EQUIPMENT AND PROCEDURES

ANSWER PAPER

SUNDAY 13/12/2015
**Question 27.2**

**a) What is the device depicted below?**

![Image of a double lumen endobronchial tube](image)

**b) List the indications for its use in the ICU**

[ Hide Answer ]

---

**College Answer**

**a) What is the device depicted below?**

Double lumen endobronchial tube (right sided)

**b) List the indications for its use in the ICU**

Anatomical or physiological lung separation  
Massive haemoptysis from unilateral lesion  
Whole lung lavage eg alveolar proteinosis  
Copious infected secretions with risk of soiling unaffected lung eg bronchiectasis, lung abscess  
Unilateral parenchymal injury  
Aspiration  
Pulmonary contusion  
Pneumonia  
Unilateral pulmonary oedema  
Single lung transplant  
Bronchopleural fistula  
Unilateral bronchospasm

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**Discussion**

Yes, that's a right sided dual lumen tube. You can tell because the blue cuff is eccentric - its unusual shape is owed to need to ventilate the right upper lobe bronchus. A normal-shaped tube would block that lobe, with predictably unhealthy consequences.

The indications for the use of the dual lumen tube are discussed in greater detail in the dual-lumen endotracheal tube chapter from the mechanical ventilation section. I will not duplicate that content, and I will merely regurgitate the college answer in a slightly adjusted form.
- **Prevention of cross-contamination of one lung by the other**, eg. in the following cases:
  - Infection (e.g. unilateral pulmonary abscess)
  - Massive pulmonary haemorrhage

- **Enable the ventilation of each lung with a different ventilation setting** in settings where the each hemithorax is wildly different from the other, for example:
  - Severe chest injury
  - Bronchopleural fistula
  - Open chest (eg. mid thoracic surgery)
  - Giant unilateral lung cyst or bulla

- **Bypass a damaged section of the airway**
  - Tracheobronchial tree disruption /Major airway trauma

- **Permit the lavage of each lung independently** - pulmonary alveolar proteinosis is frequently mentioned as an indication, and I suppose if one finds oneself bringing it up during a viva, one should then be prepared to discuss what it is.

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**References:**

A detailed autopsy of these devices can be found in the 5th edition of "Understanding Anaesthesia Equipment" By Dorsch and Dorsch. Section III, chapter 20.

This chapter seems to be available for free.

What is the item shown in the photograph below?

6.3 b) List the specific design features of Item a, which make it suitable for use.

[ Hide Answer ]

College Answer

- Adjustable flange allows variability of tracheostomy length
- Softer tube enables more flexible curvature
- Reinforced tubing prevents kinking
- High volume, low pressure cuff
- Radio-opaque due to reinforced tubing
- Able to be inserted via percutaneous technique

Discussion

This is a flanged tracheostomy tube.

John Hopkins have a good basic page about the different types of tracheostomy tubes.

A more detailed look is afforded by this product brochure from Smith.

An insanely detailed review is also available.

Thus:

- The tube has a curved portion and a straight portion, which allows the flange to be adjusted to the appropriate pretracheal tissue thickness.
- Adjustable flange allows adjustment of tracheostomy length to any length of patient neck
- It is suitable for patients with up to 50mm of pretracheal tissue
- Soft tube allows a degree of flexibility, especially when warmed to body temperature.
- The tubing is reinforced, which prevents kinking
- The material is MRI-friendly
- High volume, low pressure cuff
- Radio-opaque tubing allows visualisation of position on CXR (but there is no "blue line" like with ETTs
- Some of these are designed for percutaneous insertion

References:

a) What is the device depicted below?

b) List the contra-indications to its use

[ Hide Answer ]

College Answer

Passy Muir speaking valve

Unconscious / comatose patient
Inflated tracheostomy tube cuff
Severe upper airway obstruction that may prevent sufficient exhalation
Excessive secretions
Severe COPD with gas trapping
Foam filled cuff tracheostomy tube (eg Bivona)
Endotracheal tube

Discussion

Designed by Patricia Passy and David Muir, this device is more correctly named the Passy-Muir Speaking and Swallowing Valve. David was in fact a tracheostomy patient, and the valve is his idea. This device is discussed in greater detail in the *The Passy-Muir Valve* chapter.

The company guards its patents jealously, but there are some free educational materials to be found on their site. I have compiled a list of contraindications which closely mirrors the college answers. Some of the college answers seem bizarre. Would anybody ever really try to attach one of these to an endotracheal tube? Is that really a
contraindication?

- (you won't be able to exhale)
- (you will clog the valve)
- (you need to be able to swallow those, or they will get inhaled)
- (you will not be able to overcome the valve resistance to inspiration)
- (You can't deflate the cuff in these people)
- (the valve will increase PEEP)
List the features of the device depicted below.

College Answer

Hydrophobic pleated filter for heat and moisture exchange
Bacterial and viral filtration properties
Filter protects against liquid and airborne contamination
Minimal resistance to airflow
Luer lock gas sampling port (connects to ETCO2 monitoring)
15mm/22mm ISO standard connectors
Disposable single patient use

Discussion

This question invites the candidate to show their appreciation for the basic features of their everyday equipment.
Well, no. It really tests the candidates anaesthetic background. The anaesthetic trainee will have a detailed (some may say, intimate) understanding of all their various gadgets.

This thing is a heat and moisture exchanger (HME) and it is discussed in greater detail elsewhere.

There really isn’t much to it. Ultimately, it’s a plastic box with cardboard in it.

The features listed in the college answer will suffice.

Here they are in point form, battered and lightly fried:

- Single use item
- Transparent plastic body
- 30-40ml of apparatus dead space
- Hydrophobic pleated filter
- Antimicrobial filter lining
- $\text{ETCO}_2$ monitoring port with Luer lock connector
- Standardised ISO ventilation equipment connectors
Question 18.1

a) What gas is delivered through this cylinder shown in the photograph?

b) When this gas is delivered in the ICU through the wall outlet, what is the pressure at the wall outlet?

c) What is the pressure of the gas in a full cylinder?

