THE ANAESTHETIC CRISIS MANUAL

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Shockable Cardiac Arrest (VF/VT Adult)

Unshockable Cardiac Arrest (Asystole, PEA Adult)

Paediatric Advanced Life Support

Intraoperative Myocardial Ischaemia

Severe Intraoperative Haemorrhage

Anaphylaxis

Haemolytic Transfusion Reaction

Air Embolism

Difficult Mask Ventilation

Unanticipated Difficult Intubation

Can't Intubate Can't Ventilate

Laryngospasm

Elevated Airway Pressure

Severe Bronchospasm

Aspiration

Total Spinal (Obstetrics)

Post Partum Haemorrhage

Maternal Collapse

Neonatal Resuscitation – Newborn Life Support

Local Anaesthetic Toxicity

Hyperkalaemia

Malignant Hyperthermia

Terminal Event Checklist – The 10 Ts

Crisis Prevention

SHOCKABLE CARDIAC ARREST

VF/VT Adult

1. **Call** for help, **communicate** the problem and **delegate**.
2. Commence compressions (100–120 per minute).
3. Secure the airway. Use 100% O_2. Resume CPR.
4. **SHOCK** immediately defibrillator is ready. Resume CPR.
5. **SHOCK** at 2 minutes.* Resume CPR.
6. **SHOCK** at 4 minutes. Give **amiodarone 300mg** and **adrenaline 1mg**. Resume CPR.
7. Continue to shock every 2 minutes and review reversible causes.
8. If practical, use transthoracic ultrasound to assist diagnosis.
9. For resistant VF/VT give **adrenaline 1mg** every 3–5 minutes (alternate shocks) and a further **150mg of amiodarone** followed by an infusion of 900mg over 24 hours.
10. Following ROSC, commence post resuscitation care.

Consider: *Referral for urgent percutaneous intervention*
Therapeutic hypothermia
Avoid: *Hyperglycaemia (treat >10mmol/l)*
Hyperoxaemia (keep SpO_2 94–98%)
Hypercarbia

ROSC = return of spontaneous circulation

*In the USA, Australia and New Zealand, adrenaline is given after the second shock

SHOCKABLE CARDIAC ARREST
VF/VT Adult

Delegate a staff member to **call time prompts** and **document events**. If other members are assigned the tasks of chest compression, ventilation and monitoring cardiac output, this will allow the team leader to review potential reversible causes.

Reversible Causes 4Hs 4Ts

Hypoxia	**Tension**
Hypovolaemia	**Tamponade**
Hypothermia	**Thrombosis**
Hypo/hyperkalaemia	**Toxins**

If using transthoracic echo, use the sub-xyphoid view.

The patient should be ventilated with 100% O_2 at a rate of 10 normal tidal volume breaths per minute – do not hyperventilate.

If the patient requires intubation, this should be performed quickly and by the most experienced practitioner, confirmed by $EtCO_2$ if available, and **only after compressions have commenced (CAB)***.

Emphasis is on minimally interrupted, **high quality chest compressions**. Aim for any pause (rhythm analysis and shock delivery) to be **<5 seconds** – if using a manual defibrillator, after rhythm assessment, continue CPR while machine charges to minimize 'pre-shock pause'.

Self adhesive defibrillation pads allow faster shock delivery.

Shock energy: **Biphasic 200J** first shock. For subsequent shocks use the same or greater. **Monophasic 360J**. *For children use* 4J/kg.

Successive or 'stacked' shocks (up to 3 in a row) are reserved for witnessed VF/VT with defibrillator pads already in place – post cardiac surgery, cardiac catheter laboratory or the critical care environment.

Drugs are given immediately following defibrillation.

Drug dosages

Magnesium IV 1–2g over 3 minutes for Torsade de Pointes or hypomagnesaemia.
Calcium chloride 10% IV 0.2ml/kg (5ml max) for hyperkalaemia, hypocalcaemia or overdose of Ca2+ channel blockers.
Sodium bicarbonate 1–2ml/kg 8.4% IV for hyperkalaemia and antidepressant overdose – NOT prolonged resuscitation.
Lignocaine 1mg/kg IV if amiodarone not available.

Intraosseous is the preferred alternative route for drug administration.

** In adult cardiac arrest, the 'ABC' of resuscitation may be more effective if performed in the order of 'CAB'. That is, establishing circulation first.*

UNSHOCKABLE CARDIAC ARREST

Asystole, PEA Adult

1. **Call** for help, **communicate** the problem and **delegate**.
2. Commence compressions (100–120 per minute).
3. Secure the airway. Use 100% O_2. Resume CPR.
4. Check ECG leads without interruption to compressions.
5. Give **Adrenaline 1mg** intravenously.
6. Review reversible causes-**4Hs 4Ts**.
7. After 2 minutes check pulse and ECG rhythm – consider **sub-xyphoid** ultrasound view.
8. Continue CPR – minimize pause duration for rhythm checks.
9. Give **adrenaline 1mg** *every alternate cycle* (3–5 min).
10. If ECG shows VF/VT convert to *Shockable Cardiac Arrest* protocol see tab 1.
11. Consider cardiac pacing only in **asystole** when **p waves** are present.
12. Following ROSC, commence post resuscitation care.

Consider: Referral for urgent percutaneous intervention
Therapeutic hypothermia
Avoid: Hyperglycaemia (treat >10mmol/l)
Hyperoxaemia (SpO_2 94–98%)
Hypercarbia

UNSHOCKABLE CARDIAC ARREST

Asystole, PEA Adult

Delegate a staff member to **call time prompts** and **document events.** If other members are assigned the tasks of chest compression, ventilation and monitoring cardiac output, this will allow the team leader to review potential reversible causes (tab 1).

Minimizing pauses in CPR increases the chance of success.

Suspect **hypovolaemia** in PEA in the surgical setting – consider undiagnosed haemorrhage, particularly with laparoscopic surgery.

Hypoxia should be immediately corrected with a secure airway and ventilation using 100% O_2.

Electrolytes and metabolic abnormalities can be assessed with urgent blood chemistry – indications for **magnesium** and **calcium** are outlined in drug dosages (tab 1) and should all be corrected.

Hyperkalaemia is treated according to the protocol - see tab 21.

Tamponade, tension pneumothorax and thromboembolic obstruction are all difficult to diagnose without significant knowledge of clinical history.

Ultrasound imaging provides information that may assist diagnosis – a sub-xyphoid view obtained during the brief rhythm check is recommended.

Aim for **normovolaemia** – in the absence of hypovolaemia, excessive infusion of fluid should be avoided.

Whenever possible, confirm correct placement of airway device with CO_2 detection.

All drugs should be administered via a peripheral or central venous line. If this is not achievable, the tibial or humeral interosseous route is used. *The tracheal route is not recommended.**

Also see notes for Shockable Cardiac Arrest – tab 1.

PAEDIATRIC ADVANCED LIFE SUPPORT

1. **Call** for help, **communicate** the problem and **delegate**.
2. Commence CPR and use 100% O_2.
3. Check ECG leads without interruption to compressions.
4. Cease all vagal stimulation.
5. Give **adrenaline 10mcg/kg** IV or intraosseous.
6. Review reversible causes (**4Hs 4Ts**).
7. After 2 minutes check pulse and ECG rhythm – consider **sub-xyphoid** ultrasound view.
8. Continue CPR – minimize pause duration for rhythm checks.
9. Give **adrenaline 10mcg/kg** every 3–5 mins.
10. If ECG shows VF/VT convert to *Shockable Cardiac Arrest* Protocol (tab 1).
11. If ROSC, commence post resuscitation care (see adult protocol – tab 1).

