

**EXAMPLE 1****Question**

A 35 year-old international student with diabetes mellitus is seen in the pain clinic with a six month history of left wrist pain after a bite from her cat. A year previously, she experienced the same symptoms and was investigated by nerve conduction studies that did not show abnormalities in the large nerve fibres of the left upper limb. Local examination by palpation around her left wrist revealed the presence of allodynia, hyperaesthesia, radial and ulnar pulses, and a colder sensation compared with the right wrist. Appropriate statements regarding initial investigations that may be helpful in confirming the possibility of complex regional pain syndrome include:

- a) serial plain radiographs
- b) 3-phase bone scan of the left wrist
- c) dermal temperature testing over the left wrist using infrared video thermography
- d) sympathetic ganglion block
- e) Quantitative Sensory Testing.

**Answers**

- a) True. Serial bone radiographs would help in showing the extent of osseous involvement. Given that the patient presents with a 6-month history, there is a probability of osseous involvement and hence, serial bone radiographs and a 3-phase bone scan would help in delineating osseous involvement in this particular patient.
- b) True. 3-phase bone scan may be helpful in diagnosing complex regional pain syndrome. The earliest changes in bone are highlighted by the 3-phase bone scan well before clinical manifestations such as bone pain and spontaneous fractures. The three phases of a 3- phase bone scan are the: blood pool phase, blood phase and scan phase. Abnormal results include abnormal blood flow patterns in the first two phases and an increase in uptake of Technitium-99m labelled bisphosphonate (the tracer) into periarticular tissue in the scan phase.
- c) False. Infrared thermography enables detection of subtle changes in skin temperature but is not required in this scenario since there is clinical evidence of a temperature change between the left and right wrists. Also, thermography is an investigation that is not readily available in most hospitals and is considered as a research tool.
- d) True. In complex regional pain syndrome, it is believed that there is an overactive sympathetic nervous system leading to vasoconstriction and tissue hypoxia. Block of the sympathetic ganglia

helps to relieve pain and other symptoms by improving vasodilatation and oxygen delivery. Thus, sympathetic blocks may help to clarify the diagnosis of complex regional pain syndrome.

e) True. Quantitative Sensory Testing may be helpful in characterizing complex regional pain syndrome for the following reasons:

- It helps to map areas of sensory deficit which may be larger than that found on clinical examination.
- It is widely believed that there is involvement of the small nerve fibres in complex regional pain syndrome. This investigation helps to differentiate the extent but not the cause of involvement of small and large nerve fibres.

In this particular patient, the presence of diabetes could be a confounding factor as she may have diabetic neuropathy causing neuropathic pain.

**EXAMPLE 2****Question**

A 30 year old man presents to the Emergency Department after a traumatic amputation below his right knee. Whilst awaiting intravenous cannulation for resuscitation with fluids, a tourniquet is applied to the right thigh. Unfortunately, there is on-going blood loss which is estimated to be 1.5 litres. This patient is likely to:

- a) be hypotensive and bradycardic.
- b) have reduced production of inflammatory mediators including cytokines and oxidants.
- c) be coagulopathic due to dilution of clotting factors.
- d) have a renal blood flow of  $1.5 \text{ litres min}^{-1}$ .
- e) have microcirculatory hypoxia caused by vasoconstriction.

**Answers**

- a) False. 1.5 litres is equivalent to 20-30% of blood volume. Stimulation of the sympathetic nervous system causes a peripheral vasoconstriction and tachycardia. Bradycardia does not occur until 40% of circulating blood volume has been lost.
- b) False. Bleeding leads to poor tissue perfusion that induces an inflammatory response characteristic of ischaemic-reperfusion injury, with increased production of cytokines and oxidants.
- c) False. In this scenario, no intravenous fluids have been administered and so there is no dilution and no coagulopathy. Dilution occurs after administration of fluids that do not contain clotting factors.
- d) False.  $1.5 \text{ litres min}^{-1}$  is an increased blood flow. The blood flow would in fact be reduced as blood is diverted away from the non-vital organs to maintain perfusion to the vital organs.
- e) True. Pre-capillary vasoconstriction leads to stagnant, hypoxic blood flow to the microcirculation.

**EXAMPLE 3****Question**

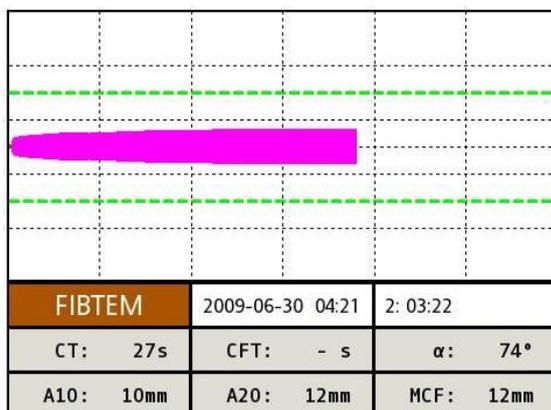
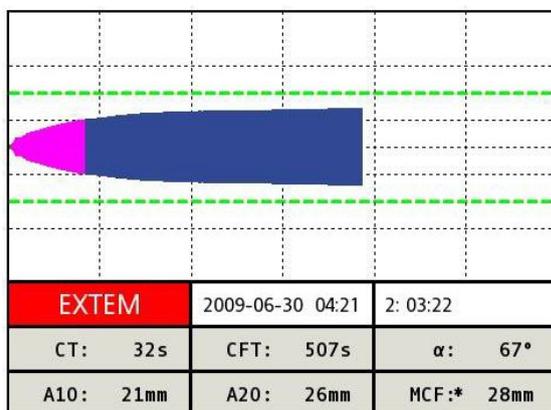
Despite fluid resuscitation with packed red blood cells and fresh frozen plasma, the patient continues to bleed from the stump. Thromboelastometry of whole blood is performed using a Rotational Thromboelastometry (ROTEM®) machine. Initial ROTEM® results by the external thromboelastometry (EXTEM) are:

Clotting Time (CT) 32 seconds (normal range is 38-79 s)

Clot Formation Time (CFT) 507 seconds (normal range is 34-159 s)

Maximum Clot Firmness (MCF) 28mm (normal range is 50 – 72 mm)

The FIBTEM MCF is 16 mm (normal range is 10-25 mm)



Appropriate statements regarding this patient's coagulation include:

- He requires platelets.
- These values are associated with a lower risk of multiorgan failure than if his ROTEM was in the normal range.

Examples of multiple choice questions.

- c) Laboratory tests are required in addition to ROTEM® in order to assess clot initiation and clot strength.
- d) The results are consistent with a reduction in haemoglobin levels.
- e) He requires fresh frozen plasma (FFP).