[Hide Answer]

College Answer

a) What gas is delivered through this cylinder shown in the photograph?
Oxygen
b) When this gas is delivered in the ICU through the wall outlet, what is the pressure at the wall outlet? The Australian Standards are 415 kPa static pressure in pipeline, which is allowed to fall to by a maximum of 50 kPa under some conditions. Therefore any answer between 365 and 415 kPa was acceptable.

c) What is the pressure of the gas in a full cylinder? Whilst it varies from cylinder to cylinder, any answer between 12 to 17 megapascals (12000-17000kPa), is acceptable.

Discussion

Yes, even though that says "N", it is in fact an oxygen cylinder, ready to be transported to a CT scan. And the porter was taking so long that I started taking pictures of the scenery.

The standard (mandatory) wall gas pressure is indeed 415 kPa (about 4 atmospheres). For the gas which powers surgical tools, the pressure is 1400 kPa.

The cylinders, according to a reputable source, can withstand a pressure of 24,000 kPa, but normally rest at around 12,000-17,000 (that is the "green zone" on the gauge).

References:

This excellent lecture from the University of Sydney has a vast amount of obscure information (did you know oxygen tanks are aged at 175°C for 8 hours, and that their walls are only 3mm thick?)

Medical Gas Standard AS 2896-2011 is available online, but you have to pay over $200 to purchase it.

Dorsch and Dorsch have a chapter dedicated to medical gas supply and suction equipment, which can be accessed by Google Books.
Question 28.3

a) What does the cylinder pictured above contain?

b) What parameters are monitored during administration of the cylinder’s contents?

College Answer

a) Nitric oxide 800ppm and Nitrogen

b) PO2 pulmonary artery pressure, methaemoglobin and nitrogen dioxide

Discussion

The marvels and wonder of nitric oxide are discussed elsewhere.

The following adverse effects have been reported with its use:

- as abundantly discussed already
- (maybe some of it does leak into the systemic circulation, or maybe this the effect of depressed LV function
- after abrupt withdrawal
- (in as many as 10% of patients)
- probably due to NO2 formation and associated lung injury

References:

Ikaria, the only company which produces this stuff in Australia, has an excellent product information pamphlet.

(a) What design features of the above equipment prevent it from being connected to the oxygen outlet device?

[ Hide Answer ]

College Answer

1) Colour coding (oxygen is white, suction is yellow)
2) A unique sleeve index arrangement for each wall gas

Discussion

“A unique sleeve index arrangement” means “it won’t fit there”.

That said, people have in the past connected oxygen wall outlets to patient’s joint cavities and IV lines, so there is a good reason for this unique sleeve index arrangement.

References:
QUESTION 15.3

Identify the item of equipment depicted below.
Outline the principles of operation of this item.

[ Hide Answer ]

College Answer

Reservoir oxygen mask / non-rebreather or partial rebreather oxygen mask

- Fresh gas flow attached to reservoir bag and adjusted to ensure bag remains 2/3 full at all times
- One-way valve between reservoir bag and patient preventing expired gas entering reservoir bag
One or two valves on side ports in mask close in inspiration reducing entrainment of room air and open in expiration to prevent rebreathing. (The presence of two valves requires close monitoring of the patient to ensure adequate fresh gas flow from the reservoir bag)

- FiO2 varies from 60-80% depending on presence of valves on side ports and mask fit

Discussion

That image comes from www.acesurgical.com; no permission whatsoever has been granted for its use, and it remains in place only until somebody complains.

Anyway. The basics:

- The reservoir fills with 100% oxygen
- The patient inhales, entraining the reservoir oxygen from the bag
- One-way valves in the mask prevent the entrainment of room air
- The patient exhales, and the one-way valve prevents expired air from entering the reservoir
- The expired air instead escapes through side-vents and around the sides of the mask
- One optimistic article suggests that NRBMs may be capable of 90% FiO2 at 10L flow rate.

References:


17.2. Examine the data provided from a co-oximeter and a simultaneous pulse oximeter recording from patient A and B. List three (3) causes in each patient for the discrepancy between the two oximeters.

| Patient A: Co-oximeter Oxy Hb 85% | Pulse oximeter oxygen saturation 95% |
| Patient B: Co-oximeter Oxy Hb 98% | Pulse oximeter oxygen saturation 88% |

[ Hide Answer ]

College Answer

**Patient A:**
- CoHb
- Met Hb
- Radiofrequency interference

**Patient B:**
- Tricuspid regurgitation
- Ambient light
- Poor peripheral perfusion Dyes- Methylene blue
- Poor probe contact

Discussion

The pulse oximeter is a dumb machine, whereas the co-oximeter will measure lots of different subtypes of haemoglobin simultaneously.

In general terms, the co-oximeter is correct, and the pulse oximeter is frequently confused.

Thus, in Patient A, the co-oximeter reads 85% (the true saturation of haemoglobin) while the pulse oximeter reads 95%. Clearly, there is some haemoglobin here which *closely resembles* normal oxygenated haemoglobin, but is in fact carrying no oxygen.

There do not seem to be causes for this apart from those suggested by the college:
- Carboxyhaemoglobin
- Methaemoglobin
- Radiofrequency interference

In Patient B, the co-oximeter confirms a normal oxygen saturation of haemoglobin; however, something is confusing the pulse oximeter.
- Poor peripheral perfusion
- Ambient light
- Poor probe contact
- Dyes – methylene blue, indocyanine green
References:

Here is the operations manual for an AVOXimeter 4000.


What device is shown below? When is it used and what are its design features which make it suitable for use?

[Image of a McCoy Blade laryngoscope]

College Answer

Name: A McCoy Blade laryngoscope (- improved visualization of the cords in the setting of a difficult intubation).

It has a controllable flexible tip which allows for the elevation of distal structures, espec the epiglottis.

Discussion

Yes, this is a McCoy Articulating Tip Laryngoscope, or the levering laryngoscope as McCoy himself called it (he did not name it after himself). Instead of relying on brute force to elevate the epiglottis, the airway enthusiast can squeeze the lever and elevate it gently. It is particularly useful in situations where the larynx is very anterior. The disadvantage is, sometimes the epiglottis can get caught in the hinge.

References:

AnaesthesiaUK have a nice page about McCoy blades.