ROSC = return of spontaneous circulation

PAEDIATRIC ADVANCED LIFE SUPPORT

Delegate a staff member to **call time prompts** and **document events.** If other members are assigned the tasks of chest compression, ventilation and monitoring cardiac output, this will allow the team leader to review potential reversible causes (tab 1).

Excluding cardiac anaesthesia, most anaesthetic related *paediatric* cardiac arrests will be aystole or PEA.
If VF or VT, follow the adult protocol - see tab 1, using drug dosages listed below.

Hypoxia and vagal stimulation are the most frequent reversible causes in children

For CPR, use a compression rate of 100–120/minute and a ventilation rate of 12–20 breaths/minute.

Adrenaline 10mcg/kg is given immediately in PEA and asystole and then every 3–5 minutes. *Atropine is not recommended.*

Adrenaline 10mcg/kg and **amiodarone 5mg/kg** are both given after the 3rd and 5th shock in VF/VT.

Drugs should be given via intravenous or intraosseous routes

Adrenaline 100mcg/kg can be given via endotracheal tube if other routes are unsuccessful.

Defibrillation

- For manual defibrillation use a shock energy of **4J/kg**.
- If using an AED, a **'paediatric attenuated adult shock energy'** should be selected in those aged less than 8 years.

Monitor $EtCO_2$ for both tube placement *and* cardiac output.

Principles of post resuscitation care are the same as adults.

Therapeutic hypothermia in the post arrest, comatose child should be considered.

Also see notes for Adult Cardiac Arrest (tabs 1 and 2).

INTRAOPERATIVE MYOCARDIAL ISCHAEMIA

1. Administer 100% oxygen.

2. Confirm there is adequate: ventilation
   anaesthesia
   analgesia

3. Control the heart rate.

If steps 1, 2 and 3 complete and patient is HYPERTENSIVE:

4. Cease stimulation
   Introduce **Beta Blockers**
   Commence **GTN** infusion

If steps 1, 2 and 3 complete and patient is HYPOTENSIVE:

5. Restore normovolaemia – use blood if anaemic

6. Treat inappropriate vasodilatation.

7. Control filling pressure.

8. Support contractility – consider an inodilator or inotrope.

9. Commence GTN infusion*.

10. Consider anticoagulation, placement of IABP and percutaneous coronary intervention.

INTRAOPERATIVE MYOCARDIAL ISCHAEMIA

Treatment is based on reducing oxygen demand and increasing oxygen supply.

Heart rate: Aim for 60–80 bpm.
Use a beta blocker and additional narcotic if required.

Treat any tachyarrhythmias if necessary using amiodarone, lignocaine or DC shock (see *Shockable Cardiac Arrest* for dosages).

Correct any abnormal electrolytes and anaemia.

Blood pressure: Aim for 100–120 systolic with MAP >75.
For anaesthetic induced **vasodilation,** carefully titrate a vasoconstrictor avoiding any adverse increase in afterload.

Filling pressure
CPP = ADP – LVEDP✈
With severe obstruction **distal coronary pressure** may be very low so avoid elevated LVEDP.

*GTN will both dilate coronaries and reduce LVEDP.

Drug dosages for 70kg patient:

Dobutamine	250mg in 50ml 0.9% saline
Adrenaline	3mg in 50ml 0.9% saline
Noradrenaline	4mg in 50ml 0.9% saline

Infusions are commenced at 5ml/hr and titrated according to response. Other diluents and dilutions are possible. See product information if necessary.

Metoprolol	2.5 mg boluses
Esmolol	0.5mg/kg bolus
	50–200mcg/kg/min infusion
Phenylephrine	25–50mcg bolus
Metaraminol	0.5–1mg bolus
GTN	50mg in 50ml 0.9% saline
	Commence at 3ml–5ml/hr and titrate to response.

Blood pressure may require continued support during GTN infusion

✈*CPP* =Coronary Perfusion Pressure
ADP =Aortic Diastolic Pressure
LVEDP=Left Ventricular End Diastolic Pressure

SEVERE INTRAOPERATIVE HAEMORRHAGE

1. **Call** for help, **communicate** the problem and **delegate**.
2. Confirm there is surgical effort to control bleeding.
3. Switch to 100% oxygen until the crisis is resolved.
4. Use vasopressors only if necessary to maintain vital organ perfusion.
5. Warm fluids. Warm theatre. Warm patient.
6. Insert 2 × 14g cannulae and consider an 8.5FG PA sheath.
7. Contact blood bank to **crossmatch blood early** and consult haematologist to plan **component therapy**.
8. Utilize the rapid fluid infuser and cell saver.
9. Consider **antifibrinolytic agents**.
10. Carefully monitor **calcium** levels.
11. Establish bedside monitoring: Arterial line, urinary catheter, CVP, temperature Haemocue®, Coagucheck® thromboelastography.
12. Follow up with laboratory testing: FBC, electrolytes, ABGs, clotting screen.

Blood bank Ext No. .....

Haematology Ext No. .....

ICU Ext No. .....

SEVERE INTRAOPERATIVE HAEMORRHAGE

Call for assistance, delegate responsibilities and communicate effectively so staff appreciate the severity and urgency. Nominate a **communicator** to relay messages between the laboratories, theatre and ICU and a **runner** to transport blood samples, packed cells and component therapy.

Early delegation allows time to coordinate management, prioritize and review possible causes.

Large bore intravenous cannulation should be delegated to suitably experienced personnel.

If time does not permit crossmatched blood (Hb 5 or less with ongoing bleeding), **O negative or group specific** should be used.

Surgical control may involve direct pressure, arterial or aortic clamping. *Consider prompting if necessary*

If a senior clinician predicts large blood loss, **early infusion of FFP (15ml/kg)** may prevent impending haemostatic failure and microvascular bleeding.

If fibrinogen <1g/l and PT or aPTT >1.5 x normal there is *established haemostatic failure* and larger volumes of FFP will be needed. The use of component therapy should be guided by laboratory tests, clinical experience and consultation with haematology (see table below).

Hypocalcaemic cold patients don't clot – aggressively manage temperature and electrolytes.

Factor rV11a is indicated in massive haemorrhage unresponsive to conventional therapy.

Therapy	Indication	Initial dosages
FFP	PT, aPTT <1.5 normal, fibrinogen <1g/l	15ml/kg
Cryoprecipitate	Fibrinogen <1g/l	5–10ml/kg
Prothrombinex	Massive haemorrhage unresponsive to conventional therapy	15mg/kg
Factor VIIa	As above	90mcg/kg
Tranexamic acid	Fibrinolysis	1gm IV over 10 min then 1gm over 8 hrs
Platelets	Platelet count <75 $\times$ 10^9	15–20ml/kg

ANAPHYLAXIS

1. **Call** for help, **communicate** the problem and **delegate**.
2. Cease all likely triggers, follow the ABC guideline and commence CPR if indicated.
3. Monitor the time, SpO_2 and haemodynamics.
4. Ventilate with 100% O_2 and intubate the patient if required to maintain the airway.
5. Infuse fluids (at least 20ml/kg) and elevate the legs.
6. Give intravenous **Adrenaline 1mcg/kg** in bolus doses. *If cardiovascular collapse use 1mg, or 10mcg/kg in children.*
7. Insert an arterial line for monitoring and gases as soon as possible – delegate if necessary.
8. Consider adjunctive therapy when haemodynamic stability is established.
9. Collect blood specimens for **mast cell tryptase** levels. Take sample during resuscitation, at 2 hours and at 24 hours.
10. Prepare for transfer to Intensive Care.