### **Answers**

- a) True. The EXTEM, showing a prolonged CFT and a reduced MCF, suggests platelet or fibrinogen deficiency. Since the MCF in the FIBTEM is normal, the deficiency is due to platelet function, not fibrinogen deficiency. Therefore, transfusion of platelets is indicated. During coagulopathy induced by trauma, the platelets present may not be functioning effectively. This problem cannot be assessed using the ROTEM alone. A platelet assay would be needed.
- b) False. There is an increased risk of multi-organ failure. The presence of coagulopathy on admission carries an increased mortality as it can lead to Systemic Inflammatory Response Syndrome (SIRS) and multi organ failure.
- c) False. ROTEM® gives a dynamic interpretation of whole blood clotting and can be used to monitor clot initiation, strength, fibrinolysis, fibrinogen and platelets. Additional laboratory tests are not required to assess clot initiation and clot strength.
- d) False. ROTEM® does not give any information about the level of haemoglobin. Haemoglobin must be assessed using a Full Blood Count or an arterial blood gas sample.
- e) True. The CT is prolonged implying prolonged clot initiation. Since clot initiation is dependent on clotting factors, transfusion with FFP is indicated.

**EXAMPLE 4****Question**

A 45 year old man presents to your elective orthopaedic list for a total knee replacement. He has a family history of haemophilia and has been diagnosed with mild haemophilia A. Previously, he has received repeated transfusions of blood, fresh frozen plasma (FFP) and factor VIII. His airway and other system examinations are unremarkable.

Blood tests show [reference values in brackets]:

haemoglobin:  $102 \text{ g L}^{-1}$  [120-180  $\text{g L}^{-1}$ ],  
 platelets:  $250 \times 10^9 \text{ L}^{-1}$  [150-400  $\times 10^9 \text{ L}^{-1}$ ],  
 prothrombin time: 13 seconds [12-14],  
 International Normalised Ratio (INR): 1 [0.8-1.1],  
 activated partial thromboplastin time: 55 seconds [28-39],  
 factor VIII levels:  $0.15 \text{ IU mL}^{-1}$  [0.5-1.5  $\text{IU mL}^{-1}$ ],  
 sodium:  $138 \text{ mmol L}^{-1}$  [135-147  $\text{mmol L}^{-1}$ ],  
 potassium:  $4.0 \text{ mmol L}^{-1}$  [3.5-5.0  $\text{mmol L}^{-1}$ ],  
 urea:  $4.5 \text{ mmol L}^{-1}$  [2.5-7.8  $\text{mmol L}^{-1}$ ],  
 creatinine:  $70 \text{ } \mu\text{mol L}^{-1}$  [55-125  $\mu\text{mol L}^{-1}$ ]

Appropriate statements regarding an anaesthetic plan include:

- a) Despite correction of factor deficiency for surgery, either regional anaesthesia or peripheral nerve block would be contraindicated during general anaesthesia.
- b) Postoperative analgesia consisting of regular paracetamol, naproxen and codeine phosphate would be beneficial.
- c) Preoperative restoration of factor VIII levels is likely to be sufficient.
- d) To manage bleeding, FFP is likely to be administered.
- e) Recombinant activated factor VIIa (rFVIIa) would be contraindicated.

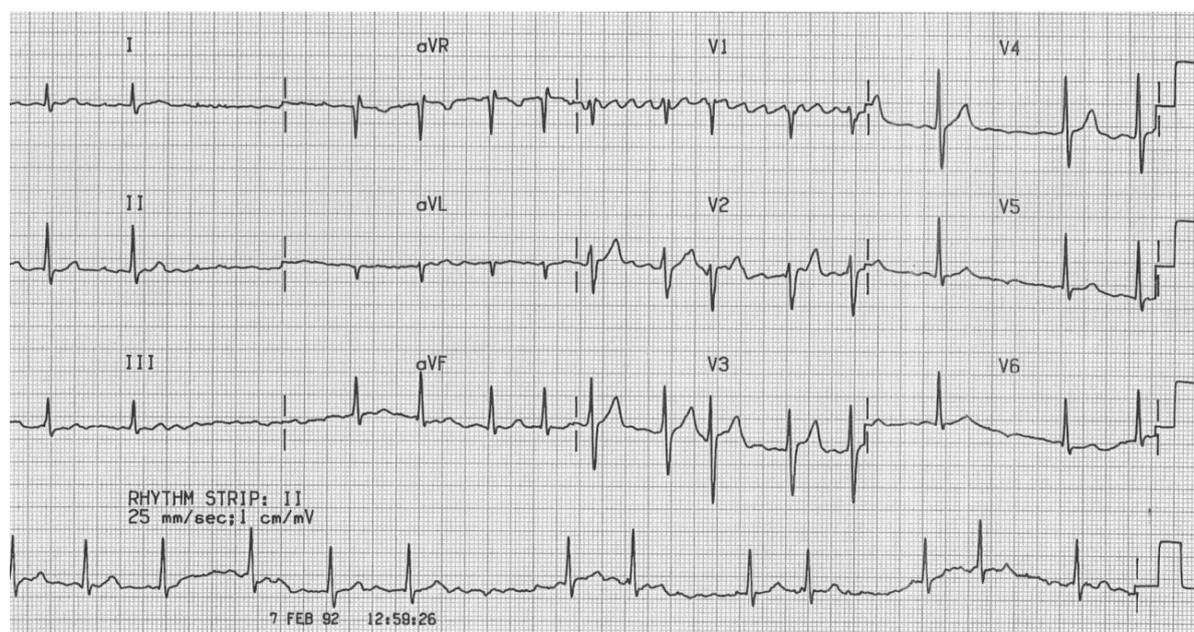
**Answers**

- a) False. The risk-benefit ratio of regional anaesthesia must be assessed on a case-by-case basis after correction of deficient factor levels. A femoral nerve block is likely to be a useful adjunct to a general anaesthetic.
- b) False. Paracetamol and codeine can be used. Paracetamol has mild anti-inflammatory effects. However, naproxen can cause platelet dysfunction and aggravate post-operative bleeding; it should be avoided.
- c) False. Deficient factor levels must be monitored both preoperatively and postoperatively. They must be maintained within normal range (50-150%) during the perioperative period and for 4 to 6 weeks after major orthopaedic and joint replacement surgery.
- d) False. FFP should not be used due to risks of volume overload and transmissible infections. Recombinant factor VIII (available as lyophilised powder) should be used for replacement. An intravenous infusion of factor VIII,  $1 \text{ unit kg}^{-1}$  will raise the plasma factor VIII level by approximately 2%. (half-life of factor VIII = 8–12 hours). Highly purified factor VIII concentrates derived from plasma of donors can be used in the absence of recombinant factors.
- e) False. rFVIIa would not be contraindicated. Owing to previous transfusions of FFP or unpurified factors, patients with haemophilia A or B may have high levels of inhibitors i.e. antibodies to factors VIII or IX respectively (>5 Bethesda units). In this situation, treatment options are by-passing agents:
- recombinant activated factor VII (rFVIIa)
  - factor VIII inhibitor bypassing activity (FEIBA).

