CHAPTER 63

ST segment changes

The ST segment of the ECG represents repolarisation of the ventricles. Changes in the appearance of the ST segments can be caused by myocardial ischaemia or myocardial infarction. In the face of ischaemia, ST segment depression or elevation may occur relative to the isoelectric line. Movement away from the isoelectric line of ≥ 1 mm is significant.

Intraoperative ST segment changes require rapid detection and management in order to correct and optimise coronary blood flow and reduce myocardial work. Intraoperatively, the commonest causes of myocardial ischaemia are rate-related ischaemia and hypotension.

How would you manage an anaesthetised patient with ST segment changes?

➤ **Immediate management:**
- Give 100% oxygen.
- Call for help and inform the surgeons of the need to conclude surgery as soon as possible.
- Perform a rapid but thorough assessment of the patient, looking for precipitating causes, e.g. hypoxia, tachycardia, hypotension and acute blood loss. Address any correctable problems.
- Ensure adequate coronary perfusion pressure (increase aortic diastolic pressure), optimise arterial oxygen content (increase FiO_2 and ensure normal Hb concentration), optimise coronary blood flow (increase diastolic time and promote coronary vasodilatation) and reduce myocardial oxygen consumption (reduce heart rate and force of contraction). Vasoactive drugs such as intravenous nitrates, β-blockers or vasopressors may be required.

➤ **Early management:**
- Consider additional monitoring (arterial line and central line) if there seems to be physiological deterioration as a result of cardiac ischaemia.
- Should the patient deteriorate further, e.g. refractory hypotension or pulmonary oedema, it would be sensible to use cardiac output monitoring devices if available (e.g. oesophageal Doppler or LiDCO). These should be used to guide fluid and inotropic therapy.

➤ **Post-operatively:**
- Following the operation, transfer the patient to an area of high dependency care for observation and investigation.
- Perform a 12-lead ECG, and if it is abnormal, continue to take serial ECGs.
- Take blood for cardiac enzymes, U&Es and FBC and glucose.
- After 12 hours, take blood for a troponin I level.
- Request an urgent review by the cardiologists for ongoing management advice.
- Document events clearly in the notes.

CHAPTER 64

Tachyarrhythmias

What are some of the causes of intraoperative tachyarrythmias?

➤ **Patient factors:** All patients undergoing anaesthesia and surgery are at risk of intraoperative arrhythmias. However, certain patients are at increased risk:
- Pre-existing cardiac disease, e.g. ischaemic heart disease or valvular heart disease
- Pre-existing arrhythmia, e.g. atrial fibrillation or Wolff–Parkinson–White syndrome
- Pre-existing electrolyte disturbances, e.g. diuretic-induced hypokalaemia and hypomagnesaemia
- Endocrine disease, e.g. thyrotoxicosis.

➤ **Anaesthetic factors:** General and regional anaesthetic techniques can have significant effects on cardiac function:
- Drug-induced alteration in cardiac preload, contractility and afterload
- Effects on coronary perfusion pressure
- Effects on myocardial irritability
- Effects on autonomic nervous system
- Effects of hypoxia and hypercapnia
- Electrolyte disturbances (either pre-existing or iatrogenic from fluid therapy)
- Effects of intravascular devices (e.g. central venous lines) advanced too far and entering the right atrium.

➤ **Surgical factors:**
- Effects of pneumoperitoneum related to laparoscopic surgery, e.g. vagal response, reduced venous return, fall in cardiac index or rise in SVR
- Effects of hypercapnia related to laparoscopic surgery, e.g. arrhythmias
- Effects of rapid fluid shifts
- Systemic inflammatory response syndrome (SIRS) induced by tissue trauma.

The combination of patient, anaesthetic and surgical factors may lead to the development of intraoperative arrhythmias. The arrhythmias may be benign (e.g. occasional ventricular ectopics) or potentially malignant arrhythmias may develop (e.g. ventricular tachycardia).

Describe your management of an intraoperative tachyarrhythmia

Management of intraoperative tachyarrhythmia follows general principles applicable to all tachyarrhythmia and specific treatments for certain types of tachyarrhythmia.

General management principles:

➤ Consider calling for assistance depending on the haemodynamic consequences of the arrhythmia.

➤ Diagnose the arrhythmia and establish the haemodynamic consequences – check blood pressure and end-tidal CO_2.

➤ Attempt to identify and treat the cause of the arrhythmia, e.g. adjust CVP line tip position or correct electrolyte disturbances.

- Attempt to maximise myocardial oxygen delivery by maintaining arterial oxygen content and coronary perfusion pressure.
- Check and correct electrolyte disturbances (potassium and magnesium): arterial blood gas analysis is the fastest method of obtaining potassium concentration (if hypokalaemia is present, in the majority of cases hypomagnesaemia will also be present).
- Attempt to correct any identified acid-base abnormalities detected on arterial blood gas.