ICU Ext No. .....

ANAPHYLAXIS

Signs during anaesthesia include:

CVS collapse	Hypotension
Bronchospasm	Angioedema
Erythema	Hypoxia
Urticaria	Cutaneous rash

Call for assistance early, **communicate** effectively and **delegate** timekeeping and monitoring roles. *Elapsed time* calls may be useful in cardiovascular collapse.

The anaesthetist should take the leadership role and coordinate management.

Common triggers include muscle relaxant, antibiotics, latex, colloid and chlorhexidine.

Drug dosages

IV adrenaline bolus = 1mcg/kg

IM adrenaline bolus = Adult 500mcg
6–12 years 300mcg
<6 years 150mcg

IV adrenaline infusion = 0.1mcg/kg/min
With 3mg in 50mls dilution, mls/hr = mcg/min. *For an adult commence at 7mls/hr.*

Additional therapy

Aminophylline bolus up to 5mg/kg IV or IM

Hydrocortisone bolus (slow IV or IM)	>12 years. 200mg
	6–12 years 100mg
	6 months–6 years. . . 50mg
	0–6 months. 25mg
Chlorpheniramine bolus (slow IV or IM)	>12 years. 10mg
	6–12 years 5mg
	6 months–6 years. . . 2.5mg
	<6 months . . . 250mcg/kg

In the unlikely event that bronchospasm does not respond to adrenaline therapy, alternative treatment is outlined in *Severe Bronchospasm* - see tab 14.

HAEMOLYTIC TRANSFUSION REACTION

1. Cease transfusion of the blood product.
2. **Call** for help, **communicate** the problem and **delegate**.
3. Follow the ABC guideline – use 100% O_2.
4. Treat any bronchospasm. See tab 14.
5. Implement cardiovascular support as required.
6. Insert an arterial line and CVC for blood gas analysis and haemodynamic monitoring.
7. Maintain urine output – use diuretic therapy.
8. Treat the developing coagulopathy – consult with transfusion services.
9. Return all products to blood bank and take **fresh blood and urine samples** for analysis.
10. ICU admission.

Blood Bank Ext No. .....

Haemotalogy Ext No. .....

ICU Ext No. .....

HAEMOLYTIC TRANSFUSION REACTION

Signs in the anaesthetized patient include:

Hypotension	Wheeze	Cola-coloured urine
Tachycardia	Tachypnoea	Bleeding (membranes, infusion sites)
Bronchospasm	Oedema	Cardiovascular collapse
Urticaria	Hypoxia	

Although rare, this carries significant mortality.
Staff should be informed immediately and the blood rechecked against the patient.
More blood should be taken for further testing.

Treatment is directed towards **circulatory support**, alleviating **respiratory symptoms** and anticipating and treating **coagulopathy** (see also Anaphylaxis, Major Haemorrhage and Bronchospasm protocols).

Diuretics and inotropic support should be commenced **to maintain urine output of 0.5 to 1.5ml/kg/hr**.

Treatment of any developing coagulopathy should be directed by the coagulation profile (see table on tab 5).

All products should be returned to transfusion for further analysis.

Drug dosages

Mannitol 25%	0.5g–1g/kg IV
Frusemide	0.5mg/kg IV
Methylprednisolone	1–3mg/kg IV

		Paediatric dose
Adrenaline	3mg/50ml saline (60mcg/ml)	0.05–0.5mcg/kg/min
Dobutamine	250mg/50ml saline (5mcg/ml)	2–20mcg/kg/min
Noradrenaline	4mg/50ml saline (80mcg/ml)	0.02–1.0mcg/kg/min

In a 70kg adult, infusions can be commenced at 5ml/hr and then titrated to response. Dilutions are given for syringe drivers.

AIR EMBOLISM

1. **Call** for help, **communicate** the problem and **delegate**.
2. Prevent further entrainment of air.
3. Flood the operative field.
4. Ventilate with 100% O_2. Avoid Nitrous Oxide.
5. Place the patient in a head down, lateral position.
6. Consider the use of **PEEP**.
7. Aspirate the CVC. Attempt closed cardiac massage.
8. Commence IV fluid therapy and keep hydrated.
9. Use **adrenaline** for haemodynamic support.
10. Consider **hyperbaric oxygen therapy** and ICU admission following successful resuscitation.

ICU Ext No. .....

Hyperbaric Chamber Ext No. .....

AIR EMBOLISM

Signs during anaesthesia include:

⇓SpO_2	Elevated PA pressure
⇓$EtCO_2$	Elevated CVP
Hypotension	Tachycardia
'Mill wheel' murmur	Bronchospasm
Pulmonary oedema	Cardiovascular collapse

Communicate effectively so staff appreciate the severity and urgency of the situation.

Delegate a person to call elapsed time and monitor the haemodynamic status.

Hyperventilate with 100% O_2 and intubate if necessary.

The use of PEEP is controversial. Initially thought to help prevent venous air embolism it may also increase the risk of paradoxical air embolism. Judicious use to support oxygenation may still be appropriate.

Aspirate only if a central venous catheter or pulmonary artery catheter is in place. There is no evidence to support emergent CVC placement.

Closed cardiac massage has been shown to break up large volumes of air in the cardiac chambers.

*Hyperbaric oxygen up to 6 hours (possibly more) following the event should be considered in large **paradoxical** air embolism – a patent foramen ovale is present in 10–30% of the population.*

As little as 0.5ml of air in the coronary arteries can precipitate ventricular fibrillation.

Drug dosages

Adult:

Adrenaline **bolus** 25 to 100mcg.
Infusion of 3mg in 50ml commenced at **5ml per hour**.
Note with 3mg in 50ml, rate in ml/hr = mcg/min.

Paediatric:

Adrenaline	**bolus**	0.1mcg/kg.
	infusion	0.05–0.5mcg/kg/min.

The use of positive pressure ventilation, end tidal monitoring, central venous or pulmonary catheters, precordial doppler and transoesophageal echo in **high risk procedures** can lead to early diagnosis and treatment.

DIFFICULT MASK VENTILATION

1. **Call** for help, **communicate** the problem and **delegate**.

2. Use high flow 100% O_2.

3. Optimize ventilation attempt: head position
   jaw thrust
   guedel airway
   dry perioral area

   If there is no improvement is associated with rapid deflation of reservoir bag, poor refilling, low circuit pressure and ongoing facemask leak, ***go to step 4***.