FEIBA is an activated prothrombin complex concentrate and contains factors II, IX, X and activated factor VII. Both FEIBA and rFVIIa work by similar mechanisms: they bind to the surface of activated platelets, thereby directly activating factor X and hence by-passing factor VIII and IX.

**EXAMPLE 5****Question**

A 61-year-old male with no known previous medical history is listed for an elective inguinal hernia repair. His pre-admission electrocardiogram (ECG) is shown below. On the day of surgery you note an irregular pulse rate of 105 beats per minute and a blood pressure of 165/95 mmHg. Appropriate statements regarding immediate management include:



- Check serum electrolytes; if they are normal, then proceed with induction of general anaesthesia.
- Repeat the ECG; if the heart rate is 60 to 90 beats  $\text{min}^{-1}$ , then proceed with induction of general anaesthesia.
- Cancel the operation; then refer to a cardiologist for investigation and pre-optimisation.
- Sedate the patient and electively cardiovert with direct current.
- Control the rate with metoprolol and then proceed to induction of general anaesthesia

**Answers**

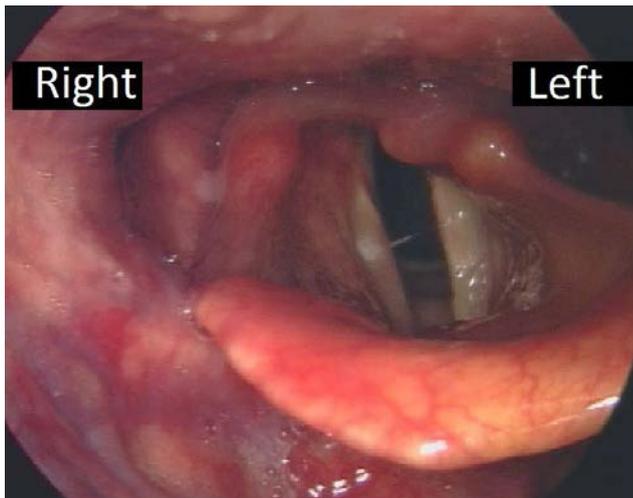
- False. Anaesthesia and surgery may precipitate fast atrial fibrillation in the absence of electrolyte abnormalities. A hypertensive patient with atrial fibrillation may have structural heart disease that will not tolerate tachyarrhythmias. Such tachyarrhythmias are difficult to control.
- False. As above. Induction of anaesthesia may lead to fast atrial fibrillation.

Examples of multiple choice questions.

- c) True. In the elective setting postponement is the correct decision. Out-patient rate control, blood pressure control, an echocardiogram and exercise tolerance test are warranted prior to elective surgery for this patient.
- d) False. Outpatient elective direct current cardioversion may be warranted. However, for this patient further investigations and an opinion from a cardiologist are required.
- e) False. In the elective setting, it is most appropriate to investigate and pre-optimize a patient prior to anaesthesia and surgery.

**EXAMPLE 6****Question**

You are asked to review a 55 year old female patient who has a hoarse voice. Two days ago she had a laparoscopically assisted hysterectomy under general anaesthesia. Her airway was managed by tracheal intubation using a size 8.0 cuffed tube. An Ear Nose and Throat surgeon is on the ward reviewing her and together you perform a nasendoscopy. The view of her glottis is displayed. Appropriate statements regarding this scenario include:



- The patient's right vocal cord is in an abnormal position.
- This appearance is likely to be attributable to a right recurrent laryngeal nerve palsy.
- This injury is more likely to occur in women than in men.
- If the hoarseness presents two days later, then it is unlikely to be a complication of anaesthesia.
- This lesion is likely to be attributable to over inflation of the tracheal tube cuff.

**Answers**

- False. The left vocal cord is paralysed and in the paramedian position.
- False. Left recurrent laryngeal nerve injury results in the left vocal cord being in the paramedian position. There is unopposed action of the cricothyroid muscle which adducts and tenses the vocal cord. The cricothyroid is innervated by the superior laryngeal nerve but not the recurrent laryngeal nerve.
- True. The smaller female glottis appears to be more vulnerable to injury from tracheal intubation.
- False. Inflammatory changes can cause injury that develops a few days after intubation.
- True. The recurrent laryngeal nerve (which innervates the intrinsic muscles of the larynx except cricothyroid) is vulnerable to compression from a tracheal cuff positioned just below the vocal cords.

Examples of multiple choice questions.

**EXAMPLE 7****Question**

A 35 year old lady is seen in the pain clinic with a five year history of pain in the bladder area. The pain started after what she describes as a water infection and persists despite numerous courses of antibiotics. At cystoscopy by an urologist, the only abnormality was the presence of granulations in the bladder mucosa. Over the course of her illness, her symptoms have become progressively worse, especially in the days leading up to her period. She experiences difficulty initiating micturition, symptoms of urge with occasional incontinence, pain on sexual intercourse and persistent constipation. Of note in the past, she has had a sterilisation procedure after the birth of her second child.

On examination, there is no motor or sensory neurological deficit. However, there is reduced range of movement in the lumbar spine. There are tender points in the lumbar paraspinal area, anterior abdominal wall and pelvic floor muscles. Voluntary contraction of the pelvic floor and vaginal examination are associated with reproduction of pain. As the pain is not relieved by paracetamol, naproxen and codeine, she finds it difficult to cope and fears for the future. Appropriate statements regarding this situation include:

- a) The diagnosis is likely to be Bladder Pain Syndrome or Interstitial Cystitis
- b) The combination of urge with incontinence together with difficulty initiating micturition make an underlying psychiatric diagnosis likely
- c) The absence of neurological features mean it is unlikely she will respond to anti-neuropathic medication
- d) Strong opioid analgesia such as morphine would be a good option in the first instance
- e) Medication often used for hormonal contraception is unlikely to be of benefit as she has already been sterilised.

**Answers**

a) False. Although there were organ-specific features at the start of her illness, there is now evidence of dysfunction in other areas such as sex and bowel function. There is also a cyclical component and a suggestion of negative psychological consequences associated with the pain. The diagnosis now is likely to be Chronic Pelvic Pain Syndrome

b) False. Psychiatric diagnosis is not likely in this situation.

Pelvic floor dysfunction is common in abdominopelvic pain syndromes. Dysfunction can be due to underactive pelvic floor (for example stress incontinence), overactive pelvic floor (pain and

difficulty initiating micturition) or a combination of the two. Additionally, functional bladder problems such as detrusor instability may complicate the clinical picture.

Mixed or unusual presentations are often ascribed to psychological or psychiatric causes although there is no evidence to support this conclusion.

- c) False. Anti-neuropathic medication is considered when simple analgesia has failed. Drugs with anticholinergic side effects such as amitriptyline and duloxetine may be useful when the patient has urinary frequency and urge. However, the potential benefits have to be balanced against the risk of exacerbating constipation.
- d) False. Opioids exacerbate constipation which usually worsens pain in these conditions. Additionally, these pains are often not opioid responsive.
- e) False. Patients with cyclical pain should be considered for hormonal contraception therapy. Sterilisation does not imply that the patient is not responsive to hormonal therapy.