Cook, T. M., and J. P. Tuckey. *A comparison between the Macintosh and the McCoy laryngoscope*

List six design features of a standard endotracheal tube which improve its safety.

College Answer

- Clear non-toxic plastic
- Single use
- Radio-opaque line so visible on CXR
- High volume low pressure cuff with pilot tube
- Murphy's eye
- Bevelled tip to assist insertion
- Centimetre markings to assess depth of insertion
- Black line to guide insertion to appropriate depth
- Standard 15mm connector
- Size labelling on pilot balloon

Discussion

The college answer represents the bare minimum. More detailed discussions of the ETT are also available:

- Endotracheal tube and intubation (a brief exam-oriented summary)
- The Endotracheal Tube (a digression into apocryphal detail)

In summary, the safety features are:

- Single use item, no risk of cross-infection
- Standardised 15mm connector to fit all airway devices
- Low-allergen PVC construction, free of latex
- Transparent body, to see blood or vomit
- Markings to indicate depth of insertion
- Black line to guide insertion to appropriate depth
- High volume low pressure cuff to seal the trachea
- Size labelling on pilot balloon
- Pilot cuff to gauge cuff pressure
- Rounded atraumatic edges
- Murphy's eye to protect against occlusion
- Bevelled tip to assist insertion
- Radio-opaque line to help gauge position on chest X-rays

References:
a) What is the diameter of the connector (shown by the arrow)?

b) List 2 factors which predispose to obstruction of this tube in intensive care?

Lack of humidification
Infrequent physio/suctioning
Patients with large volumes of secretions

c) List 3 design features of this device which improve its safety.

i. Clear non-toxic plastic
ii. Low profile, high volume low pressure cuff

d) Write down the formula to determine the size of the endotracheal tube required in children 1-10 yrs of age?
iii. Radio-opaque line for identification of tip on x-ray iv. Murphy’s eye
v. Left bevelled atraumatic tip
d) Write down the formula to determine the size of the endotracheal tube required in children 1-10 yrs of age?

\[(\text{Age in yrs}/4) + 4\] (Some use 4.25 or even 4.5 in the denominator and they are acceptable.

Discussion

The ETT and its various bits is discussed in greater detail elsewhere.

The connector pointed to is a 15mm connector, and there is a certain body which determines the size of connectors for airway equipment. The connectors are 15 and 22mm (internal diameters), conforming to ISO5356-1.

There are numerous factors which predispose the tubes to obstruction. The college has discussed the inspissation of secretions, and infrequent physiotherapy, but there are many other possibilities, such as clots due to pulmonary haemorrhage, or kinking because of patient chewing on the tube.

Safety features of the ETT are familiar. Question 30.1 from the second paper of 2013 asks this exact same thing. In summary:

- Single use item, no risk of cross-infection
- Standardised 15mm connector to fit all airway devices
- Low-allergen PVC construction, free of latex
- Transparent body, to see blood or vomit
- Markings to indicate depth of insertion
- Black line to guide insertion to appropriate depth
- High volume low pressure cuff to seal the trachea
- Size labelling on pilot balloon
- Pilot cuff to gauge cuff pressure
- Rounded atraumatic edges
- Murphy’s eye to protect against occlusion
- Bevelled tip to assist insertion
- Radio-opaque line to help gauge position on chest X-rays

There are actually several methods to guide ETT selection in children:

- diameter of the pinky finger
- \[(\text{Age in years} + 16)/4\]
- The Khine formula: \[(\text{Age} /4) + 3\]
- Broselow paediatric tape

The formula quoted by the college is also the one they teach you in the APLS course, so perhaps it has been locally accepted as the right formula for any young Australian larynx.

References:


**Question 5**

**Compare and contrast the information generated by and the usefulness of mixed venous oxygen saturation (SvO2) and central venous oxygen saturation (ScvO2) monitors.**

[Hide Answer]

**College Answer**

<table>
<thead>
<tr>
<th></th>
<th>SvO2</th>
<th>ScvO2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurement</strong></td>
<td>Pulmonary artery</td>
<td>Superior vena cava</td>
</tr>
<tr>
<td><strong>Invasiveness</strong></td>
<td>Invasive</td>
<td>Less invasive than SvO2</td>
</tr>
<tr>
<td><strong>Physiology</strong></td>
<td>SvO2 is &gt; than ScvO2 as it contains blood from both SVC and IVC</td>
<td>ScvO2 is &lt; SvO2 because it contains predominantly SVC blood which is lower than IVC blood saturation</td>
</tr>
</tbody>
</table>
| **Situations where SCvO2 > SvO2** | a) Anaesthesia – because of increase in CBF & depression of metabolism  
b) Patients with head injury where cerebral metab is depressed  
c) Shock: because of diversion of blood from splanchnic circulation, there is increased O2 extraction and therefore IVC saturation decreases.  
*** Both track each other well during shock states |
| **Other data generated from monitoring devices** | Qt, PA pressures, derived indices and body temperature measurements may be obtained  | CVP,                                          |
| **Evidence from clinical trials** | Study by Gattinoni – only RCT as far as SvO2 is | Study by Rivers- early goal directed therapy improved outcome in septic |
Discussion

The disparity between central venous and mixed venous saturation measurements is discussed in greater detail in the chapter on ScVO₂ physiology. These measurements are means of assessment of the adequacy of oxygen delivery.

A slight adjustment to the college answer is probably called for.