   If there is no improvement associated with good filling of reservoir bag, good facemask seal, high circuit pressure and difficulty emptying reservoir bag on attempted ventilation then consider ***Laryngeal Spasm*** *(tab 12) or* ***Elevated Airway Pressure*** *(tab 13).*

4. Consider waking the patient if appropriate.

5. Ensure adequate anaesthesia and attempt 2 LMA™ insertions.

6. Use a depolarizing muscle relaxant and intubate. If LMA™ insertion fails.

7. If intubation is difficult and saturations permit, continue with the difficult intubation protocol; **however time and saturations may dictate immediate CICV protocol - see tab 11**.

This is not a checklist but a guideline to regularly rehearse.

DIFFICULT MASK VENTILATION

This protocol is based on the assumption of a recently checked anaesthetic machine and an intact circuit with fresh gas flow – **confirmed by preoxygenating the patient and witnessing a visible $EtCO_2$ trace**.

In practice, these conditions may not always be met. In difficult mask ventilation when machine or circuit is suspected, removing them and using **a self-inflating resuscitator** is the most time efficient method of excluding these possibilities.

To maximise conditions consider

Head position: neck flexion head extension ('sniffing').
Jaw thrust: two hands forward pressure behind mandibles.
Guedel airway: opt for larger size.
Perioral area: clean off moisturizer and remove any excess airway lubricant to allow firm grip on face and mask.

Waking the patient may be an option if factored into the anaesthetic plan e.g. gaseous induction or gradual onset TIVA to test ventilation in suspected difficult airway.

However, if difficulty was not anticipated and the patient received a **full anaesthetic induction dose**, the anaesthetist may be committed to securing the airway.
Ensuring **adequate anaesthesia** is a prerequisite for mask ventilation and LMA™ insertion. Preserved airway reflexes and insufficient anaesthetic depth will diminish the likelihood of success.

Time management during airway crises is vital to a positive outcome. It can be complicated by partial ventilation, borderline saturations, the arrival of another clinician, equipment delays, drug onset times and fixation error. Delegating to a staff member the role of calling elapsed time interval as well as monitoring SpO_2 and $EtCO_2$ may prevent prolonged hypoxia.

Always preoxygenate the patient before induction if possible.

UNANTICIPATED DIFFICULT INTUBATION

1. **Call** for help, **communicate** the problem and **delegate**.

2. Request difficult airway trolley.

3. Monitor the time, SpO_2 and $EtCO_2$.

4. Confirm bag and mask ventilation.

If ventilation is unsuccesful,

5. Maximize laryngeal view: neck flexion head extension
   adjust cricoid pressure
   attempt external manipulation
   consider long or straight blade
   McCoy or video laryngoscope

6. Allow up to 4 intubation attempts if SpO_2 permits

7. Attempt 2 LMA™ insertions*

8. If after attempted ventilation and intubation,
   SpO_2 <90% with FiO_2=1
   No breath sounds or chest movement
   Flat $EtCO_2$ trace *then*
   Call CICV emergency response.

This is not a checklist but a protocol requiring regular rehearsal.

UNANTICIPATED DIFFICULT INTUBATION

There is overlap of the **'Difficult Mask Ventilation'** and **'Difficult Intubation'** protocols, as each technique uses the other as a rescue alternative.

The following summarizes the protocols.

1. Can't bag and mask	*Options:*	Wake the patient if possible Use LMA™ as rescue device Intubate
2. Can't intubate	*Options:*	Wake the patient if possible Bag and mask Use LMA™ as rescue device

If none of the above options is successful, implement the CICV emergency response.

Always delegate **a timekeeper and SpO_2 observer** (calling elapsed time intervals and saturations) and be aware that multiple intubation attempts can convert a 'can't intubate ***can*** ventilate' to a 'can't intubate ***can't*** ventilate' emergency (also known as 'cant intubate can't oxygenate').

Given the variability in difficult airway scenarios, familiarity with the decision making process and the underlying principles is a prerequisite for safe practice.

*Trying LMA™ insertion after muscle relaxation (given for attempted intubation) may improve rescue success rate.

Once ventilation of the lungs is established with persistent CO_2 waveform, the airway can be secured by an increasing number of techniques available. The clinician should use that which is most familiar and likely to be successful in the particular clinical circumstance.

Always preoxygenate the patient before induction if possible.

CAN'T INTUBATE CAN'T VENTILATE

Cannula Cricothyroidotomy

1. Palpate (NDH) and puncture (DH) the cricothyroid membrane.
2. Stabilize syringe (DH) and slide cannula into trachea (NDH).
3. Confirm position by aspirating the full length of the syringe.
4. Attach the ventilation system to the cannula.
5. Begin cautious ventilation – 1 second inflation, 3 second pause with high pressure (jet) ventilation.
6. Confirm ventilation of lungs and exhalation through the upper airway.
7. If unsuccessful or complications develop, proceed immediately to surgical cricothyroidotomy.

Recommendations:

Choose a 14g kink resistant cannula.
Syringe size between 5 and 20ml. DAS (UK) suggests 20ml.

Review equipment on difficult airway trolley on a regular basis.
Be familiar and confident with high pressure ventilation.
Regularly rehearse the steps outlined.
Attend advanced airway workshops for hands on experience.

DH=dominant hand
NDH=non dominant hand

CAN'T INTUBATE CAN'T VENTILATE

Surgical Cricothyroidotomy

If the anatomy is palpable.

1. Identify cricothyroid membrane.
2. Stab incision through skin and membrane. *Enlarge with dilator or blunt dissection (scalpel handle or forceps).*
3. Caudal traction on cricoid cartilage with tracheal hook.
4. Insert ETT or tracheostomy tube.
5. Ventilate from a standard low pressure source.
6. Confirm ventilation with $EtCO_2$.

Alternatively, once a horizontal stab incision is made, the scalpel blade can be rotated caudally and with lateral pressure allowing a space for a **ventilating bougie** to be passed.

If the anatomy is not palpable, a 6 to 8cm midline vertical neck incision with blunt finger dissection to separate the strap muscles will expose the trachea. Cannula cricothyroidotomy can then be achieved under vision.

In all cases, once there has been successful oxygenation, early conversion to a definitive airway is required.

CICV sometimes referred to as **CICO** *(can't intubate can't oxygenate).*

LARYNGOSPASM

1. 100% oxygen.
2. Cease all stimulation.
3. Remove airway devices and suction*.
4. Apply gentle CPAP with jaw thrust.

If spasm persists and desaturation continues,

5. **Call** for help, **communicate** the problem and **delegate**.
6. Deepen anaesthesia^.
7. Give **suxamethonium** and continue CPAP.
8. Intubate if SpO_2 does not improve
9. Consider atropine 10–20mcg/kg for the treatment of associated bradycardia.

This is a sequence to be rehearsed.
Time will not permit a checklist management approach.

LARYNGOSPASM

Although stimulating airway devices contributing to spasm should be removed, the **Guedel (oral) airway** may be helpful in providing CPAP.

Call for assistance early. The situation deteriorates rapidly in children.

Delegate responsibilities clearly including ETT preparation and suxamethonium administration.

Some paediatric anaesthetists will carry **pre-drawn suxamethonium** in their pocket to reduce drug error and save time during desaturation.

ˆDeepening anaesthesia is an option in adult anaesthesia.
Rapid development of **hypoxia** in children usually precludes this.

Spasm will 'break' with sufficient hypoxia and time, but predisposes to bradycardia, cardiac arrest, regurgitation and pulmonary oedema. These can be prevented with early intervention.

