ratio is the odds of an event occurring in one group to the odds of it occurring in another

	Outcome	
Risk Factor	Yes	No
Yes	a	b
No	c	d

$RR = \frac{a/(a+b)}{c/(c+d)}$ $OR = \frac{ad}{bc}$

Absolute risk = RR x incidence

NNT = 1/absolute risk

Number needed to treat (NNT)

Number of patients that need to be treated for one patient to benefit compared with a control not receiving the treatment

1/(Absolute Risk Reduction)

Used to measure the effectiveness of a health-care intervention, the higher the NNT the less effective the treatment

Relative risk

The difference in event rates between 2 groups expressed as proportion of the event rate in the untreated group.

Absolute risk

This is the actual event rate in the treatment or the placebo group

Power of the study

Is the ability of a study to detect a difference if indeed that difference exists. It is the probability that the test correctly rejects the null hypothesis when the alternative hypothesis exists (type II error). It depends on the treatment effect size (delta), the frequency of the outcome, population variance and and the willingness to accept type I and II errors.

P-value

A p-value indicates the probability that the observed result or something more extreme occurred by chance. It might be referred to as the probability that the null hypothesis has been rejected when it is true.

Confidence intervals

The confidence intervals indicate the level of certainty that the true value for the parameter of interest lies between the reported limits.

The 95% confidence intervals for a value indicate a range where, with repeated sampling and analysis, these intervals would include the true value 95% of the time

Classification of studies

Systematic review

Is the systematic location, appraisal and synthesis of evidence from scientific studies. They are generally qualitative studies which interpret the results of many studies.

Meta-analysis

Is a subset of systematic review which takes the data from all studies which meet certain defined criteria and then reanalyses the data to give a quantitative analysis.

Cohort study

Outcomes for groups of people observed to be exposed to an intervention, or the factor under study, are compared to outcomes for groups of people not exposed. May be prospective or retrospective

Cross-sectional study

A group of people are assessed at a particular point (or cross-section) in time and the data collected on outcomes relate to that point in time ie proportion of people with asthma in October 2004.

Case-control study

People with the outcome or disease (cases) and an appropriate group of controls without the outcome or disease (controls) are selected and information obtained about their previous exposure/non-exposure to the intervention or factor under study.

Case series

A single group of people exposed to the intervention (factor under study). Post-test – only outcomes after the intervention (factor under study) are recorded in the series of people, so no comparisons can be made. Pre-test/post-test – measures on an outcome are taken before and after the intervention is introduced to a series of people and are then compared (also known as a 'before- and-after study')

Levels of evidence (NHMRC)

- 1 Systematic review of level II studies
- II Randomised controlled trial
- III-1 Pseudorandomised controlled trial
- III-2 Comparative study with concurrent controls
- III-3 Comparative study without concurrent controls
- IV Case series with post test and/or pre test outcomes

Drug development phases

- Phase 0 Preclinical animal studies, looking for dose-response, lethal dose index
- Phase I First in human studies, usually involve dose ranging to seek maximum tolerated dose (MTD)
- Phase II Estimate of drug activity, decide if drug warrants further testing (Phase III) estimate of serious toxicities
- Phase III Provide effectiveness of drug or therapy, various designs (usually multicentre RCTs for drug testing), testing for treatment effect
- Phase IV Post marketing surveliance, long term post Phase III follow-up, monitoring for idosyncratic and rare events (eg cox-2 inihbitors and IHD)

Statistical definitions II

Sensitivity

> Sensitivity is the likelihood that those with the condition is will test positive. It is the TP/FN+TP

Specificity

> Specificity is the likelihood that those without the disease will test negative. It is TN/TN + FP

PPV

> Positive predictive value indicates how likely if you have a positive result you have the disease. It is TP/TP + FP

NPV

> Negative predictive value indicates how likely if you have a negative result you don't have the disease. It is TN/TN + FN

	Outcome	
Test Result	Postive	Negative
Positive	True P	False P
Negative	False N	True N

Likelihood ratios

> Likelyhood ratios are used to assess the value of performing a diagnostic test.

> They use the sensitivity and specificity to determine whether a result usefully changes the probability that a condition (such as a disease state) exists.

- LR (positive) = sensitivity/(1-specificity).
- LR (negative) = (1-sensitivity)/specificity.

> If the value is near 1 then the test is of little use, if it is greater than 5 (positive LR) or less than 0.2 (negative LR) then it will be a useful test.

Prevalence and pre-test odds

> The odds that a patient will have a condition before testing depends on the prevalence.

> Rare conditions have a small prevalence and therefore the pre test odds are low.

> Common conditions have a high prevalence and therefore the pre-test odds are high.

> Pre test odds = prevalence/(1-prevalence)

Post test odds

> Post test odds = Pre-test odds x Likelihood ratio

> Thus a LR which is near 1 is useless in changing our management as the odds of the patient having the condition is unchanged despite conducting the test. Furthermore, if the pretest odds are very high or low then the test is not very useful unless there is very high sensitivity or specificity as the likelihood ratio will not increase the post test probability significantly.

Standardised Mortality Ratio

Definition of the SMR

> Is observed hospital mortality / predicted hospital mortality for a specified time period.
> One can use this to compare hospitals and ICUs
> One needs to first calculate the predicted hospital mortality using an illness severity scoring system.
> An SMR of 1 means the mortality is as expected.
> An SMR of < 1 is better than expected, and >1 is worse than expected.

Limitations of the SMR

> Acceptable deviations from the SMR are not defined
> Suffers from inaccuracies associated with data collection
> SMR may be influenced by ICU admission and discharge practices (eg. discharging patients who are palliated, or admitting patients who are inevitably going to die).
> Accuracy of the SMR as a quality assessment tool may be influenced by patients who have been predominantly cared for at another ICU, and who have been received as a transfer.
> Mortality is not a surrogate for quality of care
> The populations used to calculate the predicted hospital mortality are potentially non-representative (i.e. the population may also contains a number of dying critically ill patients, or it may contain an unusually large proportion of people in robust health).

Limitations of comparing ICUs with the SMR:

> The SMR assumes all pre-ICU care is identical
> Ignores differences in case mix
> Sample sizes need to be large enough to obey the laws of logistic regression
> Data is assumed to be flawless and complete

Parametric and non parametric tests

Parametric tests

> Parametric tests are based on estimates of parameters.