Specific management:

- **Broad complex tachycardia (VF/VT/SVT with aberrant conduction)**
  - If there is no pulse follow ALS protocol.
  - If there is a pulse assess the haemodynamic consequences:
  - **Systolic < 90 mmHg/heart rate > 150:** Synchronised DC cardioversion (up to 3 shocks). If refractory consider amiodarone 150 mg over 10 minutes followed by 300 mg over 1 hour and repeat shock if necessary. Consider lignocaine and overdrive pacing.
  - **Systolic > 90 mmHg/heart rate < 150:** Correct K^+ (> 4.0 mmol/L) and Mg^{2+} (> 1.0 mmol/L). Administer amiodarone 150 mg IV over 10 minutes or lignocaine 50 mg over 2 minutes repeated every 5 minutes up to a total dose of 200 mg.
- **Narrow complex tachycardia (SVT/atrial flutter)**
  - If there is no pulse follow the ALS protocol.
  - If the rhythm is atrial fibrillation (AF), follow AF algorithm.
  - If there is a pulse and atrial fibrillation is excluded assess the haemodynamic consequences:
  - **Systolic < 90 mmHg/ventricular rate > 200:** Synchronised DC cardioversion (up to 3 shocks). Consider amiodarone 150 mg over 10 minutes followed by 300 mg over 1 hour and repeat shock if necessary.
  - **Systolic > 90 mmHg/ventricular rate < 200:** Attempt vagal manoeuvre (e.g. carotid sinus massage). Consider adenosine boluses 6 mg, followed by up to three 12 mg doses. If resistant, consider use of esmolol, amiodarone, digoxin or verapamil.
- **Atrial fibrillation**
  Management depends on the time of onset (i.e. acute/chronic AF and subsequent risk of systemic embolisation if sinus rhythm is restored), ventricular rate and the haemodynamic consequences:

Critical AF, ventricular rate > 150, hypotension and impaired perfusion

- Heparise if feasible (note risk of intraoperative bleeding)
- Administer synchronised DC cardioversion
- Administer amiodarone 300 mg IV over 1 hour followed by 900 mg over the following 23 hours

Intermediate AF, ventricular rate 100–150

If associated with haemodynamic compromise:

- Onset < 24 hours: Heparinise and administer synchronised DC cardioversion. Consider amiodarone IV 300 mg over 1 hour.
- Onset > 24 hours: Control rate initially with amiodarone IV 300 mg over 1 hour. Heparinise and later perform synchronised DC cardioversion.

If associated with normal haemodynamics:

- Onset < 24 hours: Heparinise and administer amiodarone IV 300 mg over 1 hour. Consider flecanide. Synchronised DC cardioversion may be required.

- Onset > 24 hours: Control rate initially with digoxin, verapamil or β-blockers. Heparinise and later perform synchronised DC cardioversion.

Low-risk AF, ventricular Rate < 100 with good perfusion

- Onset < 24 hours: Heparinise and administer amiodarone IV 300 mg over 1 hour. Consider flecanide.
- Onset > 24 hours: Heparinise and then later perform synchronised DC cardioversion.

Post-operative:

All patients who have suffered significant intraoperative arrhythmias should have cardiac monitoring in the initial post-operative period (including 12-lead ECG) and relevant cardiac follow-up if indicated.

ALS protocols have not been covered here but are likely to be examined in the OSCE.

CHAPTER 65

Venous air embolism (VAE)

VAE is a potential complication of many surgical procedures. The clinical features range from sub-clinical to life-threatening cardiovascular collapse depending upon the rate and volume of gas that is entrained into the circulation.

Examiners will expect an understanding of the types of procedures that are associated with an increased risk of VAE, and also the ability to diagnose and manage the problem.

What procedures are associated with a high risk of VAE?

- Neurosurgery, particularly surgery in the sitting position and surgery involving the cranium and dura
- Laparoscopic surgery with risk of direct intravascular gas insufflation
- Head and neck surgery with large areas of tissue exposed, often with vessels at subatmospheric pressure
- Orthopaedic surgery, e.g. polytrauma, cementing and reaming in long bone surgery
- Insertion of intravascular devices, e.g. central venous cannulation.

How can you diagnose VAE?

Symptoms and signs are primarily those of cardiovascular collapse (hypotension, tachycardia, arrhythmias and arterial desaturation) caused by the air embolus acting as an intracardiac air lock. In the correct clinical setting, suspicion for VAE must always remain high. In certain high-risk procedures (e.g. neurosurgery in the sitting position) monitoring should be used electively to aid early VAE detection and may include the following:

- Listen for audible hissing as gas enters the circulation.
- ECG: VAE is associated with an increase in pulmonary vascular resistance and the development of right ventricular dysfunction causing arrhythmias and possibly a right ventricular strain pattern.
- Capnography: Fall in end-tidal CO_2.
- CVP increases.
- Precordial stethoscope: Classic 'millwheel murmur'. This is insensitive and a late sign.
- Pulmonary artery pressure increases.
- Oesophageal Doppler is extremely useful in early detection of VAE.
- Transoesophageal echocardiography (TOE): Possibly the gold standard. Allows localisation of air to a specific cardiac chamber while enabling assessment of cardiac function.

What is the management of a suspected VAE?

State that this is an anaesthetic emergency and that you would call for senior anaesthetic assistance.

- Inform the surgeon who may be able to prevent further embolisation by compression of the surgical site or flooding the surgical site with saline.
- Administer 100% oxygen and discontinue nitrous oxide, which will increase bubble size due to its high solubility.

- Increase CVP by tilting the patient slightly head-down, administer fluid and increase PEEP.
- Position patient in left lateral head-down position if feasible, this may prevent embolisation into the pulmonary artery. In this position consider attempting to aspirate the air via a CVP line.
- Cardiovascular support with fluid and inotropic support may be required. CPR may also become necessary if the situation deteriorates.
- Terminate surgery as soon as safely possible.
- Arrange appropriate post-operative care (ITU or HDU).
- Document events when safely possible and complete a critical incident form.
- Explain event to the patient when possible.