Dosage: ***suxamethonium*** 0.1 to 1mg/kg IV.
2 to 4mg/kg IMI/IO/IL.

In complete obstruction, forced inflation attempts will add to obstruction (Fink ball/valve effect) and inflate the stomach.

Consider stomach deflation before emergence.

In a rapidly desaturating child, immediate intubation without relaxation may be the appropriate treatment.

IO = Intraosseous.
IL = Intralingual.

ELEVATED AIRWAY PRESSURE

1. Manually ventilate to confirm high pressure and immediately check the airway for any obvious change.

2. Exclude light anaesthesia and/or inadequate muscle relaxation.

3. Perform a systematic circuit inspection.

4. If unresolved, replace the circuit with a self inflating resuscitator connected *directly* to the airway device.

5. Check the position and patency of the airway.

6. Examine the patient's respiratory system and consider calling for assistance.

7. If any doubt, replace the airway. If ventilating with an LMA™, consider replacing with an ETT.

8. Review checklist of patient causes.

ELEVATED AIRWAY PRESSURE

Checking muscle relaxation eliminates the most likely cause. In the *unintubated* patient this is usually **laryngospasm**.

If eliminating inadequate relaxation does not correct the rise in pressure, *systematically working through steps 1 to 6* should determine the problem.

While hand ventilating, check all tubes, valves, connections and filters. Check the machine position to exclude tube kinking or obstruction.

Once the circuit is removed and replaced with a *resuscitator*, the problem is isolated to the airway device or patient.

The airway should be: *assessed for position and patency.*
be suctioned down its full length.
be replaced if the problem is unresolved.

A chest examination should be performed before undertaking airway replacement.

If there is no change following these procedures (new airway and new circuit), the problem must then be with the patient.

Consider:

Laryngospasm	Pneumothorax
Bronchospasm	Haemothorax
Oedema	Chest wall rigidity

Although calling for assistance is the last step in this sequence, it could occur at any stage the practitioner feels appropriate.

For a review of causes see *Crisis Prevention:* ↑ *Airway Pressure* (tab 27).

SEVERE BRONCHOSPASM

1. **Call** for help, **communicate** the problem and **delegate**.
2. Hand ventilate and deepen anaesthesia.
3. Check tube placement and switch to 100% O_2.
4. Utilize in-circuit **salbutamol** and **ipatropium bromide**.
5. Monitor $EtCO_2$ waveform and airway pressures.
6. Consider IV fluids, arterial line and serial ABGs.
7. Commence **adrenaline** or **salbutamol** as an IV bolus and use infusions if indicated to maintain stability.
8. Use a long expiratory phase, intermittent disconnection and low pressure PEEP to reduce *hyperinflation.*
9. Consider hydrocortisone, aminophylline or magnesium as adjunctive or alternative treatment.
10. Prepare for ICU admission if required.

ICU Ext No. .....

SEVERE BRONCHOSPASM

Bronchospasm will vary in severity under anaesthesia.
Mild bronchospasm will usually respond to removal of irritants (instrumentation and incorrect tube position), 'in-circuit' bronchodilators and deepening anaesthesia.
Severe bronchospasm requires more aggressive, intravenous bronchodilator therapy.

Drug dosages

Adrenaline bolus: 0.1–1.0mcg/kg *titrated to haemodynamics.*
infusion: 0.1mcg/kg/min.
Note with 3mg in 50ml, rate in ml/hr = mcg/min.
Therefore commence at 7mls/hr for a 70kg man.

Use an arterial line and serial ABGs to guide management.

Salbutamol bolus: 5mcg/kg up to 2 years.
15mcg/kg up to 18 years (max 250mcg).
infusion: Start at 100mcg/kg/hr (up to 300mcg/kg/hr).

Aminophylline: Loading dose of 5 to 7mg/kg over 15 minutes.
Infusion of 0.5/kg/hr to follow.

Magnesium: 50mg/kg over 20 minutes with a max dose of 2g.

Hydrocortisone: 1–2 mg/kg IV.

IV fluids: commence therapy with 10–20ml/kg of crystalloid.

Intermittent disconnection allows CO_2 escape and prevents hyperinflation. Hand ventilation with *permissive hypercapnia* may also be required to avoid the complications of high airway pressure ventilation.

Treatment can be assessed by haemodynamic parameters, airway pressure, ABGs and the CO_2 waveform. With resolution, the 'sloping' upward trace of $EtCO_2$ returns to normal with the more horizontal alveolar plateau.

ASPIRATION

1. **Call** for help, **communicate** the problem and **delegate**.
2. Place the patient in a head down and lateral position.
3. Remove the airway and suction the pharynx.
4. Intubate and suction bronchial tree when airway secured.
5. Ventilate with 100% oxygen.
6. If aspiration is severe, proceed only with emergency surgery.
7. Empty the stomach before emergence.
8. Consider admission to ICU.

ICU Ext No. .....

ASPIRATION

How much assistance required depends on the severity and circumstances.

Immediate **communication** with the surgeons and **delegation** of tasks (e.g. turning the patient) may limit the amount of aspiration.

Positioning the patient will depend on the type of surgery and practical limitations.

Steps 1 to 4 should be achieved before step 5 if SpO_2 permits.

Cricoid pressure can be used during intubation but NOT during active vomiting or regurgitation.

Mild aspiration usually resolves without specific treatment.

If at 2 hours post aspiration, the patient is not symptomatic, the chest X-ray is clear and the SpO_2 is normal, ICU is not indicated.

However, if there is ***particulate matter***, indicative of more severe aspiration, ICU will be required.

Steroid and antibiotic therapy are ***NOT*** usually indicated in the short term management of aspiration.

TOTAL SPINAL
Obstetrics

1. **Call** for help, **communicate** the problem and **delegate**.
2. Follow the ABC protocol.
3. Time the resuscitation and use elapsed time prompts.
4. Intubate and ventilate with **100% O_2** if respiratory arrest.
5. Use **vasopressors** to maintain an adequate blood pressure.
6. Elevate the legs and rapidly infuse IV fluids.
7. Commence CPR if there is no detectable cardiac output.
8. Give **atropine** for associated bradycardia.
   Steps 1-8 also apply to non pregnant patient.
9. Deliver the baby after ***4 minutes*** if there is no response.
10. Inform ICU and the neonatal unit

Cardiac Arrest	Ext No. . . . .
Obstetric Emergency	Ext No. . . . .
Neonatal Unit	Ext No. . . . .
ICU Unit	Ext No. . . . .

TOTAL SPINAL
Obstetrics

Call for assistance immediately. An unconscious pregnant woman will require many hands to manage during resuscitation.
Delegate clearly and convey the sense of urgency.

Although the steps are listed sequentially, with delegation key interventions should be occurring simultaneously – leg elevation, fluids and vasopressors can all occur during the securing of the airway.

The diagnosis is usually apparent – rapidly ascending numbness and paralysis following spinal or epidural.

If not witnessed or diagnosis uncertain, see *Maternal Collapse* (tab 18).

The differential diagnosis includes:
- Vasovagal
- Haemorrhage
- LA toxicity
- IVC compression
- Embolus

A pregnant woman is prone to reflux. Intubation is preferred but should not exclude any other form of airway management if conditions don't permit (cricoid pressure is recommended).