**A Comparison of Central Venous and Mixed Venous Saturation Measurements**

<table>
<thead>
<tr>
<th></th>
<th>SvO₂: mixed venous saturation</th>
<th>ScvO₂: central venous saturation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurement</strong></td>
<td>Pulmonary artery</td>
<td>Superior vena cava</td>
</tr>
<tr>
<td><strong>Invasiveness</strong></td>
<td>Invasive</td>
<td>Less invasive than SvO₂</td>
</tr>
<tr>
<td><strong>Blood content</strong></td>
<td>Mixed right atrial blood with blood from the coronary sinus,</td>
<td>Mixed blood from the head and</td>
</tr>
<tr>
<td><strong>Higher measurements</strong></td>
<td>: Oh's Manual specifies that under normal physiological conditions central venous saturation (ScvO₂) is 2-3% lower than mixed venous oxygen saturation (SvO₂).</td>
<td>ScvO₂ can be abnormally elevated under the following conditions:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Decreased cerebral metabolism:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Hypothermia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Anaesthesia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Decreased upper body metabolism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Paralysis</td>
</tr>
<tr>
<td><strong>Lower measurements</strong></td>
<td>SvO₂ can be abnormally depressed under the following circumstances:</td>
<td>: ScvO₂ is usually 2-3% lower than SvO₂.</td>
</tr>
<tr>
<td></td>
<td>• Increased myocardial oxygen extraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Hyperdynamic cardiac failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shock (decreased ScvO₂ in the IVC, mixing with the right ventricular blood)</td>
<td></td>
</tr>
<tr>
<td><strong>Other data generated from</strong></td>
<td>The PA catheter can measure the following variables directly:</td>
<td>CVP. Only CVP.</td>
</tr>
</tbody>
</table>
monitoring devices
- Core temperature
- RA pressure
- PA pressure
- PAWP

On top of that, thermodilution measurements can be performed, with numerous derived variables including cardiac output.

| Evidence from clinical trials | Study byGattinoni – only RCT as far as SvO2 is concerned showed no benefit from SVO2 monitoring | Study by Rivers - early goal directed therapy improved outcome in septic shock |
| Other benefits | In general no benefit from PACs. | CVCs are required for drug administration |
| Complications: | More risk from PACs | Less invasive and therefore fewer complications. |

References:
Describe the anatomy of the tracheobronchial tree, as seen down a bronchoscope inserted via an endotracheal tube.

[ Hide Answer ]

College Answer

As the bronchoscope exits the endotracheal tube, the tracheal rings are seen anteriorly. They are deficient posteriorly, where the trachealis muscle runs longitudinally. As the bronchoscope is advanced a narrow antero-posterior ridge (the carina) is seen, where the trachea divides into the right and left main bronchi. The right main bronchus is relatively in line with the trachea, while the left comes off at a greater angle. Advancing down the right main bronchus; the right upper lobe bronchus comes off laterally (3 o’clock) approximately 2 cm past the carina, and divides into the branches to the apical, anterior and posterior segments; the middle lobe bronchus is seen anteriorly (12 o’clock) and divides into the branches to the medial and lateral segments; soon after the apical segment of the lower lobe is seen posteriorly (6 o’clock); then the four basal segments are seen (medial, lateral, anterior and posterior). Pulling back to the trachea, then advancing down the left main bronchus; at approximately 5 cm the left main bronchus divides into the left upper lobe bronchus which is seen laterally (9 o’clock) and the left lower lobe bronchus. The upper lobe bronchus divides into the superior division and the lingular division. The superior division gives rise to two branches, the apicoposterior and anterior segments. The lingula gives rise to the superior and inferior segments. The lower lobe bronchus gives rise to the apical segment of the lower lobe seen posteriorly (6 o’clock), then the three basal segments (lateral, anterior, and posterior).

Fourteen out of forty-one candidates passed this question.

Discussion

A picture is worth a thousand words. However, there is no concise graphical summary of this, and one can really go berzerk with bronchial nomenclature.

The low pass rate for this question demonstrates the lack of access to quality bronchoscopy teaching in our specialty.

Additionally, the college answer seems to fail to acknowledge the need to change the orientation of the bronchoscope when advancing it. Thus, instead of coming off at 3o’clock, the right main bronchus is actually seen at 12 o’clock (because you have turned the bronchoscope in order to guide the flexible tip into the right main bronchus).

In short, these are the landmarks one encounters when performing a bronchoscopy.

- Right main bronchus
  - right upper lobe bronchus at 12 o’clock
    - branches to the apical, anterior and posterior segments
  - right bronchus intermedius
    - right middle lobe bronchus
      - 3 branches: to the right middle medial and lateral segments
- right lower lobe bronchus
  - apical segment of the lower lobe
  - four basal segments: medial, lateral, anterior and posterior
- Left main bronchus
  - left upper lobe bronchus
    - superior division
      - apicoposterior and anterior segments
    - lingular division
      - superior and anterior segments
  - left lower lobe bronchus
    - apical segment of the lower lobe
    - three basal segments: lateral, anterior, and posterior.

References:

LITFL have some excellent bronchoscopy videos.

Educational resources for bronchoscopy are available from the wonderful website of the American Thoracic Society.

Additionally, ThoracicAnaesthesia.com has a full-on virtual bronchoscopy simulator which is essentially a Flash-based game, and which is disturbingly fun to play with.

Lastly, bronchoscopy.org is probably the definitive resource for all this, and represents the pinnacle of bronchoscopic excellence. Their bronchoscopic anatomy poster is the best thing ever.
Compare and contrast the advantages and disadvantages of humidification of a ventilator circuit using a wet circuit versus a Heat and Moisture Exchanger.

College Answer

Wet ventilator circuits require power for heating, a chamber for water to be heated, and temperature sensors to feedback appropriate temperature within chamber and ideally to within circuit. Benefits include potential for optimal efficiency (under all circumstances), reliability, ability to warm patient, and proven track record of safety. Disadvantages include potential for condensation (rain-out) with excessive (potentially hot) fluid delivery to airways, microbiological colonisation, lack of transportability, and increased cost.

Heat and moisture exchangers come in a variety of types (with more emphasis on humidification and/or microbiological filter). Benefits include ease of use (including during transport), lower staff workload, lower costs and potential for decreased ventilator associated pneumonia [Kola, Intensive Care Med (2005) 31:5-11]. Disadvantages include inability to use with all patients (eg. those haemoptysis, tenacious secretions, increased airway resistance, ARDS), problems with increased dead space and resistive load, and potential for airway occlusion.

Discussion

The various features of the HME are discussed in greater and more general detail elsewhere. A good article which is both recent and detailed is this 2014 piece from BioMed Research International.

This question would benefit from a tabulated answer.