**EXAMPLE 8****Question**

A 26-year-old soldier is admitted to a remote field hospital with limited diagnostic capabilities. He has collapsed during exercise and is diagnosed with hypovolaemia and rhabdomyolysis secondary to extreme exercise. Basic biochemistry tests including renal profile (potassium  $5.3 \text{ mmol litre}^{-1}$ , urea  $16.2 \text{ mmol litre}^{-1}$ , creatinine  $92 \text{ mmol litre}^{-1}$ ) and creatine kinase ( $12,500 \text{ u litre}^{-1}$ ) are available but serum and urine myoglobin are unavailable. Appropriate statements regarding myoglobin and the diagnosis of rhabdomyolysis include:

- a) Urinary dipstick for blood is likely to detect myoglobin in the absence of trauma to the urinary tract.
- b) Creatine kinase alone can be used to diagnose rhabdomyolysis.
- c) The absence of myoglobinuria is likely to exclude rhabdomyolysis.
- d) Myoglobin levels peak before the increase in creatine kinase.
- e) Serum or urine myoglobin levels are essential when diagnosing rhabdomyolysis.

**Answers**

- a) True. Urinary dipstick for blood is positive in the presence of myoglobin and has a sensitivity of 81% for the detection of rhabdomyolysis.
- b) True. Rhabdomyolysis is typically diagnosed when the creatine kinase is  $>5000 \text{ u litre}^{-1}$ .
- c) False. Myoglobin is rapidly metabolized, so myoglobinuria may not be present at the time of testing in the presence of rhabdomyolysis.
- d) True. Myoglobin levels peak prior to rises in creatine kinase in rhabdomyolysis. However, since myoglobin is rapidly metabolized outside the kidney (probably through the liver or spleen), creatine kinase a more reliable marker than myoglobin.
- e) False. Serum and urine myoglobin are not required to diagnose rhabdomyolysis. A creatine kinase greater than five times the upper limit of normal is the usual standard ( $>5000 \text{ u litre}^{-1}$ ).

**EXAMPLE 9****Question**

During an all-day theatre session of healthy patients requiring dental extraction, a supervisor teaches fibreoptic intubation to a trainee doctor. Statements referring to appropriate patient consent for this process include:

- a) The patient considers the risks of this process but agrees voluntarily for training to proceed.
- b) As an example of heteronomy, the patient gives consent for training to go ahead.
- c) The supervisor informs patients about what the trainee may be doing and the degree of supervision.
- d) Patients who give consent are aware that they are placed early on the list.
- e) After consent was obtained initially, training proceeds in a patient who becomes anxious after further reflection about oral damage.

**Answers**

- a) True. Consent must be voluntary.
- b) False. Patients who decide themselves do so with their own autonomy. To be legally valid, consent must be autonomous. Heteronomy means that the will of an individual is governed by an outside force or power.
- c) True. Details of training enable patients to give their informed consent.
- d) False. This example may be perceived as coercion. Coercion occurs when an individual's will is overborne by another individual. Consent must be un-coerced.
- e) False. Patients have the right to rescind their consent if they wish; this must be made clear to them. Effectively patients can retract their consent if they change their mind.

**EXAMPLE 10****Question**

In the United Kingdom (UK), percutaneous cervical cordotomy is likely to be:

- a) indicated in patients with unilateral pain due to cancer.
- b) indicated in patients with non-malignant pain.
- c) effective for neck pain.
- d) guided by computed tomography (CT) rather than fluoroscopy.
- e) deferred until less invasive techniques been shown to be unsuccessful.

**Answers**

- a) True. Percutaneous cervical cordotomies are performed for unilateral pain. Bilateral percutaneous cervical cordotomies may be performed, but they are associated with a high incidence of respiratory failure.
- b) False. As with all neurodestructive interventions, there is a risk of delayed onset neuropathic pain. Percutaneous cervical cordotomy is neither used for non-malignant pain nor in cancer patients with long life expectancy.
- c) False. Percutaneous cervical cordotomy is not effective for head or neck pain. It does not relieve pain originating above the level of the 2<sup>nd</sup> cervical dermatome since it is performed at this level.

During unilateral percutaneous cervical cordotomy, there is block of transmission of pain (and temperature) in ascending fibres that have crossed from the side of the pain to the side of the block, caudal to the 2<sup>nd</sup> cervical dermatome.

However, block of pain originating between the 2<sup>nd</sup> and 4<sup>th</sup> cervical dermatomes is likely to be unreliable since some pain fibres ascend for one or two dermatomal segments on the side of the pain, before crossing to the side of the block.

- d) False. Percutaneous cervical cordotomy can be performed under CT, but the most common technique in the UK uses fluoroscopy guidance. Open cordotomy is still performed surgically in some centres.
- e) False. Percutaneous cervical cordotomy may be offered when failure of less invasive techniques is anticipated.

In malignant pleural mesothelioma, percutaneous cervical cordotomy should be considered as soon as the patient commences strong opioids (World Health Organisation analgesic ladder, step 3). Percutaneous cervical cordotomy is not a rescue procedure; the patient must be able to travel to the treatment centre and lie flat and still for 40 to 90 minutes.

**EXAMPLE 11****Question**

A 60 year old man of Rhesus positive blood group A receives a blood transfusion following a gastrointestinal bleed. Immediately prior to the transfusion, his haemoglobin concentration was  $83 \text{ g l}^{-1}$  (normal range  $138\text{-}172 \text{ g l}^{-1}$ ). Within 15 minutes of the start of the infusion he complains of pain at the infusion site, nausea and back pain. The infusion is stopped and blood samples are sent to the laboratory. They reveal the following results:

haemoglobin concentration of  $71 \text{ g l}^{-1}$  (normal range is  $138$  to  $172 \text{ g l}^{-1}$ ),  
 prothrombin time of 17.2 seconds (normal range is 10 to 14 seconds),  
 activated partial thromboplastin time of 41 seconds (normal range is 25 to 39 seconds),  
 fibrinogen concentration of  $1.2 \text{ g l}^{-1}$  (normal range is  $1.45$  to  $3.48 \text{ g l}^{-1}$ ),  
 d-dimers of  $2400 \text{ ng ml}^{-1}$  (normal range  $\leq 250 \text{ ng ml}^{-1}$ ),  
 free haemoglobin concentration of  $1.1 \text{ g dl}^{-1}$  (normal value is  $0 \text{ g dl}^{-1}$ ),  
 serum haptoglobin of  $0 \text{ mg dl}^{-1}$  (normal range is  $100$  to  $150 \text{ mg dl}^{-1}$ ),  
 On visual inspection, the plasma appears pink.