If the patient has lost consciousness, intubation can be accomplished without an induction agent or with relaxant only.

In profound spinal blockade with an detectable cardiac output CPR should commenced be until there is a response to fluids and vasopressors.

It should be performed in accordance with the maternal resuscitation guidelines (see *Maternal Collapse* - tab 18) including emphasis on uterine displacement, left lateral tilt and delivery of the baby.

Delivery should be considered 4 minutes after commencement of CPR

Bolus drug dosages:

Atropine	0.6–1.2mg
Ephedrine	12–15mg
Phenylephrine	50–100mcg
Adrenaline	25–50mcg

POST PARTUM HAEMORRHAGE

1. **Call** for help, **communicate** the problem and **delegate**.
2. Administer 100% oxygen.
3. Insert 14g IV cannula × 2.
4. Use crystalloid or colloid resuscitation*.
5. 'Rub up' the uterus or use bimanual compression.
6. Notify blood bank for crossmatch and component therapy.
7. Consider group specific or O negative blood.
8. Notify operating theatres for immediate transfer.
9. Use **oxytocics** for *uterine atony*.
10. Support vital organ perfusion with vasopressors.
11. Induce general anaesthesia with RSI for surgical control.
12. Continue with *Severe Haemorrhage Protocol* (tab 5).

Obstetrics	Ext No. . . . .
Duty anaesthetist	Ext No. . . . .
Blood bank	Ext No. . . . .
Operating Theatres	Ext No. . . . .

POST PARTUM HAEMORRHAGE

Blood loss is frequently underestimated and coagulopathy may be disproportionate to blood loss.

*There is no advantage of colloid over crystalloid supported by evidence (meta-analysis in Cochrane library favoured crystalloid).

Use normal saline or lactated Ringer's solution... NOT 5% dextrose.

1 litre blood loss requires 3–5 litres of crystalloid.

Uterine manoeuvres including 'rubbing up' the uterus or bimanual compression can significantly slow and reduce blood loss.

FFP, platelets, cryoprecitate, antifibrinolyitics and recombinant Factor VII and Prothrombinex may all be required.

Products should be administered initially as clinical circumstances dictate but then guided by coagulation testing.

Life threatening haemodynamics may require the use of uncrossmatched (O negative) or group specific blood.

Oxytocic dosages:

Oxytocin	5IU slow push IV
	10IU per hour infusion
Ergometrine	500mcg IMI
Misprostol	400 to 1000mcg PR/SL
Carboprost	250mcg IMI/intrauterine
	(15 minutely, max 8 doses)

Vasopressor dosage:

Ephedrine	6 to 12mg bolus
Metaraminol	1mg bolus
Phenylephrine	25–50mcg bolus

MATERNAL COLLAPSE

1. **Call** for help, **communicate** the problem and **delegate**.

2. Commence CPR.
   Use left, cephalad uterine displacement or max 30° tilt.

3. Intubate early and ventilate with 100% O_2.

4. Establish IV access.

5. Place monitor leads and assess cardiac rhythm.

6. Follow the appropriate cardiac arrest protocol see tab 1 and 2.

7. Treat any reversible causes.

8. **Deliver baby after 4 minutes** *if pregnancy > 24 weeks.*

9. Debrief and support the resuscitation team.

Emergency Call Ext No. . . . . .

Obstetric team Ext No. . . . . .

OR Ext No. . . . . .

Paeds Ext No. . . . . .

MATERNAL COLLAPSE

Key differences in maternal resuscitation are: uterine displacement
early intubation
baby delivery

Early intubation reduces aspiration risk.

Task delegation includes: Airway
Chest compression
Uterine displacement
IV insertion

Common causes (delivery less likely)

Vasovagal
High epidural/spinal block (tab 16)
LA toxicity (tab 20)
Haemorrhage (tab 17)
Hypertensive disease of pregnancy

Commence magnesium sulphate therapy for seizures
Loading dose 4g over 15 minutes (1g = 4mmol Mg)
Infusion 1g/hr for 24 hours
2g bolus if still fitting

Uncommon causes (delivery more likely)

Pulmonary embolus	Cardiac event (4Hs 4Ts, tab 1)
Uterine rupture	Cerebral event
Amniotic fluid embolus	Anaphylaxis (tab 6)

A **PERIMORTEM** delivery pack should be kept on the resuscitation trolley.

The most experienced clinician performs C-section with a vertical incision (or obstetrician preference) for rapid extraction of baby.

Maternal resuscitation is a traumatic event for all concerned. Debriefing and supportive counselling are recommended.

NEONATAL RESUSCITATION – NEWBORN LIFE SUPPORT

1. Dry, warm and cover the baby to conserve heat.
2. Assess the colour, tone, breathing and heart rate.
3. **Call** for assistance, **communicate** the problem and **delegate** tasks if nonvigorous or condition deteriorating.
4. Open the airway and give **5 inflation breaths**.
5. Reassess heart rate (target >100bpm) and chest movement.
6. If there is no improvement or chest movement, reposition and repeat.
7. Visualize the pharynx, suction and intubate if necessary.
8. If the heart rate falls below **60/min** commence chest compressions.
9. Reassess every 30 seconds and if no response
   Give
   - **adrenaline** 10–30mcg/kg
   - **glucose** 10% 2.5ml/kg
10. In the presence of **hypovolaemia**, 10ml/kg of isotonic crystalloid or O negative, CMV negative blood can be given and repeated if necessary.
11. Continue Paediatric Advanced Life Support (tab 3) and admit to Neonatal ICU if successful resuscitation

Neo-natal ICU Ext No. .....

NEONATAL RESUSCITATION – NEWBORN LIFE SUPPORT

An inflation breath is **2–3 seconds in duration and 30cm H_2O pressure** – if the heart rate responds by increasing, continue to ventilate at a rate of **30–40/min** until there is adequate spontaneous ventilation.

If there is no chest movement, reposition and try **airway manoeuvres** to aerate effectively include: Postioning of head (neutral)
Jaw thrust (assistance may be required)
Oropharyngeal airway (Guedel)
Laryngoscopy, suction +/− intubation

Gentle oropharyngeal suctioning is preferred. Nasopharyngeal suctioning has been associated with **bradycardia** during resuscitation.

Endotracheal suctioning is still indicated in *nonvigorous babies* when meconium is present.

The LMA™ can be used as an alternative airway device.

Colour is not a reliable indicator of SpO_2 in the newborn but **pallor** may indicate an *acidotic* or *anaemic* baby.

SpO_2 soon after birth should be 60% increasing to >90% at 10 minutes. Room air is appropriate for the term newborn. However if SpO_2 is still unacceptable, introduce oxygen supplementation – use oximetry for guidance.

Hyperoxaemia, particularly in preterm babies, should be avoided.

Chest compressions are given at 120/min.
Ventilation chest compression ratio should be 1:3 with a pause for ventilation. Once intubated, the pause is no longer necessary.

Ventilation and chest compression fail to resuscitate less than 1 in 1000 babies

Adrenaline dose is 10mcg/kg but can be increased to **30mcg/kg** if the lower dose is not effective. **Bicarbonate** is not recommended.

Post resuscitation care should include *therapeutic hypothermia* if evidence of evolving encephalopathy.