> In the case of normally distributed data, the tests are based on sampling distributions derived from mu (mean) or gamma (variance).

> Parametric tests are based on the actual magnitude of values (quantitative, continuous) and can only be used for data on a numerical scale.

> It should only be used when the inherent assumptions are met,

- normal distribution,
- any interval is meaningful (eg height in cm)
- the samples have the same variance (assessed by the F-test)
- observations within a group are independent
- samples are randomly drawn from the population.

> The tests for parametric data include

> student t test.

> ANOVA (analysis of variance)

Non parametric tests

> Non parametric tests were developed for when the researcher does not know the parameters of the variable in question.

> Non parametric methods do not rely on the estimation of parameters (such as the mean or standard deviation) and should generally be used in small studies when the parametric assumptions are not met, and in the use of ordinal data.

> The Mann-Whitney U test is the non parametric equivalent to the unpaired student t-test.

> The Wilcoxon signed rank test is a non parametric equivalent to the paired student t-test.

Equipment and Procedures

Invasive versus non invasive blood pressure measurement

2001/1 The nurse notes a marked difference between blood pressure recorded via an arterial line in one arm and non-invasive pressure recorded from the other arm. What may be causing this difference? Which reading will you use to guide management?

Non-invasive measurement error

The cuff is the wrong size

The oscillometric measurement is confused by an arrhythmia

The patient is moving around too much

Invasive measurement error

The transducer is zeroed incorrectly

The zero level is incorrectly selected

The transducer system is incorrectly set up

Patient factors

The artery being measured is in spasm

There is peripheral vascular disease, which is unequally distributed

The patient has subclavian artery stenosis

There is aortic pathology which influences flow into the limbs (eg. aneurysm)

End Tidal CO2 Monitoring

Multiple previous Critically evaluate the use and limitations of End-Tidal Carbon Dioxide measurement in Intensive Care practice.

Rationale

> CO2 elimination is an important component of gas exchange
> This can be assessed indirectly by serial measurements of arterial PaCO2; however ideally the measurement should be performed continuously.
> Trends in gas exchange are an important parameter to observe in patients whose respiratory function is compromised
> CO2 monitoring is also of critical importance in patients with increased intracranial pressure

Applications in ICU

> Confirmation of ETT placement
> Airway disconnection alarm
> Monitoring during transport
> During CPR to assess adequacy of cardiac compression
> Recognition of spontaneous breath during apnoea test
> Neurosurgical patient to provide protection against unexpected hypercapnia
> Quick bedside assessment of bronchospasm
> Alert of sudden changes in pulmonary perfusion (eg. PE)
> Early alert of PEA in the absence of continuous BP monitoring
> More accurate monitoring of respiratory rate

Advantages

> Continuous monitoring
> Immediate feedback regarding cardiac output and ETT position
> Waveform analysis is possible
> Cheap
> Increased safety; decreased risk of undetected airway circuit disconnection

Disadvantages

> Produces vigilance-impairing false alarms
> EtCO2 values may not correlate with PaCO2 values and the two may be substantially different
> The monitor in-line connector creates a small amount of apparatus dead space
> The adaptor fitted to the end of the ETT may be heavy, and may increase the risk of accidental extubation, particularly in children and neonates
> The gas sampling models of EtCO2 monitors can diminish the delivered minute volume, as they access the circuit gas at a rate of about 200ml/min.
> Nitrous oxide can confuse some capnometers (i.e. be mistaken for CO2)
> The presence of helium can cause the EtCO2 measurement to be incorrectly elevated in some capnometers (i.e. those which use a reporting algorithm that assumes that the only gases present in the sample are those that the device is capable of measuring)

Evidence and Guidelines

> EtCO2 rapidly detects lifethreatening complications in transported patients.
> American Heart Association Guidelines for Cardiopulmonary Resuscitation make the following recommendations
  - Use EtCO2 to assess ETT position
  - Use EtCO2 to assess efficacy of CPR
  - Use EtCO2 to confirm the return of spontaneous circulation

HME versus humidified circuit

Rationale

> The body humidifies inhaled gas with 47mmHg of H2O at 37 degrees
> Mechnical ventilation bypasses the most effective area for this humidification (the nasopharynx)
> A humidified will therefore reduce insensible water loss by the patient and reduce energy consumption
> Options include a HME filter and a humidified circuit

Comparison of Circuit Humidification and Heat/Moisture Exchangers

	HME	Humidified circuit
Device description	A hygroscopic in-line air filter	A circuit which incororates an inline heated water chamber, with an integrated thermostat-controlled heating element
Cost	Cheap	Expensive - both the device and the attached consumables
Reusability	Single-use	Reusable humidified, disposable circuit
Workload	Minimal	Requires attention to water replacement and occasional troubleshooting
Humidification efficiency	Low efficiency; approximately 50% of the required humidity is achieved. The devices are expected to produce a consistent level of humidity around 30mg/L; whereas 20mg/L is the more typical performance	Highly efficient. Humidity acieved ranged from 33mg/L to 44mg/L, which is near to the humidity achieved by the human respiratory tract.
Lifespan	Should not be used for longer than 72-96 hrs	Provided the circuit is well maintained and regularly changed, humidified ventilation can continue indefinitely
Risks with use	Increases dead space; Becomes progressively more waterlogged, increasing resistance to gas flow; Potentially, can become a source of infection	"Rain-out": evaporated water collects in the circuit, pooling and attracting bacteria.The water bath itself is a nice warm environment which acts as a good incubator for bacteria
Contraindications to use	Need to minimise dead space; Large volumes of secretions Decreased expiratory airflow Large minute volume (>10L/min) Bronchopleural fistula Long term ventilation Frequent nebulised medications	There are no contraindications to circuit humidification.
Evidence	• No evidence for any difference in mortality, morbidity or incidence of VAP.	