Appropriate statements regarding this incident include:

- a) The most likely diagnosis is an acute allergic transfusion reaction.
- b) Initial treatment is most likely to include stopping the infusion and the intravenous administration of adrenaline and chlorpheniramine.
- c) The transfused blood was noted to be AB positive suggesting a likely haemolytic transfusion reaction.
- d) Investigations should include a blood sample sent to the laboratory for a direct antiglobulin (Coombs) test.
- e) Treatment should include broad spectrum antibiotics

**Answers**

- a) False. The most likely diagnosis is an acute haemolytic transfusion reaction due to the administration of an ABO incompatible transfusion. Acute allergic transfusion reactions are characterised by wheeze, angioedema or rarely anaphylaxis. They occur due to soluble antigens within the donor unit in a previously-sensitized recipient.

Examples of multiple choice questions.

- b) False. Initial treatment should include stopping the transfusion, the administration of oxygen and maintenance of the urine output with fluids and frusemide.
- c) True. Patients with blood type A have type A antigens on their red blood cells and circulating plasma anti-B antibodies; they can therefore only receive blood of type A or O which have no type B antigens on their red blood cells.

If type B or AB blood is given, then anti-B antibodies in the plasma of the recipient will react with the donor red cells carrying B antigens leading to inflammation and haemolysis characteristic of an acute haemolytic transfusion reaction.

- d) True. A sample of blood from the patient should be sent to the blood bank for a direct anti-globulin (Coombs) test. This test involves application of anti-human globulin to the blood sample. If the sample contains recipient anti-B antibodies which bind to B antigens on the surface of the donor red cells, then agglutination of the red cells will be observed, confirming ABO incompatibility.
- e) False. Antibiotics are antimicrobial and do not have a role in the management of an acute haemolytic transfusion reaction.

**EXAMPLE 12****Question**

Your junior trainee has been in theatre for 5 hours with a patient undergoing a femoro-distal bypass procedure. He is yawning and seems withdrawn. The trainee's fatigue is likely to be improved by:

- a) Imbibing one 60ml shot of espresso coffee.
- b) Taking a 1-hour nap.
- c) Increasing the brightness of the theatre lighting.
- d) Walking around and chatting to other members of staff.
- e) Microsleeps.

**Answers**

- a) False. Caffeine improves performance at doses between 200 to 600mg. 60ml espresso contains 100mg of caffeine and is unlikely to improve alertness.
- b) False. Sleep consists of 2 phases: non-rapid eye movement sleep (NREM) and rapid eye movement sleep (REM). NREM sleep is considered to consist of 4 stages based on electroencephalographic changes. NREM stages 1 and 2 sleeps are light sleeping and act as the interface between wakefulness and sleep. Stages 3 and 4 are deep sleep, also known as slow wave sleep. A normal night's sleep is made up of repeated 90-minute sleep cycles where all stages and phases of sleep are revisited in each cycle throughout the night. It is estimated that stages 1 and 2 sleep constitute 50% of total sleep time whilst stages 3 and 4 NREM sleep and REM sleep make up the remaining 50%.

Napping is synonymous with a short sleep and has been demonstrated to temporarily improve alertness and psychomotor performance in shift workers. The duration of a nap and hence attenuation of fatigue are related to the stages of the sleep cycle in the following ways:

- During a nap shorter than 20 minutes, stage 1 and stage 2 sleep occur. This short nap is too short to gain any benefit.
- During a nap of 20 to 30 minutes, there is a predominance of stage 2 sleep, providing the best compromise between length of restful sleep and the avoidance of disorientation and increased grogginess ('sleep inertia') associated with waking during slow wave and REM sleep.

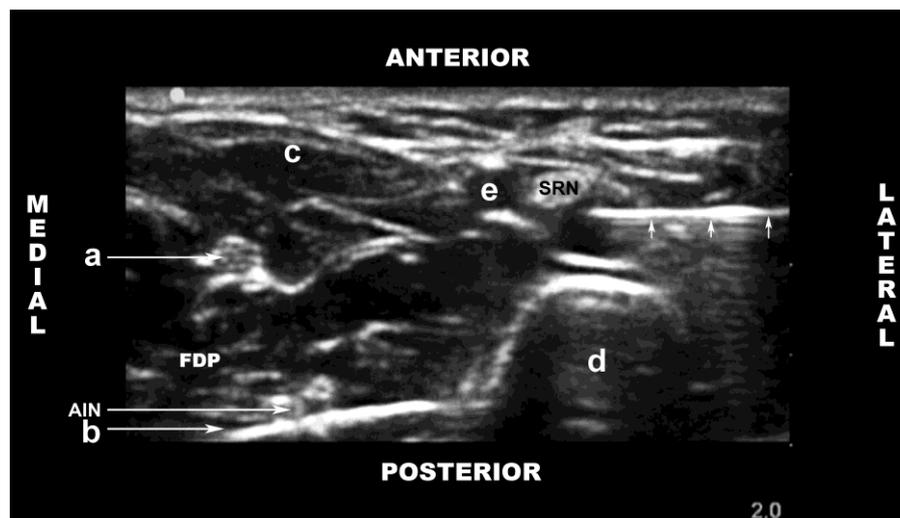
- During a nap of 30 to 90 minutes, there is a predominance of slow wave and REM sleep. Thus, napping for this duration of time would result in sleep inertia.
- What happens during a nap of 90 to 120 minutes? The sleep cycle is 90 minutes long, and so by sleeping for more than 90 minutes, a person will enter the next sleep cycle. Stage 2 sleep is encountered within the first 30 minutes of each sleep cycle and is encountered again after napping for 90 to 120 minutes.

In conclusion, optimal nap lengths are therefore 20-30 minutes and at 2 hour cycles thereafter.

- c) True. Light, particularly short wave blue light, increases wakefulness by suppressing melatonin synthesis. Light stimulates gamma-aminobutyric acid release from retinal ganglion cells. This neurotransmitter inhibits sympathetic activity that drives melatonin production
- Other non-Melatonin related pathways involving long wave red light are currently under investigation and are thought to increase alertness during day-time hours. It is thought that photoreceptors other than melanopsin-containing retinal ganglion cells are involved in this process.
- d) True. Increasing arousal such as chatting can temporarily improve alertness.
- e) False. Microsleeps are spontaneous, uncontrolled episodes of stage 1 sleep lasting up to 30 seconds. They do not improve alertness or performance. During microsleeps performance level drops to zero placing an anaesthetised patient at a greatly increased risk of error and harm.

**EXAMPLE 13****Question**

An ultrasound image of the distal forearm is shown during peripheral nerve block. A needle, indicated by the small vertical arrows, lies adjacent to the superficial radial nerve (SRN). The anterior interosseus nerve (AIN) and the flexor digitorum profundus muscle are shown. Appropriate statements regarding this image include:



- a) "a" is the median nerve.
- b) "b" is the anterior interosseus membrane.
- c) "c" is flexor carpi ulnaris.
- d) "d" is the humerus.
- e) "e" is the ulnar artery.