LOCAL ANAESTHETIC TOXICITY

1. **STOP** giving the drug.

2. **Call** for help, **communicate** the problem and **delegate**.

3. Review the airway, secure if necessary with intubation and ventilate with 100% O_2.

4. Commence CPR if there is circulatory arrest.

5. Secure intravenous access and treat convulsions.

6. Follow standard arrhythmia protocols (tab 1 and 2).

7. **Administer 20% intralipid intravenously**.
   The intralipid is kept in the .....

8. Consider **cardiopulmonary bypass** if readily accessible.

Perfusion Ext No. .....

LOCAL ANAESTHETIC TOXICITY

If there is no circulatory arrest, use conventional supportive measures to maintain haemodynamic stability.

Delegate a staff member to monitor *haemodynamic status* and to call out elapsed time (1 to 2 minutely).

Amiodarone can be used for ventricular irritability but lignocaine and other class 1B antiarrhythmic agents should be avoided – for dosage see tab 1. **Beta blockers** can also have an adverse effect through myocardial depression and *decreasing clearance* of anaesthetic agent.

Advanced life support should be continued for at least **one hour** because of the duration of binding to the myocardium.

Drug dosages

Anticonvulsants		***70kg patient***	***20kg patient***
Midazolam	0.05–0.1mg/kg	5–10mg	1–2mg
Diazepam	0.1–0.2 mg/kg	5–10mg	2mg
Thiopentone	1mg/kg	50mg	20mg
Propofol	0.5–2mg/kg	50–100mg	20–40mg

Intralipid regimen

Immediately: 1.5mg/kg *bolus* over 1 minute (100ml in adult). Commence *infusion* of 15ml/kg/hr (1000ml per hour in adults).

At 5 minutes: Repeat the bolus dose and double the infusion rate if not responding.

Allow a total of three bolus doses 5 minutes apart.

Although there are significant practical considerations, a well rehearsed cardiac unit with bypass readily available may be lifesaving.

HYPERKALAEMIA

1. Exclude any possible artifact. Repeat sample.

2. Establish cardiac monitoring and intravenous access.

3. Cease any source of K+ administration.

4. Hyperventilate the patient.

5. Give:
   Calcium chloride
   $NaHCO_3$
   Glucose
   Insulin

6. Consider continuous nebulized salbutamol.

7. Undertake dialysis if dangerous levels persist or longer term control required.

8. Correct any reversible precipitating factors.

HYPERKALAEMIA

Treatment is required if hyperkalaemia is considered severe (>7mmol/L) or there are obvious ECG changes.

To exclude artifact, repeat venepuncture from a new site.

ECG changes:

Peaked T waves	Loss of P wave
Prolonged PR	Loss of R amplitude
Widened QRS	Sine wave pattern – asystole

Drug dosages

Adult:	**Calcium chloride**	5ml 10% IV slow push
	Calcium gluconate	10ml 10% IV slow push
	$NaHCO_3$	50ml IV stat
	50% dextrose	25–50ml IV stat
	Insulin	10 units IV stat
Paediatric:	**Calcium chloride**	0.2ml/kg 10% IV over 5 min (5ml max)
	Calcium gluconate	1ml/kg 10% IV over 3–5 mins (10ml max)
	Glucose 25%	0.5g/kg (2ml/kg)
	Insulin	0.1units/kg IV stat

Precipitating factors include:

trauma
burns
suxamethonium (burns, spinal injury, neurological disease)
malignant hyperthermia
acidosis
acute renal failure
organ reperfusion following clamp release
haemolyis/massive transfusion
medications

Avoid: suxamethonim
respiratory acidosis
Hartmann's solution

MALIGNANT HYPERTHERMIA (MH)

1. **Call** for help, **communicate** the problem and **delegate**.
2. Request pre-prepared MH box. Use task cards.

   Box is located.....
3. Cease and remove volatile agents. Change soda lime only if quick and easy.
4. Hyperventilate with 15l/min 100% O_2 – **do not waste time changing circuit or machine**.
5. Commence **IV dantrolene**. Use 2.5mg/kg.
6. Maintain anaesthesia – use TIVA.
7. Insert arterial line and consider CVC – do not delay dantrolene.
8. Actively cool the patient.
9. Treat associated conditions: Hyperkalaemia
   Acidosis
   Arrhythmias
10. Maintain urine output at >2ml/min.
11. Monitor with serial ABGs, electrolytes and temperature.
12. Admit to the ICU.

MH box is located.....

Laboratory Ext No.....

ICU Ext No.....

MALIGNANT HYPERTHERMIA (MH)

Signs suggesting possible MH

Early	*Developing*	*Late*
Elevated $EtCO_2$	Acidosis	Cola-coloured urine
Masseter spasm	Temperature rise	↑↑CK
Tachycardia	CVS instability arrest	Coagulopathy
Arrhythmias	Hyperkalaemia	↓SpO_2

If there is a malignant hyperthermia pre-prepared 'box' in the hospital, use it and follow the **task card system**.

If not, prioritize treatment: **D**antrolene
Anaesthesia
Supportive therapy

Dantrolene requires dedicated staff to prepare. It is dissolved in **sterile water**.

TIVA – use propofol TCI 4mcg/ml or 30–50ml/hr in adult.

Hyperkalaemia is treated according to protocol - see tab 21.

Diuresis is maintained using **0.5g/kg of mannitol**. *Aim for >2ml/kg/hr with a pH>7.0.*

Consider the treatment of acidosis with **8.4% $NaHCO_3$** *only* if there is associated hyperkalaemia.

Active cooling includes:

Intra-abdominal lavage (saline at 4°C)
Cool IV fluids
Cool sponging and ice packs
Lowering theatre temperature

Blood chemistry includes FBC, electrolytes, ABG's, CK, clotting profile and myoglobin levels.

TERMINAL EVENT CHECKLIST – THE 10 Ts

1. **T**ubes: airway placement, obstruction, disconnection, constriction, disruption.
2. **T**orrential haemorrhage.
3. **T**ryptase: anaphylaxis induced cardiac arrest.
4. **T**erminal rhythm: primary cardiac disease.
5. **T**amponade: traumatic or surgical.
6. **T**ension pneumothorax.
7. **T**hrombus: cardiac, pulmonary embolus, amniotic fluid, air or fat embolus.
8. **T**oxic: drugs, electrolytes, metabolic derangement.
9. **T**otal spinal.
10. **T**umour: space occupying lesions producing ↑ICP.

The 10 Ts checklist may help clinicians managing an anaesthetic crisis when the diagnosis has not been established.

NOTES

References

Association of Anaesthetists of Great Britain and Ireland Safety Guidelines

- *Management of Patient with Suspected Anaphylaxis during Anaesthesia*
- *Blood Transfusion and the Anaesthetist; Management of Massive Haemorrhage*
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- *Checklist for Anaesthetic Equipment (2004)*
- *Management of a Malignant Hyperthermia Crisis (2007)*
- *Management of Severe Local Anaesthetic Toxicity 2 (2010)*

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For further references, please see www.cambridge.org/9780521279864

CRISIS PREVENTION
Contents

15 POINT ANAESTHETIC MACHINE CHECK

1. Check the machine is switched on, uncluttered and positioned appropriately for the operating session.

2. Check service date and be aware of any notifications on the machine.

3. Check monitors are on with appropriate limits, cycling times and sampling lines connected – confirm oxygen analyzer, pulse oximeter and capnograph are functioning.