### Comparison of Circuit Humidification and Heat/Moisture Exchangers

<table>
<thead>
<tr>
<th>Device description</th>
<th>A hygroscopic in-line air filter</th>
<th>A circuit which incorporates an inline heated water chamber, with an integrated thermostat-controlled heating element</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Cheap</td>
<td>Expensive - both the device and the attached consumables</td>
</tr>
<tr>
<td>Reusability</td>
<td>Single-use</td>
<td>Reusable humidified, disposable circuit</td>
</tr>
<tr>
<td>Workload</td>
<td>Minimal</td>
<td>Requires attention to water replacement and occasional troubleshooting</td>
</tr>
<tr>
<td>Humidification efficiency</td>
<td>Low efficiency; approximately 50% of the required humidity is achieved.</td>
<td>Highly efficient. Humidity achieved ranged from 33mg/L to 44mg/L, which is near to the humidity achieved by the human respiratory</td>
</tr>
</tbody>
</table>
The devices are expected to produce a consistent level of humidity around 30mg/L; whereas 20mg/L is the more typical performance

### 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.

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**References:**


Compare and contrast the advantages and disadvantages of enteral feeding via a nasogastric tube, a PEG and a percutaneous feeding jejunostomy.

[ Hide Answer ]

College Answer

Nasogastric tube: simple, commonly used, cheap, can assess and retrieve residual gastric contents (depends on tube size), advantages of gastric feeding (tolerant of bolus and continuous feeds, buffers gastric acids, bactericidal action of acid, gastric pepsin and lipase facilitate absorption of most feeds)

BUT aesthetic appearance, potential trauma of insertion, potential misplacement during insertion (especially critically ill), requires radiological confirmation of placement, easily dislodged, sinusitis, increase aspiration risk (less competence gastro-oesophageal sphincter), potential for gastric distension, tolerance of feeding susceptible to gastroparesis (emesis, regurgitation).

PEG: avoids nose/mouth issues, better tolerated than nasogastric, less likely to be displaced than nasogastric, can assess and retrieve gastric contents (if large bore and in stomach), advantages of gastric feeding (see above), avoids interfering with gastro-oesophageal sphincter

BUT more complex to insert, less commonly performed, more expensive tube, requires endoscopy (with associated complications), percutaneous wound, often larger bore tube with potential for trauma and displacement, potential for gastric distension, tolerance of feeding susceptible to gastroparesis (emesis, regurgitation).

Percutaneous feeding jejunostomy: avoids nose/mouth issues, better tolerated than nasogastric, less likely to be displaced than others, avoids interfering with gastro-oesophageal sphincter, bypasses stomach and allows earlier feeding (avoids gastric distension and problems of gastroparesis), theoretically better for pancreatitis (less pancreatic exocrine secretion)

BUT more complex to insert, less commonly performed, more expensive tube, requires endoscopy &/or surgery (with associated complications), percutaneous wound, small bore tube with potential for displacement and blockage (eg. with enteral drugs), less tolerant of bolus or high volume infusions.

Discussion

Elsewhere, there is a brief summary of the routes of enteral nutrition, and it contains this table, which is essentially a tabulated form of the stream-of-consciousness answer offered by the college.
## Enteral Feeding Routes

A Comparison of the Nasogastric Tube, Percutaneous Endogastic Tube and Feeding Jejunostomy

<table>
<thead>
<tr>
<th>Nasogastric</th>
<th>Nasojejunal tube</th>
<th>PEG tube</th>
<th>Feeding jejunostomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to insert</td>
<td>Decreased risk of aspiration.</td>
<td>Improved tolerance in the awake patient</td>
<td>Improved tolerance in the awake patient</td>
</tr>
<tr>
<td>The tubes are cheap</td>
<td>Decreased stimulus to pancreatic secretion.</td>
<td>None of the facial pressure are complications</td>
<td>None of the facial pressure are complications</td>
</tr>
<tr>
<td>Gastric aspiration is possible</td>
<td></td>
<td>No sinusitis or mucositis</td>
<td>No sinusitis or mucositis</td>
</tr>
<tr>
<td>Gastric food delivery buffers gastric acids and protects the gastric mucosa</td>
<td></td>
<td>No risk of oesophageal stricture</td>
<td>No risk of oesophageal stricture</td>
</tr>
<tr>
<td>The gastric acid has a bactericidal action which helps prevent gastroenteritis</td>
<td></td>
<td>Better tolerance in the extremely long term (one can have a percutaneous tube for their entire life)</td>
<td>Better tolerance in the extremely long term (one can have a percutaneous tube for their entire life)</td>
</tr>
<tr>
<td>Gastric secretions (gastric pepsin and lipase) facilitate absorption of feeds, which means one is not limited to any specialised feed mixtures</td>
<td></td>
<td>Nice, large bore tube - less likely to block</td>
<td>Nice, large bore tube - less likely to block</td>
</tr>
<tr>
<td>Uncomfortable in the awake patient</td>
<td>Uncomfortable in the awake patient</td>
<td></td>
<td>Uncomfortable in the awake patient</td>
</tr>
<tr>
<td>It is easily dislodged by a delirious patient</td>
<td>Difficult to place.</td>
<td>Needs to be surgically placed</td>
<td>Needs to be surgically placed</td>
</tr>
<tr>
<td>It may increase aspiration risk because the gastro-oesophageal sphincter is less competent when there is something constantly in it.</td>
<td>Not exactly cheap</td>
<td>Requires endoscopy to position</td>
<td>Requires endoscopy, or more usually laparoscopy, to position</td>
</tr>
<tr>
<td>Decreased risk of aspiration.</td>
<td>One must wait for the tip to migrate into the jejunum</td>
<td>Risk of early dislodgement and loss of the immature fistula tract</td>
<td>Risk of early dislodgement and loss of the immature fistula tract</td>
</tr>
<tr>
<td>Decreased stimulus to pancreatic secretion.</td>
<td>Impossibly to administer large boluses.</td>
<td>Tube can block unless it is wide-bore</td>
<td>Tube can block unless it is wide-bore</td>
</tr>
<tr>
<td>Gastric mucosa is unprotected from acid, and loses trophic stimulus</td>
<td>Gastric mucosa is unprotected from acid, and loses trophic stimulus</td>
<td>Skin erosion and ulceration may take place.</td>
<td>Skin erosion and ulceration may take place.</td>
</tr>
<tr>
<td>The feeds do not benefit from the bactericidal activity of stomach acid</td>
<td>The feeds do not benefit from the bactericidal eactivity of stomach acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absorption may be impaired due to the loss of gastric pepsin and lipase; specialised mixtures may be required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
emptying is not an issue
• Decreased stimulus to pancreatic secretion.