**Answers**

- a) True. "a" is the median nerve which is usually found between flexor digitorum superficialis and flexor digitorum profundus muscles.
- b) True. "b" is the anterior interosseus membrane which is seen immediately posterior to the anterior interosseus nerve.
- c) False. "c" is the flexor digitorum superficialis which is anterior to the median nerve in the forearm. Flexor carpi ulnaris is anterior to the ulnar nerve.
- d) False. "d" is the radius which is on the lateral aspect of the distal forearm and adjacent to the superficial radial nerve.
- e) False. "e" is the radial artery which lies medial to the superficial radial nerve in the forearm.

Examples of multiple choice questions.

**EXAMPLE 14****Question**

Two hours after dousing petrol over his head and setting himself on fire in his kitchen, a 21 year old man of 80 kg is presented to the emergency department. The flame burn of full thickness occupies 75% of his body surface area but spares his lower legs. His trachea is intubated and his lungs are ventilated with an inspired oxygen of 100%. Using the Parkland formula, intravenous fluid is administered. Other observations one hour after arrival include:

urine output of 20 ml h<sup>-1</sup>,  
 arterial blood pH 7.21, lactate  
 5.2 mmol L<sup>-1</sup>,  
 carboxyhaemoglobin (COHb) of 2%.

During the delay of 4 hours for transfer to the regional Burn Centre, mechanical ventilation of his lungs deteriorates, with decreasing tidal volumes. Appropriate statements regarding the management of this patient include:

- a) In view of the possible inhalational injury, administration of fluid using the Parkland formula should be reduced.
- b) Prior to transfer, escharotomy of the chest should be discussed with the Burns Centre.
- c) A diagnosis of carbon monoxide poisoning is likely to be excluded.
- d) Bronchoscopy is likely to be beneficial.
- e) Owing to the high probability of death, transfer to a Burn Centre is not likely to be needed and should be cancelled.

**Answers**

- a) False. Fluid requirements can be higher if inhalation injury is present. Parkland formula resuscitation should be started and adjusted to clinical response
- b) True. Deteriorating ventilation is an indication for early chest escharotomy. Burn centres can advise on its necessity.
- c) False. High levels of COHb may resolve prior to arrival in the emergency department by application of high flow oxygen in the pre-hospital setting
- d) True. Bronchoscopy will allow:

Examples of multiple choice questions.

- evaluation of the inhalation injury
  - clearing of soot and casts from the airway
  - improvement in lung compliance
- e) False. Without his inhalation injury, his predicated mortality is around 50%, in UK Burn centres. He should be transferred to a Burn Centre for full assessment.

**EXAMPLE 15****Question**

You are debriefing the theatre team following the intraoperative death of a child. With the BICEPS model (Brevity, Immediacy, Centrality, Expectancy, Proximity, Simplicity) in mind, you are likely to:

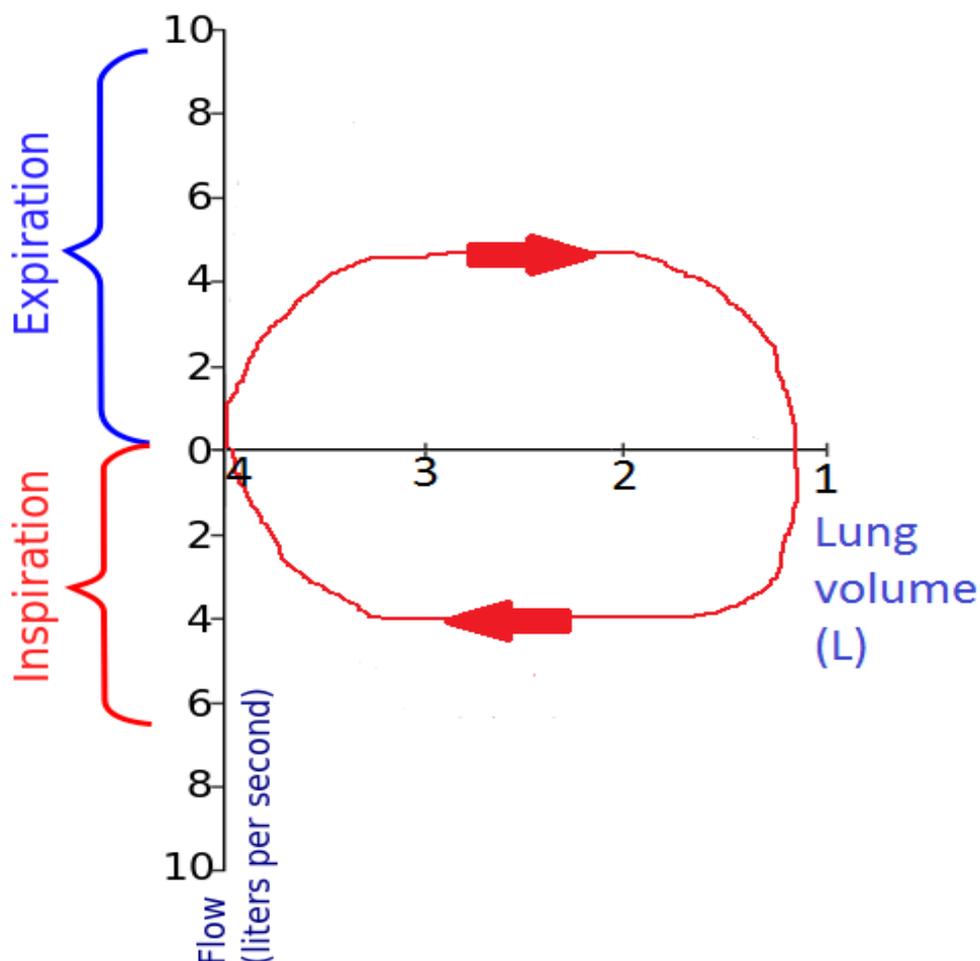
- a) Keep the session brief and focus on the facts.
- b) Tell staff to take time off.
- c) Conduct the session in close proximity to the work environment.
- d) Aim to treat the current problem.
- e) Confront the feelings of the staff.

**Answers**

- a) True. BICEPS is brief and focused.
- b) False. Return to work is a defined expectancy of the process.
- c) True. BICEPS is conducted in the work environment.
- d) True. BICEPS is focused on the current problem.
- e) True. Feelings of guilt or grief should be dealt with soon after the event to enable early return to work.

**EXAMPLE 16****Question**

A 45 year old woman presents to her General Practitioner with a history of progressive shortness of breath. Her medical history reveals a two week period of intubation on intensive care for pneumonia one year ago. She has been unsuccessfully treated with inhalers for asthma and so the General Practitioner decides to investigate her respiratory function further. Using spirometry, the flow-volume loop is displayed below. Appropriate statements regarding this situation includes:



- This pattern is likely to be caused by obstruction of small airways
- The obstructing lesion is likely to be intrathoracic.
- Post intubation tracheal stenosis is unlikely if her trachea was intubated with a tracheal tube with a high volume low pressure cuff.
- Her tracheal lumen is likely to be more than 75% stenosed.
- Duration of intubation is a significant factor in the development of post intubation tracheal stenosis.