4. 'Tug test' the pipeline connections.

5. Check the oxygen is connected to the machine.

6. Check there is an adequate reserve supply of O_2.

7. Check other gas supplies are adequate and all pipeline pressures are between 400–500kpa.

8. Check flow meters are operating smoothly throughout the flow range.

15 POINT ANAESTHETIC MACHINE CHECK

9. Check the antihypoxia device and O_2 bypass are correctly functioning.

10. Check vapourizers are filled, seated, not leaking and then switched off.

11. Check the breathing circuit
    - configuration
    - connections
    - valves
    - leaks (include inner tube if present)

12. Check the ventilator
    - tube connections
    - pressure relief valve
    - disconnect alarm
    - settings

13. Check the scavenging system is
    - connected
    - correctly configured
    - functioning

14. Check the airway trolley – make sure all equipment needed for the anaesthetic plan (and contingency plan) is present *and functioning*.

15. Check suction, bed tilt, and confirm an alternative means of ventilation.

⇑AIRWAY PRESSURE

Circuit	Ventilator bag switch Ventilator setting Obstructed or kinked circuit Filter blockage Circle valve malfunction APL valve closed or stuck O_2 flush malfunction
Airway	Laryngospasm Tube position Tube size Tube obstruction
Patient	Bronchospasm Tracheal pathology Respiratory tract tumours Pneumothorax Pneumoperitoneum Chest wall rigidity Obesity Chest compression Alveolar pathology: *Oedema* *Fibrosis* *Contusion* *Infection* *ARDS*
Most likely	**Inadequate muscle relaxant** **Airway position** **Laryngospasm** **Bag/ventilator settings**

DESATURATION ($\downarrow SpO_2$)

⇓Delivery of O_2 to lungs	Oxygen supply – low FiO_2 Apnoea Low or inappropriate FGF ETT in left main bronchus Airway postion/obstruction Laryngospasm Brochospasm Ventilator malfunction/setting Circuit obstruction/disconnect
⇓Delivery of blood to lungs	Cardiac arrest Cardiac failure Anaphylaxis Pulmonary embolism
Impaired oxygen exchange or ⇑ A V shunt	One lung ventilation Pulmonary oedema Aspiration Contusion Atelectasis Pneumothorax Pneumoperitoneum Pneumonia Sepsis/ARDS
Artifact	Hypothermia Poor peripheral circulation Probe displacement
Most likely	**Probe displacement** **Apnoea/hypoventilation** **Tube position** **Laryngospasm**

HYPERTENSION

27

Anaesthesia	Emergence Inadequate depth Inadequate analgesia Hypoxia Hypercarbia Malignant hyperthermia Drugs Transducer height
Surgery	Tourniquet application Aortic clamping Carotid endarterectomy Baroreceptor stimulation
Patient	Essential hypertension Full bladder Pre-eclampsia Renal disease Phaeochromocytoma Thyroid storm Raised intracranial pressure

Most likely

Intubation/emergence
Inadequate anaesthesia/analgesia
Drugs
Essential hypertension

HYPOTENSION

⇓**Preload**	Blood loss Obstructed venous return Dehydration Capillary leak Elevated intrathoracic pressure Tamponade Embolism Patient position
⇓**Contractility**	Drugs (including volatile agents) Ischaemic heart disease Cardiomyopathy Myocarditis Arrhythmia Valvular heart disease Sudden increased afterload
⇓**Systemic vascular resistance**	Volatile agents Narcotics Vasodilators Regional blockade Sepsis Post cardiopulmonary bypass Neuropathy Tourniquet release Addison's disease Thyroid disease Anaphylaxis Bone cement
Most likely	**Anaesthetic agent** **Narcotics** **Regional blockade** **Hypovolaemia**

TACHYCARDIA

Primary causes

Ischaemic heart disease
Post cardiac surgery
Cardiomyopathy
Accessory conduction pathways
Sick sinus syndrome
Congestive heart failure
Myocarditis
Pericarditis
Valvular disease
Congenital heart disease

Secondary causes

Hypovolaemia
Anaesthetic depth
Drugs
Anxiety
Hypertension
Electrolyte abnormalities
Tamponade
Sepsis
Throtoxicosis
Lung disease
Malignant hyperthermia

Most likely

Anxiety
Intubation
Anaesthetic depth
Drugs
Hypovolaemia

BRADYCARDIA

Primary causes	Ischaemic heart disease Sick sinus syndrome Degeneration of conduction system Valvular disease Myocarditis Cardiomyopathy Post cardiac surgery Hereditary conduction disorders Physiological fitness
Secondary causes	Electrolyte abnormalities Antiarrhythmic medication Anaesthesia Hypothyroidism Hypothermia Vasovagal syndrome Increased intracranial pressure
Anaesthetic causes	Hypoxia Volatile agent Muscle relaxant Narcotic Anticholinesterase High spinal/epidural Vasopressor reflex
Most likely	**Drug related** **Vasovagal** **Spinal anaesthesia** **Fitness**

HYPERCAPNIA

⇑**Production**	***Endogenous***	Sepsis Malignant hyperthermia Thyroid storm NLMS Reperfusion
	Exogenous	Bicarbonate administration CO_2 insufflation TPN CO_2 in fresh gas flow Exhausted soda lime
⇓**Excretion**	***Circuit***	Airway obstruction Dead space Inadequate fresh gas flow Valve malfunction in circuit Incorrect ventilator settings
	Lungs	Spontaneous hypoventilation Bronchospasm Chronic airways disease
	Most likely	**Spontaneous hypoventilation** **Exhausted soda lime** **Ventilator setting** **Fresh gas flow setting**

HYPOCAPNIA

⇓**Production**	Hypothermia Hypothyroidism
⇑**Excretion**	Spontaneous hyperventilation Inappropriate ventilator setting
⇓**Transport in blood**	Cardiac arrest Severe hypotension Anaphylaxis Pulmonary embolus
⇓**Transport in lungs**	ETT obstruction Incorrect airway placement Laryngospasm Severe bronchospasm
Sampling dilution	Disconnect Entrainment Inappropriate sampler placement High fresh gas flows
NO $EtCO_2$	Disconnect No sampling No ventilation Cardiac arrest
Most likely	**Hyperventilation** **Inadequate tidal volume** **Laryngospasm** **Incorrect airway placement** **Hypotension**

CRISIS PREVENTION CHECKLIST

1. Check the machine.
2. Know the assistant's qualifications and experience.
3. Outline the anaesthetic plan – ask for feedback or questions.
4. Have a contingency plan – if uncertain consult with a colleague.
5. Know the location of dantrolene, difficult airway trolley and resuscitation trolley.
6. Confirm correct patient, procedure and side.
7. Be aware of any drug allergy.
8. Review airway and fasting status.
9. Check drug label and syringe.
10. Preoxygenate – check O_2 is on and confirm $EtCO_2$ trace.
11. Perform a post induction check "OCAB"

    O *xygenation*
    C *arbon dioxide*
    A *naesthetic agent*
    B *lood pressure*

12. In crisis management **call for help early**.