Pulmonary artery catheters

2013/1 Critically appraise the use of PA catheters

Pros of PA Catheter

> Direct measurement of several variables with one device:
  - RA pressure
  - PA pressure
  - PA wedge pressure
  - Core temperature
  - Mixed venous saturation
> Measurement of cardiac output, and mathematical derivation of other variables from thermodilution
> Titration of therapies to these measurements

Complications

> Same as CVC
  - Perforation of SVC
  - Hemothorax, pneumothorax
  - Atrial fibrillation
> Unique to PA catheter
  - Ventricular Arrhythmia
  - Thromboembolic events (the catheter is a nidus for clot formation)
  - Mural thrombi in the right heart (up to 30%)
  - Air embolism from ruptured balloon
  - Pulmonary infarction
  - Endocarditis of the pulmonary valve (2%)
  - Right bundle branch block
  - If you already have LBBB, this causes complete heart block
  - Knotting on structures or on itself (~ 1%) If it has gone into the right ventricle by 25-30cm and its still not in the pulmonary artery, you start to worry
  - Damage to the valves (Never pull the catheter back with the balloon inflated! You could tear the valve leaflets)
  - Pulmonary artery rupture: 0.2% risk, 30% mortality (pulmonary hypertension, mitral valve disease, anticoagulants and age over 60)

When to use?

> Patients who require the titration of multiple simultanous resuscitation strategies (inotropes, vasopressors and fluid resuscitation)
> Situations where non-invasive assessment of hemodynamic parameters and cardiovascular funtion is not available, or impossible (eg. where there is no TTE service, or where TTE or TOE is impossible, for instance in patients with oesophagectomy or an open mediastinum)
> Situations where therapy is titrated to pulmonary artery pressure (eg. inhaled pulmonary vasodilators), and more generally situations when therapy is titrated to any of the directly measured variables
> Situations where the risk of PA catheter insertion is outweiged by the benefit, and where less invasive methods of monitoring are considered inferior, or are impossible (eg. when PiCCO pulse contour analysis is invalidated by arrhythmia)

Pulse oximetry

Exam Date 1/2000 Describe the principles of how the pulse oximeter derives arterial oxygen saturation. List causes of the false reading of SpO2.

Definition

Pulse oximetry uses the absorption of light to continuously assess arterial blood haemoglobin saturations and is considered safe and non-invasive.

Theoretical Principles

> Beer - Lambert Law is the equation employed to measure light absorbance.
> Beer's law which states that the absorbances of light is proportional the concentration of the medium
> Lambert's law which states that the absorbance of light is proportional to the path length.
> Oxygen saturation is the ratio of reduced haemoglobin to oxyhaemoglobin
> Reduced haemoglobin and oxyhaemoglobin absorb different wavelengths;
> Reduced Hb absorbs red light (660nm)
> Oxygenated Hb absorbs infra-red light (940nm)
> When fingertip blood is exposed to these two wavelengths, one can measure the absorption of red and infra-red light, and from this infer the concentration of the two types of haemoglobin.
> Tissue and venous absorption is eliminated by processing the signal and rejecting non-pulsatile components.

Causes for false readings of the pulse oximeter:

> Technical problems
  - Poor calibration
  - Damage to sensor or leads
  - Interference
  - Ambient lighting
> Patient movement
  - Poor signal quality due to decreased access to blood
  - Poor perfusion
  - Nail polish
> Abnormal blood contents:
  - Carboxyhaemoglobin
  - Methaemoglobin
  - Methylene blue dye
  - Indocyanine blue dye

Ethics and Administration

Breaking bad news

2013/1 Describe your method of conveying bad news to family members

Introduction

This is a key component of critical care medicine and whilst every interaction will be dictated by the family dynamic and the circumstances of the particular patient there are basic principles worth adhering to.

Setting

Set aside sufficient time

Delivery in a comfortable location offering privacy and relative quiet

Identifying support network for the family members and endeavour to have them present

Delivery by or with a staff member who knows the family

Style

Sitting close to family members without physical barriers in between

Non-verbal messages consistent with the verbal message

Deliver at a pace appropriate to the family, allowing time for discussion

Present information in a way that conveys respect and empathy

Use of touch may be appropriate in some circumstances

Content

Establish the families understanding of the medical details and get a baseline of expectations

Fire a warning shot early "We have brought you here today to discuss our grave concerns about John"

Use language appropriate for the families level of medical understanding and avoid acronyms and jargon

Explain the progress so far and expectations for recovery

Unless you are discussing withdrawal of treatment it is acceptable to convey some hope

Conclusion

Provide for follow up meetings

Document information regarding meeting in medical record

Impaired doctor notifications

Created Question You are approached by the NUM of your ICU who informs you that the nursing staff are concerned that one of the registrars is abusing opiates while on duty. Outline your response to this problem?

Guiding priniciples

> Ensure patient and public safety is maintained
> Provide pastoral care for the potentially impaired doctor
> Ensure that the registrar has adequate representation and a presumption of innocence whilst the claims are investigated

Mandatory notifications

> Are required when there is a reasonable belief that;
  - practising while intoxicated by alcohol or drugs
  - sexual misconduct in the practice of the profession
  - placing the public at risk of substantial harm because of an impairment (health issue), or
  - placing the public at risk because of a significant departure from accepted professional standards.
> In NSW this notification is made to the HCCC (most other states report to APHRA)

My response

Establish in discussions with the NUM and RNs that there is a reasonable belief that the registrar is impaired

Involve the Supervisor of Training, ICU Director and and Junior Medical Officer Unit Manager

Ensure that confidentiality is maintained with respect to all others

Notify the HCCC of the concerns raised

> The HCCC will then review the case
> A doctor (usually a psychiatrist or drug and alcohol specialist) will assess the potentially impaired registrar

Discuss our concerns with the registrar and provide support

Encourage the registrar to access independent advice from their medical defence association/GP

Move the registrar into a non-clinical role temporarily whilst the assessment by the HCCC proceeds

Await response from the HCCC regarding immediate action/limitations of care

Needlestick injuries

2015 May Q5 You are supervising a registrar who suffers a needle stick injury during the insertion of a central line in a patient with a history of intravenous drug use.

Outline your approach to this problem.