Examples of multiple choice questions.

Answers

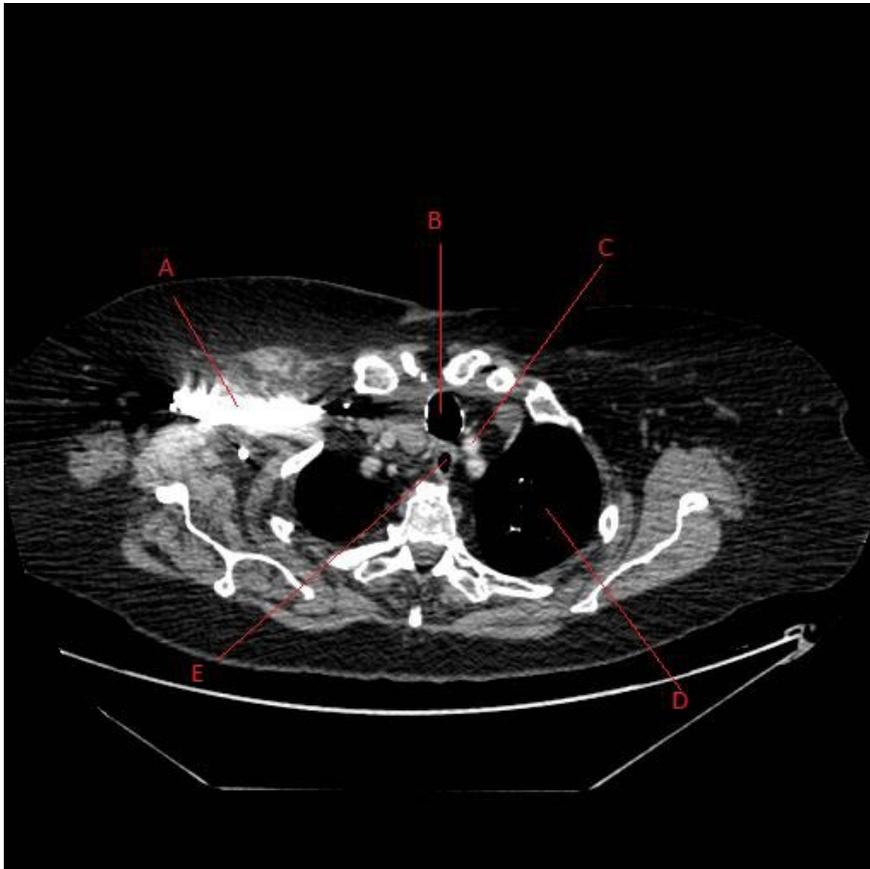
- a) False. In patients with asthma, there is obstruction of the small airways. This pattern of inspiratory obstruction is consistent with tracheal stenosis and therefore a lesion of the large airways.
- b) False. Compared to a normal flow loop, the pattern shown here is the characteristic “squashed” appearance of fixed upper airway obstruction. Note the maximum inspiratory and expiratory flow rates here are about  $4 \text{ L}\cdot\text{s}^{-1}$ . Normal adult values are about  $10 \text{ L}\cdot\text{s}^{-1}$  on expiration and about  $6 \text{ L}\cdot\text{s}^{-1}$  on inspiration.

Intrathoracic obstructive lesions impair *expiration* as lung volume falls. Extrathoracic lesions may interfere with *inspiration* as the lesions is “sucked” into the chest. Examples might include laryngeal tumours, extrathoracic goitre, vocal cord paralysis.

- c) False. Tracheal stenosis still continues to be an issue despite low pressure high volume cuffs
- d) True. The tracheal lumen typically needs to be reduced by 75% before the patient becomes symptomatic.
- e) True. A consistent relationship has been shown.

**EXAMPLE 17****Question**

Appropriate statements regarding the CTPA (computed tomography pulmonary artery) image of the chest, shown below, include:



- a) The structure labelled 'A' is the left subclavian vein.
- b) The structure labelled 'B' is the trachea.
- c) The structure labelled 'C' is the hemiazygos vein.
- d) The structure labelled 'D' is the apex of the left lung.
- e) The structure labelled 'E' is the oesophagus.

**Answers**

- a) False. The structure labelled 'A' is the right subclavian vein.
- b) True. The structure labelled 'B' is the trachea.
- c) False. The structure labelled 'C' is the left common carotid artery.
- d) True. The structure labelled 'D' is the apex of the left lung.
- e) True. The structure labelled 'E' is the oesophagus.

Examples of multiple choice questions.

**EXAMPLE 18****Question**

A 50 year old patient presents to the accident and emergency department with a five day history of diarrhoea and vomiting. She appears to be mildly confused and is hypotensive with a low urine output. Her past medical history is unremarkable. Her blood results include:

Na  $109 \text{ mmol l}^{-1}$  (normal range  $134$  to  $146 \text{ mmol l}^{-1}$ ) K

$4.1 \text{ mmol l}^{-1}$  (normal range  $3.5$  to  $5.0 \text{ mmol l}^{-1}$ )

Ur  $15.9 \text{ mmol l}^{-1}$  (normal range  $2.5$  to  $7.8 \text{ mmol l}^{-1}$ )

Creatinine  $147 \text{ } \mu\text{mol l}^{-1}$  (normal range  $55$  to  $125 \text{ } \mu\text{mol l}^{-1}$ )

Serum osmolality  $258 \text{ mmol l}^{-1}$  (normal range  $280$  to  $295 \text{ mmol l}^{-1}$ )

Urine osmolality  $565 \text{ mOsm l}^{-1}$

Urine Na  $<10 \text{ mmol l}^{-1}$  Blood

glucose  $5 \text{ mmol l}^{-1}$

Thyroid Stimulating Hormone  $2.4 \text{ mU l}^{-1}$  (normal range  $0.4$  to  $4.5 \text{ mU l}^{-1}$ )

Cortisol  $665 \text{ nmol l}^{-1}$  (normal  $>550 \text{ nmol l}^{-1}$ ) at 9am

You are likely to:

- a) Administer 0.9% saline for rehydration.
- b) Administer 3% saline to increase serum sodium to  $120 \text{ mmol l}^{-1}$ .
- c) Allow the rate of increase of sodium to be up to  $8-10 \text{ mmol l}^{-1}$  in the first 24 hours.
- d) Request a computed tomogram of her chest and abdomen in the next few days so that you are able to rule out possible malignancy.
- e) Have her admitted to your Critical Care Unit.