References:

M Keymling Technical aspects of enteral nutrition Gut 1994; supplement 1: S77-S80

Hayden White1*, Kellie Sosnowski1, Khoa Tran1, Annelli Reeves2 and Mark Jones A randomised controlled comparison of early post-pyloric versus early gastric feeding to meet nutritional targets in ventilated intensive care patients. Critical Care 2009, 13:R187 doi:10.1186/cc8181


Identify the item of equipment depicted in the image below.

- Outline how you would ensure correct position of the balloon labelled 'A' on insertion.
- List three complications of its use AND for each complication briefly outline the relevant precautions you would take.

[ Hide Answer ]

College Answer

a)

Sengstaken-Blakemore tube
(Gastro-oesophageal balloon tamponade device or Minnesota tube acceptable)

b)

- Estimate appropriate length of tube to be inserted for the patient
- Evaluation of compliance curve of gastric balloon pre-insertion by inflation of balloon with incremental 100ml aliquots of air to maximal recommended volume (usually 250-300ml for SBT, 450-500ml for Minnesota) and notation of corresponding balloon pressure at each step.
- If, post-insertion, balloon pressure on inflation with a given volume is >15 mmHg than the pre-insertion pressure, the balloon may be in the oesophagus and should be deflated and position
iii) Check balloon position with Xray or ultrasound post insertion

Any other acceptable technique.

E.g.: inflate gastric balloon with no more than 80 ml of air (or contrast) and confirm position on AXR or via gastroscope then inflate gastric balloon slowly to a volume of 250-300 ml (up to 450 for Minnesota tube) and clamp balloon inlet.

c) Aspiration:

- Use only in intubated patient and position patient head-up 30-45°

Oesophageal perforation:

- Ensure both balloons completely deflated prior to insertion
- Avoid inflation of oesophageal balloon
- Ensure gastric balloon is correctly positioned during inflation

Pressure necrosis of gastric mucosa:

- Do not leave SBT in situ for more than 24-36 hr
- Avoid prolonged inflation of gastric balloon – deflate after 12 hr and reinflate if ongoing bleeding

Upper airway obstruction secondary to balloon migration:

- Avoid use in unintubated patient. If SBT in unintubated patient and develops respiratory distress, immediately cut lumens for oesophageal and gastric balloons and remove tube

Discussion

The college had omitted their own image. The picture above was stolen from www.medipicz.com.

The college say “Minnesota tube acceptable”. But... is it really? Is there any difference between them?

Well. Yes there is.

The Minnesota tube is actually a modified version of the original Sengstaken-Blakemore device. The modification is an oesophageal suction port, which prevents the pooling of filth in the upper oesophagus. You can tell them apart instantly - the Minnesota tube has four ports at the end, whereas the SB tube has only three. One can also have a Linton-Nachlas tube, which only has two ports, and a single 600ml gastric balloon.

Thus, the device in my picture is properly called a Sengstaken-Blakemore tube, and to call it a Minnesota tube would just be plain wrong.

Now then.

The balloon labelled 'A’ is the gastric ballon. It inflates to a considerable diameter, and so it is fairly important that you do not inflate it in the oesophagus. Hence the anxiety regarding its position.

One can do this in a number of ways. The college would have accepted ‘any other acceptable technique’.

For instance:

- One can inflate it with a safe 80mls of air, and look for its position on AXR
- One can inflate it with radio-opaque contrast, and look for its position on AXR
- One can position it under direct vision during gastroscopy
- One can compare the balloon pressure pre and post insertion (as suggested by the college), observing a change of 15mmHg as a sign that it is in the oesophagus.

The complications and preventative measures are best presented in the form of a table:

<table>
<thead>
<tr>
<th>Complications of Sengstaken-Blakemore Tube Insertion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspiration</td>
</tr>
<tr>
<td>- Use only in intubated patients</td>
</tr>
<tr>
<td>- Sit the patient up to 45°</td>
</tr>
</tbody>
</table>
Aspirate all gastric content before inflating the gastric balloon

| Oesophageal rupture | Ensure both balloons completely deflated prior to insertion |
|                     | Avoid inflation of oesophageal balloon |
|                     | Ensure gastric balloon is correctly positioned during inflation |

| Gastric balloon migration; upper airway obstruction | Only use in intubated patients |
|                                                    | Avoid inflation of oesophageal balloon |
|                                                    | Ensure gastric balloon is correctly positioned during inflation |
|                                                    | Oesophageal necrosis |
|                                                    | Only use in intubated patients |
|                                                    | Avoid using this device for longer than 24-36 hrs |
|                                                    | Avoid using traction for prolonged periods |
|                                                    | Deflate the balloon regularly to check for rebleeding |
|                                                    | Monitor the gastric/oesophageal pressure carefully - keep it under 15mmHg |

What are the indications for the use of the SB tube? There really is only one. Control of variceal bleeding. However, others have used it to tamponade uterine bleeding, which can possibly extend to rectal bleeding via protocol creep.

What are the contraindications for the use of the SB tube?

Well;

- Unprotected airway
- Oesophageal rupture (eg. Boerhaave syndrome)
- Oesophageal stricture
- Uncertainty regarding the source of bleeding (how do you know it is not duodenal?)

References:


Critically evaluate the use and limitations of End-Tidal Carbon Dioxide measurement in Intensive Care practice.

College Answer

Measurement of ETCO2 implies the use of a quantitative device, and usually this is one which allows assessment of waveform morphology (ETCO2 vs time). Specific roles include: confirmation of tracheal placement of artificial airway, pattern recognition of ETCO2 waveform, use of value of ETCO2 during cardiac arrest or hypotensive states, prediction of arterial PaCO2.

Confirmation of tracheal placement is highly sensitive and specific in the presence of pulmonary blood flow. False negative values may occur with minimal pulmonary blood flow, but should not usually occur with adequate CPR. False positives are very uncommon and short lived (eg. CO2 in stomach).