(answer below is directly from CICM)

Immediate Response:

> Stop the procedure
> Ensure patient is safe
> Takeover / delegate patient management as required

Further response:

> Wash the registrar's wound immediately with soap and water
> Express any blood from the wound
> Initiate injury-reporting system used in the workplace
> Patient may need to be consented and then tested for HIV, hepatitis B, Hepatitis C
> Refer registrar to designated treatment facility: Emergency Department / Infectious

Disease Physician / Immunology as per hospital protocol

> With consent, registrar to be tested immediately and confidentially for HIV, hepatitis B and C
> Document the exposure in detail for your own record and for the employer
> If the patient is HIV positive, post exposure prophylaxis needs to be started within two hours of the exposure.
> For possible Hepatitis C exposure, no treatment is recommended but advice must be obtained from Infectious Disease Specialist
> If the source patient tests positive for HIV, hepatitis B, hepatitis C, get post-exposure prophylaxis in accordance with CDC guidelines and as per recommendations from Infectious Disease Specialist or other expert.
> Registrar to have follow up with post exposure testing
> Advise re: taking precautions (including safe sex) to prevent exposing others until follow up testing is complete.
> If exposed to blood borne pathogen, he/she should not donate blood for six months until cleared

Counselling:

> While definitive testing is essential, counsel the registrar that the risk factors for infection are: deep injury, visible blood on devices, and needle placement in a vein or artery, lower risk with solid suture needle.

Related to procedure:

> Review of registrar's technique, equipment used, unit policy for procedural training, assessment of competency, etc.

ANZICS End of Life Care Summary

10 principles of EoLC

- Return pt to level of fn acceptable to them, minimise disability or support the dying process
- Simultaneous attention may focus on both intensive therapy and managing symptoms, however the balance between the two may vary
- When aiming for comfort and dignity a palliative care plan should be in place
- No ethical or legal obligation to provide treatments where the burden outweighs the benefits despite family wishes
- Any adult patient with capacity may refuse treatment
- Shared decision making model is recommended with an aim for consensus
- External medical advice, non medical advice such as spiritual leaders and ethicists and lawyers should be sought when there is disagreement
- Decisions to withdraw or withhold should be documented in the notes
- These principles hold regardless of circumstance
- ICUs should all develop and implement EoLC guidelines

The ethics of EoLC

- Autonomy - the patient's right to know and choose what happens to their bodies
- Beneficence - is the aim to benefit the patient
- Non-malficence - is the avoidance of harm (some interventions are painful but provide benefit, an inherent conflict)
- Justice - distributive justice implies that resources are finite and this is an important EoLC consideration
- The balance of these four principles occurs as a social construct - influenced by actors cultural and religious beliefs
- Withholding and withdrawi ng treatment are the same

Definition of death

- (a) irreversible cessation of all function of the person's brain, or
- (b) irreversible cessation of circulation of blood in the person's body.

Admission criteria for ICU

- Treatment of a potentially reversible disease
- Optimise end of life care
- Family management
- Organ donation

Documentation regarding EoLC

- The discussion process (who, where, and what was discussed)
- The agreed goals
- Limitations of care

In the setting of attempted suicide

- Aggressive treatment should be instituted in the emergency situation under the provision of the Mental Health Acts or common law
- Withdrawal may occur when the extent of injury or illness makes ongoing treatment not in the pts best interests

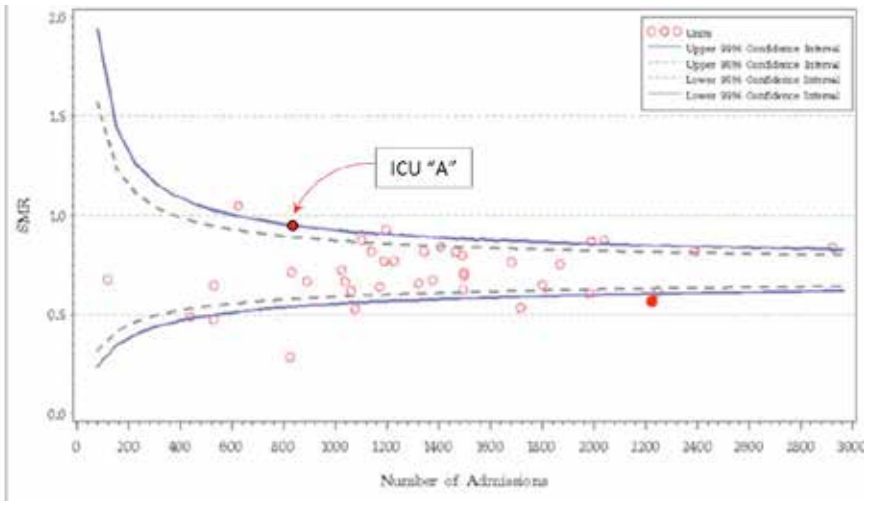
In the paediatric setting

- The issues are the same but the patient is limited in their ability to express their own wishes

Standardised mortality ratio

As part of a nationwide quality improvement program, the standardised mortality ratio (SMR) of your Intensive Care Unit was compared to other similar Intensive Care Units using a funnel plot.

You are ICU "A"



a) What does the graph show about your ICU "A"? (20% marks)

b) Explain how the SMR is calculated. (20% marks)

c) Give the causes of an increased SMR. (60% marks)

SMR

The SMR of ICU A is above the upper 99% CI indicating the SMR is significantly higher than similar hospitals. Your ICU has significantly more deaths than expected compared to similar hospitals.

The overall SMR for the group is less than 1 and the SMR for ICU A is less than 1

SMR Calculation

SMR = O/E O= observed number of deaths, E = expected number of deaths

E is derived from a standardised measure of risk of death such as the APACHE II score.

Usually a risk adjustment model is used to calculate and account for severity of illness.

Increased SMR Score

Can be "apparent" or "real".

> Apparent
- Data quality
- Incomplete or errors in data submission causing underestimated expected risk
- Different casemix of this ICU compared to others.
- Statistical model (risk adjustment) may no longer well calibrated

> True increase in mortality which can be due to
- i. Factors internal to ICU: very high occupancy, poor processes,, inadequate staffing,
- ii. Factors external to ICU; problems in services that are high users of ICU e.g. surgery, system issues

Levels of intensive care units

Level 1

- Mechanical ventilation
- Simple invasive cardiovascular monitoring
- 24-hour timeframe is the limit unless staffed by a FCICM

Level 2

- Complex multi-system life support for an indefinite period
- Minimum of 6 beds
- At least 4 full time specialists on the roster

Level 3

- Complex multi-system life support for an indefinite period
- Commitment to academic education and research
- At least 4 full time specialists per 12-bed "pod"

PICU

- as for a Level 3 unit, but dedicated to the under-16s

Requirements

Staffing

- 1:1 nursing for ventilated/dialysis etc, 1:2 nursing for HDU patients
- Director, Specialist + junior as a minimum at any one time, NUM, Nurse educator

Structure

- Patients are visible and in minimum 20m2 bedspace
- Dedicated spaces - equipment, staff room, offices, cleaners, clean utility, dirty utility

Equipment

- Equipment for invasive and non invasive ventilation
- Suctioning
- Defibrillation and pacing
- Vascular access equipment and ultrasound

Monitoring

- Modular,
- Trending capability
- Alarm recording

SOFA and APACHE

2009/1 Q11 List the desirable features of an Illness Severity Scoring System for Intensive Care patients.? Compare and contrast the Acute Physiology and Chronic Health Evaluation (APACHE) and Sequential Organ Failure Assessment (SOFA) scoring systems.