**Answers**

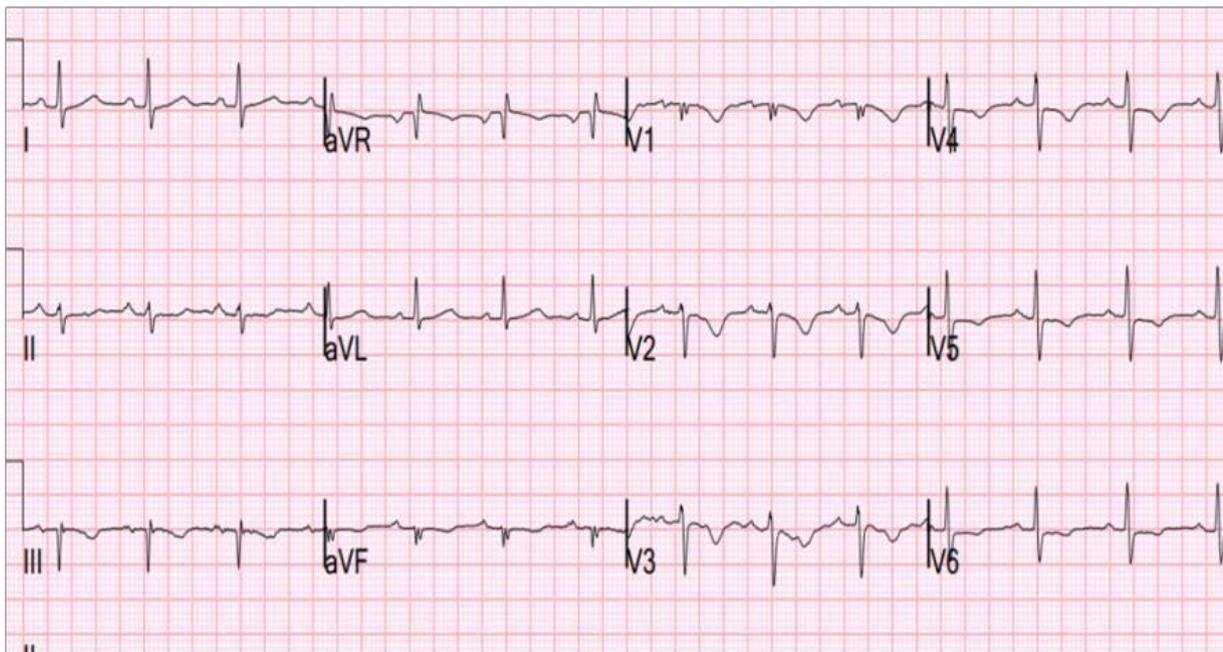
- a) True. 0.9% saline can be infused slowly, with the addition of a glucose infusion if that rate of rise of sodium is greater than recommended. Hartmann's solution would also be appropriate as the sodium content is  $131 \text{ mmol l}^{-1}$
- b) False. The use of hypertonic 3% saline should only be used if patients are severely neurologically compromised.
- c) False. The maximum recommended rise has recently been decreased to  $4-6 \text{ mmol l}^{-1}$  in the first 24 hours
- d) False. This patient is likely to be hyponatraemic due to the gastrointestinal symptoms. She does not have SIADH, unless there are other indicators from the history. There would be no need for further investigation
- e) True. This patient will need frequent blood sampling and adjustments to treatment. This process is best managed in a critical care environment with an arterial line.

Examples of multiple choice questions.

**EXAMPLE 19****Question**

As a member of the Outreach team, you are asked to see a 61 year old lady on the respiratory ward. She was admitted 2 days ago with an infective acute exacerbation of asthma. She did not require intensive care support as her symptoms resolved after administration of nebulisers and steroids. She has a history of smoking, hypertension, diabetes mellitus and obesity.

Unfortunately, 12 hours ago she develops central chest tightness, dyspnoea and sweating for an hour. The ECG taken during the episode and blood test results taken 12 hours after the onset of pain are shown below. Her current vital signs include a blood pressure of 159/90 mmHg, and a pulse rate of 94 beats per minute.



Haemoglobin  $12.6 \text{ g dL}^{-1}$  ( $12-17 \text{ g dL}^{-1}$ ),  
 Platelets  $352 \times 10^9 \text{ L}^{-1}$  ( $150-400 \times 10^9 \text{ L}^{-1}$ ),  
 International normalised ratio 1.0 (0.9-1.1),  
 Serum Sodium  $142 \text{ mmol L}^{-1}$  ( $135-145 \text{ mmol L}^{-1}$ ),  
 Serum Potassium  $4.8 \text{ mmol L}^{-1}$  ( $3.5-5.0 \text{ mmol L}^{-1}$ ),  
 Urea  $5.8 \text{ mmol L}^{-1}$  ( $2.5-6.7 \text{ mmol L}^{-1}$ ),  
 Serum Creatinine  $98 \text{ } \mu\text{mol L}^{-1}$ ,  
 Troponin I (cTnI)  $3.9 \text{ ng mL}^{-1}$  ( $<0.01 \text{ ng mL}^{-1}$ ).

She was given oral aspirin 300mg during the pain. No further medication has been given. Appropriate statements regarding this patient include:

- The diagnosis is ST-segment elevation myocardial infarction.

Examples of multiple choice questions.

- b) The pro-drug clopidogrel, should be prescribed and taken for 12 months.
- c) Non-dihydropyridine calcium channel blockers should be used for heart rate control rather than beta blockers if required.
- d) You manage to arrange primary coronary intervention (PCI) which will occur within the next 8 hours. Treatment dose fondaparinux should therefore be given.
- e) Prasugrel has a faster onset of action than clopidogrel.

### **Answers**

- a) False. The ECG shows T wave inversion in the anterolateral chest leads suggesting ischaemia. This together with the history of non-pleuritic chest tightness at rest, risk factors for ischaemic heart disease and raised troponin would suggest a Non-ST elevation myocardial infarction.
- b) True. Clopidogrel is a pro-drug. It is metabolised in two steps by separate cytochrome P450 enzymes. This pathway accounts for its genetic variability and how drugs interacting with cytochrome P450 metabolism, such as proton pump inhibitors, may affect its efficacy. It inhibits platelet aggregation by preventing ADP binding to its receptor on the platelet.
- c) True. Non-dihydropyridines such as diltiazem and verapamil may be used when beta blockers are contraindicated in patients with asthma. Diltiazem causes vasodilatation of the coronary arteries as well as reduction in atrio-ventricular (AV) conduction. Use of beta-blockers with verapamil should be avoided due to possible profound AV node blockade.
- d) False. Fondaparinux is offered to all patients with NSTEMI-ACS without high bleeding risk. However unfractionated heparin should be used if primary coronary Intervention is anticipated within 24hours, as in this situation, or if there is renal failure.
- e) True. The first of prasugrel's two step metabolism is by plasma esterase, which is faster than clopidogrel's first step of cytochrome P450 metabolism. It is therefore faster and more predictable in onset than clopidogrel. It is recommended by NICE to be used in patients with STEMI undergoing immediate PCI. The European guidelines recommend either prasugrel or ticagrelor with aspirin as first line antiplatelet use for ACS instead of clopidogrel.