Waveform pattern can assist in the diagnosis in particular of expiratory flow obstruction (and gas trapping) and attempts at spontaneous breathing particularly during apnoea testing.

During cardiac arrest, the absolute level of ETCO2 is proportional to pulmonary blood flow (and hence cardiac output). It may be used to guide cardiac compression, but apart from this it adds little to prognostication (ie. confirms patient that patient likely to die is likely to die). Sudden decreases in ETCO2 may be indicative of the decrease in pulmonary blood flow associated with pulmonary emboli.

Prediction of PaCO2 from ETCO2 is fraught with difficulty. Very few candidates demonstrated an understanding of this area. The major limiting factors are pulmonary blood flow and V/Q balance. Unless these factors are constant, even the trending of the relationship of between PaCO2 and ETCO2 unreliable. Unfortunately if the PaCO2 is important (eg. major head injuries), it must be measured.

Utility in neonates and children may be impaired by small tidal volumes.

Discussion

Though EtCO2 has been discussed in Question 9.2 from the second paper of 2008, it was not a "critically evaluate" style of question.

A systematic "critical evaluation" should resemble the following:

- 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

- 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

- Continuous monitoring
- Immediate feedback regarding cardiac output and ETT position
- Waveform analysis is possible
- Cheap
- Increased safety; decreased risk of undetected airway circuit disconnection

- 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)

- 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

Capnography is discussed in greater detail elsewhere:

- The normal capnometry waveform
- The relationship of abnormal capnograph waveforms to lung pathology

There is also an excellent site by Prasanna Tilakaratna which explains infra-red absorption spectrophotometry using vividly colourful diagrams.

References:

The best, most detailed review:


Outline the advantages and limitations of various methods for induction of therapeutic hypothermia.

[ Hide Answer ]

**College Answer**

Therapeutic hypothermia can be induced by a number of methods. These differ in their ease of use and the rapidity of onset of hypothermia. In all cases, irrespective of the methods used, core temperature should be monitored, as should be invasive arterial pressure, ECG etc. Shivering needs to be suppressed with sedation +/- muscle relaxants.

The various methods are outlined below:

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface cooling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulating cold water</td>
<td>Readily available</td>
<td>Slow – takes up to 8 hours to reduce temp to 32-34°C</td>
</tr>
<tr>
<td>blankets</td>
<td>Easy to use</td>
<td>Titration of temperature can be difficult</td>
</tr>
<tr>
<td>Forced cold air</td>
<td>Relatively cheap</td>
<td>Ice packs carry risk of burns</td>
</tr>
<tr>
<td>convective blankets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice packs to axillae,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>groin etc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol and fans</td>
<td>Cheap</td>
<td>Use of fans not practical in ICU</td>
</tr>
<tr>
<td>Immersion in ice bath</td>
<td></td>
<td>Limited practical use</td>
</tr>
<tr>
<td>Newer devices</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling garment / pads /</td>
<td>Increased efficiency</td>
<td>Cost</td>
</tr>
</tbody>
</table>
Discussion

The college has presented an excellent tabulated answer. Following such an effort, one can do little other than provide references.

One such reference is a 2009 article by Kees Polderman and Herold Ingeborg which goes though cooling methods listing their advantages and limitations. In this article, I was surprised to find a table (Table 2) which is almost identical to the college answer - only more detailed. The table is huge, it spans over two pages, and the article as a whole is an amazing resource. This paper, sadly, is not available as a free full text offering. The table below is a stripped-down surrogate.

### Methods of Inducing Therapeutic Hypothermia

<table>
<thead>
<tr>
<th>Methods</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooling by skin exposure</td>
<td>Easy, cheap, and without procedural risk</td>
<td>Not very effective. And you cannot rewarm them this way.</td>
</tr>
<tr>
<td></td>
<td>Cooling rate is around 0.5°C</td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>Effort, cost, and risk</td>
<td>Unique effects</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Air cooling with electric fans</td>
<td>Easy, cheap, and without procedural risk</td>
<td>As you fan the patient, you blow aerosolised pathogens all around your ICU, which is a potential infection risk. And you cannot rewarm them this way.</td>
</tr>
<tr>
<td></td>
<td>Cooling rate is around 1.0℃ per hour</td>
<td></td>
</tr>
<tr>
<td>Evaporative air cooling by skin exposure with alcohol, water, sponge baths etc</td>
<td>Easy, cheap, and without much procedural risk.</td>
<td>Labour intensive.</td>
</tr>
<tr>
<td></td>
<td>Cooling rate is around 1.0℃ per hour</td>
<td>The patient ends up wet - that may be a major problem for patients with wounds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alcohol is not benign, it may absorb into eroded skin areas and it may irritate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electrical safety becomes a concern with exposed transvenous or epicardial pacing wires. And you cannot rewarm them this way.</td>
</tr>
<tr>
<td>Air cooling with an inflatable blanket</td>
<td>Easy, cheap, and without procedural risk</td>
<td>Not any more effective effective than cooling by passive air-skin exposure.</td>
</tr>
<tr>
<td></td>
<td>Frequently the ICU will already have one.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cooling rate is around 0.5℃ per hour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>One can change the air temperature, and rewarm the patient in this fashion.</td>
<td></td>
</tr>
<tr>
<td>Specially designed air-cooling beds (with an air-pumped inflating mattress)</td>
<td>Without procedural risk, and potentially offering a protection against pressure areas.</td>
<td>Expensive and noisy.</td>
</tr>
<tr>
<td></td>
<td>Cooling rate is around 1.0℃ per hour</td>
<td>Not available everywhere</td>
</tr>
<tr>
<td></td>
<td>One can change the air temperature, and rewarm the patient in this fashion.</td>
<td></td>
</tr>
<tr>
<td>Surface cooling by ice packs</td>
<td>Easy and cheap.</td>
<td>Labour intensive.</td>
</tr>
<tr>
<td></td>
<td>Cooling rate is around 1.0℃ per hour</td>
<td>Uneven cooling - some areas may have little cooling while other areas may develop frostbite or pressure areas.</td>
</tr>
<tr>
<td>Surface cooling by immersion in cold water</td>
<td>Rapid cooling rate: around 8-10℃ per hour</td>
<td>Impractical for large patients - this technique may only be suitable for infants and children.</td>
</tr>
<tr>
<td></td>
<td>Cold water is inexpensive.</td>
<td>The patient ends up wet - that may be a major problem for patients with wounds.</td>
</tr>
<tr>
<td></td>
<td>It may be possible to rewarm</td>
<td></td>
</tr>
</tbody>
</table>
the patient this way by changing the bath temperature.