Ideal scoring system

1. Scores calculated on the basis of easily/routinely recordable variables
2. Well calibrated
3. A high level of discrimination
4. Applicable to all patient populations in ICU
5. Can be used in different countries
6. The ability to predict mortality,functional status or quality of life after ICU discharge

A Comparison of the SOFA and APACHE Scoring Systems

	APACHE	*SOFA*
Basic premise	ICU mortality depends on three domains: • Premorbid health • Severity of illness • Patient's physiological reserve Thus, if one can quantify these domains, one may be able to predict mortality on the basis of such measurements.	Degree of organ dysfunction is related to acute illness. Originally designed with sepsis in mind, but subsequently validated in other disease states.
Measured parameters	Heuristic groupings of 12 physiologic variables, Glasgow Coma Score (GCS), age, and chronic health evaluation status.	6 domains of organ system function
Measurement collection	Worst score within the first 24 hours	Daily measurement of
Unique features	Incorporates chronic illness, emergency admission, age, surgical vs non-surgical admission, and cardiorespiratory arrest	Incorporates the use of organ system support sug as vasopressors and dialysis
Scoring	0 to 71	0 to 24
Mortality prediction	The risk of hospital death is computed by combining APACHE II score with Knaus' weighted coefficient for different types of disease entities. A score of 25 represents a predicted mortality of 50% and a score of over 35 represents a predicted mortality of 80%.	SOFA does not predict mortality, and the original authors intended it to be used as a means of reproduceably describing a sequence of complications in the critically ill. That said, higher SOFA scores are in factassociated with increased mortality.
Prognostic value	APACHE is a poor predictor of individual patient outcome.	One can monitor response to therapy by the change of daily SOFA scores

Fire emergency management

2011/2 An electrical fire breaks out in the equipment room of your fully occupied 15-bed ICU. Outline the principles of management of this emergency

Immediate management

Remove the staff and patients from immediate danger.

Alert the switch board and fire department

Contain the fire by closing doors and windows

Extinguish the fire if it is practical and safe to do so.

Subsequent management

Liaison with ED, OT, HDU, CCU and other high care areas in the hospital and/or neighbouring hospitals for ongoing care of the evacuated patients

Review of incident and response to identify cause of fire and any issues with management with subsequent review of fire policy and implementation of staff education and simulation exercises

Transport of the Critically Ill

2005/2 Q7 Outline your principles of management in the transport of the critically ill patient.

Introduction

> Transport should occur in accordance with the CICM/ACEM/ANZCA joint guideline on transport of the critically ill patient
> All should agree that the benefit outweighs the risk

Interhospital transfer vehicle

> Determined by nature of illness and urgency or retrieval
> Need to be mindful of the effects of transport on the illness (eg. the effect of low cabin pressure on gas-filled obstructed bowel loops)
> Number of staff and volume of equipment
> Road conditions, weather conditions

Equipment

> Airway equipment
> Suction
> Ventilator
> Oxygen supply (in excess)
> Defibrillator
> Thermal insulation
> Monitoring equipment
> All drugs checked and labelled

Monitoring

> Pulse oximeter
> Capnometer
> ECG
> NIBP or arterial line
> Airway equipment must have disconnection alarms

Patient preparation

> Ideal patient is intubated, ventilated and paralysed
> The patient should ideally be stabilised on a transport ventilator before departure
> Vascular access should be secure; you should not be doing any elective procedures during transfer
> One last pre-departure assessment

Communication and documentation

> Confirmation that the destination is aware of transfer, and is ready
> Documentation travels with the patient

Clinical Examination

Cardiac Murmurs Descriptions

Pan-systolic murmurs

These tend to be the result of a high pressure chamber draining into a low pressure chamber.

> Mitral regurgitation
> Tricuspid regurgitation
> Ventricular septal defect
> Aortopulmonary shunts

Ejection systolic murmurs

These tend to involve a ventricle ejecting blood through some sort of stenotic orifice, be it a conventional valve or narrow outflow tract. They follow a classical crescendo-decrescendo pattern.

> Aortic stenosis
> Pulmonary stenosis
> Atrial septal defect
> Hypetrophic cardiomyopathy - with LVOT obstruction, and turbulent flow through this narrowed tract

Late systolic murmurs

These are the outcome of some sort of regurgitant valve, leading backwards out of a ventricle.

> Mitral valve prolapse: This one typically commences with a click
> Pulmonary stenosis: this may be present in the company of an S4, and there may be features of right heart failure. Its a late ejection systolic murmur which does not radiate to the carotids.

Early diastolic murmurs

> Aortic regurgitation
  - This tends to occur together with aortic stenosis.
  - Blood regurgitating back through the aortic valve forms a high-pitched early diastolic murmur, best heard at the 3rd and 4th intercostal spaces.
> Pulmonary regurgitation
  - Blood regurgitating back through the pulmonic valve forms an early diastolic murmur along the left sternal border. They also call it the Graham Steell murmur.

Mid-diastolic murmurs

> Mitral stenosis
  - This tends to be associated with a loud S1 and an opening snap.
  - It is best heard in the left lateral position, with the bell of the sthethoscope. It is louder on expiration.
> Tricuspid stenosis
  - This is best heard at the left sternal edge. It is louder on inspiration.
> Atrial myxoma
  - The tumour makes various sounds, but usually one expects to hear a diastolic murmur as the blood finds its way around the mass in diastole.
> Carey Coombs diastolic murmur
  - Is a "short mid-diastolic rumble" associated with rheumatic mitral valve disease, and which disappears with resolving valvular disease.
> Austin Flint diastolic murmur
  - Its a murmur of the aortic regurgitation jet hitting the apex of the left ventricle in diastole.

Presystolic murmurs

- Mitral stenosis, tricuspid stenosis, atrial myxoma.

Continuous murmurs

- Patent ductus arteriosus or Aortopulmonary connection (eg. Blalock-Tausig shunt)

Cardiac Murmurs

2013/1 In each part of this question, list clinical examination findings for each of the two underlined conditions that would help you to distinguish between them: Aortic regurgitation or mitral stenosis as the cause of a patient's diastolic murmur.

Aortic Regurgitation

- Collapsing pulse / wide pulse pressure
- Decrescendo murmur heard over left 3rd intercostal space parasternally
- Murmur loudest sitting forward in expiration
- Signs associated with large pulse volume and peripheral vasodilation; eg Corrigans, De Musets. Quinckes, Duroziez.
- Evidence of associated conditions; Infective endocarditis, ankylosing spondylitis, other seronegative arthropathies, Marfans.
- Soft 2nd heart sound
- 3rd heart sound
- Displaced apex beat
- Signs of LV failure

Mitral stenosis

- Malar flush
- Atrial fibrillation
- Small pulse pressure
- Loud 1st heart sound
- Opening snap
- Low-pitched, rumbling diastolic murmur over apex loudest in left lateral position
- Pulmonary hypertension

2011/2 List 4 causes of a diastolic murmur over the apical area.

Apical diastolic murmurs

- Mitral stenosis
- Severe mitral regurgitation (flow murmur)
- Significant left to right shunt (VSD)
- Austin-Flint murmur of aortic regurgitation
- Carey-Coombs murmur

2010/2 On palpation of the arterial pulse, a double peak was noted with each cardiac cycle. List 4 conditions/ situations which can produce this phenomenon.

Double peak arterial pulse

- AS + AR
- Severe AR
- HOCM
- IABP

2006/1 Clinical examination of a 35 year old man who is short of breath reveals a pansystolic murmur. Outline the salient clinical features and investigations which will help you distinguish between mitral regurgitation, tricuspid regurgitation and a ventricular septal defect in this setting

Neurological Hot Case (exam)

Introduction

> A brief gestalt, think about the question that has been asked of you. Check the logistics of the bedspace.
> Introduce yourself to the patient (hands behind back)
> "I am going to have a look around your bedspace and then undertake an examination. I may comment as I go to the other medical staff on some of the pertinent findings."
> "Are you in any pain?"

Navigating the bedspace

Drip stand

> Look at each of the infusions
> Ask if you can turn off the sedation?
> Clarify paralysis, barbituates, benzodiazepienes, opiates

Ventilator - Comment of the mode, Pressure, volumes and FiO2

Review the monitor Saturations achieved, ETCO2 trace morphology, HR, blood pressure and other values (ICP, PAP, CVP)

Catheters, drains and IDCs

> Clarify drain outputs and trends
> Urine output trend and ask for the temperature

Look around the bedspace for any other equipment - Dialysis machine, Cooling machine, ECMO etc.

Assess the GCS

> Normal voice "can you open your eyes? then louder. "Can you wiggle your toes?" "Can you squeeze my fingers?"
> Painful stimuli - tap the chest first, then orbital press for central pain, then nail bed to check for withdrawing etc

Assess the cranial nerves

> Either complete the full 2-12 if the patient is away and compliant OR
> EYES: Pupillary reflexes (CN II and III) and Corneal reflex (CN V and VII) and Dolls eyes (CN III, VI and VIII)
> MOUTH: Gag reflex (IX and X) and Cough reflex (X)

Assess tone

> Upper limb tone, lower limb tone and then clonus

Assess motor

> Look for wasting, assymetry, posturing or a preference to use one limb over the other
> Upper limb: Elbow flex C5, Wrist extension C6, Elbow extension C7, Middle finger DIP flex C8, Pinky abduction T1
> Lower limb: Hip flexors L2, Knee extension L3, Ankle dorsiflex L4, Hallux extensor L5, Ankle plantar flex S1

Assess reflexes

> ARM: Biceps C5, Brachioradialis C6, then Triceps C7
> LEG: Knee L4, Achilles S1 + Babinski (UMN)

Assess sensation

> If conscious light touch then pin prick

Assess coordination

> Dysmetria, disdiadokinesis, dysarthria

ICU Complications Hot Case (exam)

Introduction

> A brief gestalt, think about the question that has been asked of you. Check the logistics of the bedspace.
> Introduce yourself to the patient (hands behind back)
> "I am going to have a look around your bedspace and then undertake an examination. I may comment as I go to the other medical staff on some of the pertinent findings."
> "Are you in any pain?"

Navigating the bedspace

Drip stand

> Look at each of the infusions
> Ask if you can turn off the sedation?
> Clarify paralysis, barbituates, benzodiazepienes, opiates

Ventilator - Comment of the mode - Pressure, volumes and FiO2

Review the monitor

> Saturations achieved, ETCO2 trace morphology, HR, blood pressure and other values (ICP, PAP, CVP)

Catheters, drains and IDCs

> Clarify drain outputs and trends
> Urine output trend and ask for the temperature

Look around the bedspace for any other equipment - Dialysis machine, Cooling machine, ECMO etc.

Assess the GCS

Screen for delerium

> Calculate RASS (if -4 (deep sedation therefore only moving to painful stimuli then cease assessment)
> Perform S-A-V-E-A-H-E-A-A-R-T
> Clarify if the level of GCS has been fluctuating OR disorganised thinking (stone floating, fish in the sea, different wts)

Assess the cranial nerves

> Either complete the full 2-12 if the patient is away and compliant

Assess motor

> Look for wasting, assymetry, posturing or a preference to use one limb over the other
> Upper limb: Elbow flex C5, Wrist extension C6, Elbow extension C7, Middle finger DIP flex C8, Pinky abduction T1
> Lower limb: Hip flexors L2, Knee extension L3, Ankle dorsiflex L4, Hallux extensor L5, Ankle plantar flex S1

Assess reflexes and tone

> ARM: Biceps C5, Brachioradialis C6, then Triceps C7, LEG: Knee L4, Achilles S1 + Babinski (UMN)

Assess sensation

> If conscious light touch then pin prick

Listen to the chest for VAP

Check for pressure areas - roll the patient

Look at the lower limbs for swelling consistent with DVT

Extubation Hot Case (exam)

Introduction

> A brief gestalt, think about the question that has been asked of you. Check the logistics of the bedspace. Introduce yourself to the patient (hands behind back) "I am going to have a look around your bedspace and then undertake an examination. I may comment as I go to the other medical staff on some of the pertinent findings." "Are you in any pain?"