Unusual problems arise with attempting to ventilate a partially submerged patient.

Electrical safety becomes a concern with exposed transvenous or epicardial pacing wires.

<table>
<thead>
<tr>
<th>Method</th>
<th>Cooling Rate</th>
<th>Additional Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface cooling by skin contact with circulating cold water in a cooling blanket</td>
<td>Good cooling rate: around 1.5°C per hour</td>
<td>Cold water is inexpensive. Changing the water temperature can be used to rewarm the patient. Some systems can be coupled in feedback with a temperature probe for more accurate temperature maintenance.</td>
</tr>
<tr>
<td>Surface cooling by skin contact with circulating cold water in a cooling vest</td>
<td>Rapid cooling rate: around 8-10°C per hour</td>
<td>The cooling blankets may be reusable, but the jackets are not - and these can be expensive. The jackets may leave marks on the skin, and theoretically could cause pressure areas.</td>
</tr>
<tr>
<td>Infusion of cold fluids</td>
<td>Easy and cheap.</td>
<td>A large volume of fluid needs to be infused; this may result in electrolyte derangement and fluid overload. The patient cannot be rewarmed in this way. Also, there is little control over the temperature which is achieved in this way. Lastly, exposure of the myocardium to a jet of cold fluid may result in arrhythmias and asystole.</td>
</tr>
<tr>
<td>Peritoneal lavage with cold fluids</td>
<td>Potentially, a good cooling rate</td>
<td>Invasive, requires some surgical expertise. Infused cold fluids will be absorbed to some extent, giving rise to electrolyte abnormalities. The patient cannot be rewarmed in this way.</td>
</tr>
<tr>
<td>Method</td>
<td>Cooling Rate</td>
<td>Additional Considerations</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Intravascular cooling catheters:</td>
<td>Good cooling rate: around 2.0°C per hour</td>
<td>Invasive, expensive, and disposable. Catheter-related thrombosis may be an issue.</td>
</tr>
<tr>
<td>balloons filled with cold saline,</td>
<td>Most of these double as central lines, offering central venous access and central temperature monitoring</td>
<td></td>
</tr>
<tr>
<td>metal catheters for heat exchange,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extracorporeal circuit cooling</td>
<td>Rapid cooling rate: around 4-6°C per hour</td>
<td>Very invasive. Major disadvantage due to the need for anticoagulation.</td>
</tr>
<tr>
<td></td>
<td>Convenient if the patient is already on ECMO or CVVHDF; little additional workload.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The patient can also be rewarmed in this way.</td>
<td></td>
</tr>
<tr>
<td>Antipyretic drugs</td>
<td>Easy and cheap.</td>
<td>Poor cooling rate: 0.1-0.5°C per hour</td>
</tr>
</tbody>
</table>

References:


The images (Image A and Image B) below depict a mechanical / automated chest compression device.

With respect to the use of these devices in cardiopulmonary resuscitation:

a) What are the potential advantages of these devices over standard practice? (40% marks)

b) What are the potential disadvantages associated with their use? (30% marks)

c) Summarise the role of these devices in clinical practice. (30% marks)

College Answer

a)

- Consistent quality CPR
- Decreases number of personnel required to run the arrest (remote locations)
- Reduced interruptions to chest compressions
- Defibrillation can be administered during compressions
- Improves ability to perform procedures such as ECMO insertion, percutaneous coronary intervention.
- Improves ability to transport patient to definitive care while performing effective CPR.

b)

- Increased “hands-off” time due to delay in application of the device
- Visceral injuries- lung, liver, spleen, gastric
- Rib and sternal fractures
- Bleeding-mediastinal, epicardial, pericardial, aortic (rate of injuries with mechanical CPR are probably higher than those seen with manual CPR)

c)

- Randomised controlled trials (CIRC, LINC, ParaMeDiC) have shown no improvement in outcome when comparing these devices to manual compressions
- May have a role in transporting patients, during procedures or in settings where there are limited personnel
- May contribute to good outcomes when used as part of an aggressive interventional bundle,
Discussion

The following answer pertains mainly to the Zoll Autopulse and the LUCAS Device.

- CPR is of uniform (presumably, high) quality.
- CPR is not interrupted for defibrillation.
- Angiography or ECMO cannulation may take place with CPR in progress.
- The device is more portable than a group of rescuers.

- The device takes time to set up. This is time "off the chest".
- An incorrectly aligned device might actually perform poorer compressions than a rescuer, because a rescuer corrects their own position.
- There may be more injuries: in the CIRC trial for example the rate of rib fractures was almost doubled (from 31 to 69 out of ~2100 patients), and the risk of pneumothorax increased by a third (those guys were using the Zoll).
- Other theoretical injury patterns include liver, lung, spleen and stomach lacerations, as well as mediastinal or aortic trauma. It is assumed that this will not be seen with normal human CPR because the humans perform weaker CPR on average, i.e. the machine is too effective.

- CIRC (Wik et al, 2014)
- LINC (Rubertsson et al, 2014)
- PARAMEDIC (Perkins et al, 2015)
- CHEER (Stub et al, 2015)
- Gates et al (2015) - a meta-analysis of all of the above: did not find any benefit in in-hospital mortality, rates of ROSC or neurological recovery. Moreover there did not seem to be any difference between the two devices.

- Use where CPR will be prolonged, and consistent quality will be required
  - Cardiac arrest due to hypothermia
  - Cardiac arrest following thrombolysis for PE or MI
- Use where rescuers are few, or unskilled:
  - Pre-hospital setting
  - Rural and regional setting
- Use where space is limited
  - Aeromedical retrieval
  - Ambulance transport
  - Interventional radiology suite
- Use as a part of a larger ECPR bundle a’la CHEER

References:


Steen, Stig, et al. “The critical importance of minimal delay between chest compressions and subsequent