Navigating the bedspace

Drip stand and feeds

> Look at each of the infusions
> How long have the feeds been off?
> Ask if you can turn off the sedation? Clarify paralysis, barbituates, benzodiazepienes, opiates

Ventilator

> Comment of the mode, Pressure, volumes and FiO2
> Discuss a trial of reduced support (ATC only)
> Calculate the rapid shallow breathing index (RR/TV), useful to predict failure if >105
> High minute ventilation indicates increased work of breathing but is a poor predictor of extubation failure

Review the monitor

> Saturations achieved - oxygenation is not a great predictor of extubation success
> ETCO2 trace morphology - evidence of obstructive lung pathology
> HR, blood pressure and other values (ICP, PAP, CVP)

Catheters, drains and IDCs

> Clarify drain outputs and trends, Urine output trend and ask for the temperature

Look around the bedspace for any other equipment - Dialysis machine, Cooling machine, ECMO etc.

Assess the GCS and strength

> Eyes should open to voice at the least
> Ask the patient to raise their arms up above shoulder height, squeeze fingers, straight leg raise, ankle flexion

Look at the airway

> ETT size and position at the teeth, and look in the mouth, assess the TMD, review neck mobility
> Request check for a cuff leak and check for a cough reflex at the same time when performing supraglottic suctioning

Assess breathing and cardiovascular

> Look at the hands, make sure the trachae is midline, check the chest expansion
> Ask the patient to take a big breath and check the tidal volume
> Feel the trachea and the expansion of the chest
> Listen to the lung fields and the heart sounds

Examine the abdomen

> Ask to lie the patient flat
> Look for distension, injuries and surgical scars
> Feel for hepatosplenomegaly, bollot the kidneys, and AAA (watch the patients face)

Ask questions

> Plan for surgery or procedures, laryngoscopic grade, is the underlying reason for admission corrected, have they had a previous extubation failure

Respiratory or Cardiovascular Hot Case (exam)

Introduction

> A brief gestalt, think about the question that has been asked of you. Check the logistics of the bedspace.
> Introduce yourself to the patient (hands behind back)
> "I am going to have a look around your bedspace and then undertake an examination. I may comment as I go to the other medical staff on some of the pertinent findings."
> "Are you in any pain?"

Navigating the bedspace

Drip stand and feeds

> Look at each of the infusions
> Ask if you can turn off the sedation?
> Clarify paralysis, barbituates, benzodiazepienes, opiates

Ventilator

> Comment on the mode, Pressure, volumes and FiO2
> High minute ventilation suggests increased metabolic workload

Review the monitor

> Saturations achieved - comment on likely aA gradient
> ETCO2 trace morphology - evidence of obstructive lung pathology
> HR, blood pressure and other values (ICP, PAP, CVP)

Catheters, drains and IDCs

> Clarify drain outputs and trends, Urine output trend and ask for the temperature

Look around the bedspace for any other equipment - Dialysis machine, Cooling machine, ECMO etc.

Assess the GCS and strength

> Eyes to voice or painful stimuli
> Ask the patient to raise their arms up above shoulder height, squeeze fingers, straight leg raise, ankle flexion

Look at the airway

> ETT size and position at the teeth, and look in the mouth, assess the TMD, review neck mobility
> Clarify duration of intubation

Assess breathing and cardiovascular

> Look at the hands, arms, eyes, mouth, make sure the trachae is midline, look at the JVP
> Check the chest expansion
> Ask the patient to take a big breath and check the tidal volume
> Feel the trachea and the expansion of the chest
> Listen to the lung fields and the heart sounds

Examine the abdomen

> Ask to lie the patient flat
> Look for distension, injuries and surgical scars, Feel for hepatosplenomegaly, bollot the kidneys, and AAA (watch the patients face)

Ask questions

> Plan for surgery or procedures

Trauma Hot Case (exam)

Introduction

> A brief gestalt, think about the question that has been asked of you. Check the logistics of the bedspace.
> Introduce yourself to the patient (hands behind back)
> "I am going to have a look around your bedspace and then undertake an examination. I may comment as I go to the other medical staff on some of the pertinent findings."
> "Are you in any pain?"

Navigating the bedspace

Drip stand

> Look at each of the infusions
> Ask if you can turn off the sedation?
> Clarify paralysis, barbituates, benzodiazepienes, opiates

Ventilator - Comment of the mode, Pressure, volumes and FiO2

Review the monitor - Saturations achieved, ETCO2 trace morphology, HR, blood pressure and other values (ICP, PAP, CVP)

Catheters, drains and IDCs

> Clarify drain outputs and trends, Urine output trend and ask for the temperature

Look around the bedspace for any other equipment - Dialysis machine, Cooling machine, ECMO etc.

Assess the GCS

> Normal voice "can you open your eyes? then louder. "Can you wiggle your toes?" "Can you squeeze my fingers?"
> Painful stimuli - tap the chest first, then orbital press for central pain, then nail bed to check for withdrawing etc

Assess extremities for injuries and splints

> Look for wasting, assymetry, posturing or a preference to use one limb over the other
> Brief assessment of power if compliant

Assess the head and the neck

> Look for assymetry, surgical sites, fractures, collar type (miami-j - blue, versus philladelphia collar brown foam)
> Assess for a horner's sign, battle sign, racoon eyes, haemotympanum, CSF leak, orbits, teeth and mandible

Examine the praecordium

> Look for chest expansion, assymetry, evidence of trauma
> Feel for surgical emphysema (especially in high risk sites) feel for rib #s and palpate the clavicles, feel for chest expansion
> Listen to the heart and the lung fields, listen to the carotids for bruits
> Clarify rolling restrictions and ask about the back

Examine the abdomen

> Ask to lie the patient flat
> Look for distension, injuries and surgical scars
> Feel for hepatosplenomegaly, bollot the kidneys, and AAA (watch the patients face)
> Listen for bowel sounds and bruits

Examine the perineum

> Especially for bruising and evidence of fracture
> Palpate the pelvis for fracture

Subarachnoid Hot Case (discussion)

Introduction

> I have examined Mrs Jones at 48 year patient who has suffered a neurological event which I believe most likely to be a subarachnoid haemorrhage.

> My findings in greater detail; focal deficits were not evident and globally she demonstrates...

> My differential for intracranial bleeding includes extradural, SDH, SAH and ICH or which SAH is the most likely in this patient because of the nimodipine infusion currently running...

> My first step in managing this patient whould be to establish the diagnosis with a CT Scan and DSA

Discussion topics

Complications of subarachnoid haemorrhage

> Seizures

> Hydrocephalus

> Rebleeding

> Delayed cerebral ischaemia (which may be precipitated by vasospasm)

Causes of SAH

> Aneurysmal

> Non aneurysmal

- Ateriovenous malformations
- Spontaneous - drugs such as cocaine
- Perimesencephalic (blood in the interpeduncular and ambient cisterns without extension)
- Trauma, Tumour

Prognosis in SAH

> Most important factors

- Age, neurological grade at presentation, amount of blood on initial CT

> Other factors

- Patient related
  - Medical comorbidities - hypertension, ischaemic heart disease, liver disease, Previous SAH, Smoking
- Aneurysm related
  - Posterior circulation do worse, Global cerebral oedema, ICH and IVH do worse
  - Modifiable risk factors, Management of complications, High volume centre improves outcomes

> How has the patient progressed during admission?

Grading systems

> WFNS

- G1: GCS 15, no motor, G2: GCS 13/14, no motor G3: GCS 13/14, with motor, G4: GCS 7 to 12 G5: GCS 3 to 6

> Fisher

- Grade 1: No blood Grade 2: Blood <1mm Grade 3: Blood >1mm Grade 4: ICH or IVH extension

Clipping versus coiling

> Clipping: less invasive, can access posterior fossa better, cheaper, more independent survivors at 12 months (ISAT) however: risks of rupture, thrombosis risk increased and therefore requires anticoagulation, if fails needs surgery

> Coiling: better for wide neck aneurysms, less likely to need retreatment, blood can be removed reducing vasospasm risk, however: more invasive, collateral damage to brain tissue during surgery, needs a GA, higher cost

Traumatic brain injury (discussion)

Introduction

> I have examined Mr Smith at 24 year patient who has evidence of a head injury and traumatic brain injury
> My findings in greater detail;
> There are focal neurological deficits most evident on the right side...
> Globally he demonstrates...
> My first step in managing this patient whould be to establish the diagnosis with a CT Scan

Discussion topics

Causes of acute confusional states in ICU (PIMNT)

> Physiological derangements - hypoxia, hypercarbia, low output states, hypertensive
> Infection - sepsis due to brain, chest, heart, skin/celluilitis/bone, intra-abdominal, ENT, urinary tract
> Neurological - haemorrhagic or embolic stroke, TBI, vasculitis, encephalitis, seizures
> Metabolic disturbances - BSL derangements, acidosis, hyponatraemia, uraemia
> Toxidromes - drug injestion, Wernikes, drug withdrawal states

Recommendations for ICP monitoring in TBI

> Brain trauma foundation recommends ICP monitoring in severe TBI
  - if there is a significantly abnormal CT
  - if the CT is normal but age is >40, there is motor posturing or the SBP is <90
> recommends treatment of ICPs greater than 20-25mmHg
> identifies intraventricular devices as the best ICP monitoring device
> BEST TRIPS suggested that ICP monitors do not change outcome but result in fewer interventions after placement

Reducing secondary brain injury in TBI

> Avoid
  - Hypoxia - Ensure a PaO2 > 80 and/or SpO2 > 92%
  - Hyper/hypocarbia - PaCO2 35 - 40mmHg
  - Hypotension - SBP > 90 mmHg and/MAP > 70 mmHg / CPP > 50 mmHg
  - Metabolic disturbance (Na, glucose, osmo) - Na+ of 140 – 150 mmol/L, glucose 6 – 10, Serum osmo 320 mOsm/L
  - Fever or hypothermia (Eurotherm trial)
  - Seizures - Phenytoin x 72hrs
  - Raised ICP - ICP lowering therapy (head up 30o, neck neutral alignment, sedation and paralysis, osmotherapy, drain CSF, surgical decompression)
  - Secondary surgical lesion (delayed subdural/parenchymal haemorhage) - Repeat CT, surgical therapy
> Standard supportive ICU care FASTHUG

Prognositication in TBI

> age (>40 years, worse with increasing age)
> initial GCS post-resuscitation
> hypotension, hypoxia
> pupil size and reaction to light (i.e fixed and dilated is bad!)
> ICP
> nature & extent of the intracranial injuries (worst to least, subdural -> extradural -> SAH)
> co-morbidities

OOHCA (discussion)

Introduction

> I have examined Mrs Nguyen at 55 year patient who has suffered an out of hospital cardiac arrest and I am concerned about her prognosis primarily from a neurological perspective

> My findings in greater detail;

> Her brain stem reflexes are impaired

> Globally she demonstrates...

> The predicted prognosis for a 55 year old day three post arrest with evidence on upper motor neuron impairment and a reduced GCS is poor. My first step in managing this patient would be to confirm the aetiology of her presentation with a review of her presentation characteristics.

Discussion topics

Prognositication in OOHCA

> Underlying cause of cardiac arrest

> Presence of co-morbidities (e.g. metastatic cancer, dementia)

> Features of the the cardiac arrest and cardiovascular assessment
  - Initial rhythm - VF is better than asystole
  - Duration of anoxia (>8 minutes worse)
  - Time for CPR to ROSC

> Neurological assessment
  - Initial GCS post-resuscitation
  - Brain stem reflexes at presentation (pupils) and at 72 hrs
  - Presence of myoclonic status epilepticus

> Investigations
  - Biochemical - neuron specific enolase, S-100
  - Electrophysical - SSEPs and EEGs
  - Imaging - CT or MRI suggestive of global encephalopathy and loss of grey-white differentiation