CRISIS MANAGEMENT MANUAL

COVER ABCD
A SWIFT CHECK

While every effort has been made to ensure the currency, validity and accuracy of the contents of this Manual, it may contain flaws. If in doubt, use your commonsense and think from "first principles".

Constructive criticism is invited - please write with comments to:

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WHY USE A CRISIS MANAGEMENT MANUAL?

All anaesthesiologists have to manage complex, rapidly evolving life-threatening crises with little or no warning.

It has been shown, however, that human beings can only perceive and process information at a finite rate.

In a crisis, events may unfold at a rate which exceeds our capacity to keep pace.

Several studies have shown that not all crises are managed well, even by experienced anaesthesiologists.

It is best, when all is not going well or in crisis situations, to carry out pre-determined sequences of actions which have been shown to be safe and to cater for rare, dangerous problems as well as for more common, mundane ones.

This manual provides an approach, via a series of easy-to-access algorithms, to any crisis which occurs when a patient is undergoing general or regional anaesthesia.

These have been checked against all relevant incidents amongst the first 4000 reported to the Australian Incident Monitoring Study (AIMS). Correctly used, they will guide the anaesthesiologist to an appropriate set of actions and responses in over 99% of applicable incidents.

The responses outlined here have been developed after thousands of hours of analysis of anaesthesia incident reports and after seven one or two-day meetings, each attended by 60-100 anaesthesiologists. See inside the back cover for a brief story about how this manual came into existence.

As this 2nd Edition goes to print, the Australian Patient Safety Foundation is analysing the most recent 2000 AIMS incident reports from 2005-6. Thus regular updating of this Manual and of its web version (www.apsf.net.au) will keep pace with the significant advances and changes in clinical anaesthesia practice.

At the same time it should be remembered that no manual will work in every circumstance and a good outcome cannot be guaranteed. Always use your common sense, and revert, if necessary, to working from first principles.

WHEN AND HOW TO USE THIS MANUAL

The manual is based on the mnemonic

"COVER ABCD - A SWIFT CHECK"

and is designed for use when any patient is undergoing general or regional anaesthesia. The sequence becomes AB COVER CD - A SWIFT CHECK when the patient is breathing spontaneously, and some components become redundant in certain circumstances; examples are given at the end of this section.

The mnemonic serves as a reminder to **always cycle systematically** through a basic series of thoughts and actions, the intensity of which will depend on the circumstances. This series of thoughts and actions is:

C **C**irculation, **C**apnograph, and **C**olour (saturation)
O **O**xygen supply and **O**xygen analyser
V **V**entilation (intubated patient) and **V**aporisers
E **E**ndotracheal tube and **E**liminate machine
R **R**eview monitors and **R**eview equipment

A **A**irway (with face or laryngeal mask)
B **B**reathing (with spontaneous ventilation)
C **C**irculation (in more detail than above)
D **D**rugs (consider all given or not given)

A Be **A**ware of **A**ir and **A**llergy - page 6.

SWIFT CHECK of patient, surgeon, process, and responses.

The **four levels of intensity** for each of these components are represented by another mnemonic:

"SCARE" (**S**CAN, **C**HECK, **A**LERT/**R**EADY, **E**MERGENCY),

and comprise - pages 6 to 13 of this manual.

The **S**CAN sequence should be followed every 5 minutes of any anaesthetic, or more often if necessary. This overcomes the need for special training sessions, as the sequence rapidly becomes second nature and can usually be completed in 40-60 seconds. The **C**HECK sequence should be used whenever all is not going according to plan, and should also be practised regularly.

Do not hesitate to move on to the **A**LERT/**R**EADY and **E**MERGENCY sequences if you are worried, if events are moving quickly, or if it seems that an adverse outcome is possible. These should also be practised from time to time.

Depending on the circumstances, components of each level of **S**CARE may be assembled as appropriate, as long as the sequence of **COVER** is always adhered to. For example, with sudden, severe hypertension, if the first four components of **COVER** (**C**irculation, **C**olour, **O**xygen, **O**xygen **A**nalyser) are stable and normal at the **S**CAN level, no further action is required for these. However, it would be desirable to use the **C**HECK level for the **V**entilation, **V**aporiser, **R**eview monitors, and **R**eview equipment components of **COVER**, for the **C** (**C**irculation) and **D** (**D**rugs) components of **ABCD**, for the **A** (for **A**wareness) and for **SWIFT CHECK** (especially with respect to what the surgeon is doing). Hypertension and awareness are two crisis circumstances in which the concentration of volatile agent may be increased - for most crises it is left alone at the **S**CAN and **C**HECK levels and turned off at the **A**LERT/ **R**EADY and **E**MERGENCY levels.

On the other hand, if, for example, it is suddenly noticed that the patient is pulseless and blue, the full **E**MERGENCY sequence of **COVER** (i.e. the **"E"** level of SCAR**E**) should be carried out immediately with progression to any appropriate sub-algorithms (the "sub-algorithms" are the derived algorithms that address respectively each specific anaesthesia crisis dealt with in this Manual).

It is important that the basic **COVER ABCD** sequence is followed before becoming focused on any particular sub-algorithm; a major problem is "locking onto" a diagnosis which may not be correct. When assistance is called for, one person should repeatedly cycle through the **COVER ABCD** sequence and consider other possibilities, whilst the steps in any relevant sub-algorithms are followed. Some sub-algorithms repeat components of **COVER** (e.g. "give 100% oxygen"), usually when the entire sequence does not necessarily have to be followed in full at the outset, whereas others start by instructing anaesthesiologists to ensure that the full **COVER** sequence has been completed before starting the sub-algorithm (e.g. that for persistent desaturation, or air embolism).

Although the standard **COVER ABCD - A SWIFT CHECK** sequence should always be followed, some components become less important or redundant under particular circumstances: for intubated, ventilated patients the **A** and **B** after **COVER** become redundant; for patients breathing spontaneously via a mask, **A** and **B** precede **COVER**, as indicated at the start of this section, and **V** for **V**entilation becomes redundant. For a patient being ventilated via a laryngeal mask, **B** becomes redundant; and for a patient breathing spontaneously and receiving oxygen from a source independent of an anaesthetic machine (e.g. from a wall-mounted flowmeter during regional or intravenous anaesthesia), the **V** and **E** of CO**VE**R become redundant.

SOME FINAL TIPS

REMEMBER: Always go through **COVER ABCD** for ventilated patients and **AB COVER CD** for spontaneously breathing patients - followed in each instance by - **A SWIFT CHECK**. It will be obvious in any particular circumstance which components become redundant.

REMEMBER: Request assistance early on, allocate tasks and calmly coordinate activities, repeatedly cycling through **COVER** as well as any sub-algorithm/s thought to be appropriate.

REGIONAL ANAESTHESIA

There are two differences with regional anaesthesia.

1 At the **A** for **A**wareness stage of **A** - SWIFT CHECK: if the patient is sedated or conscious, talk to the patient, and, if concerned, ask how they are feeling.

2 At the **CHECK** level of A SWIFT **CHECK**: check the quality and extent of any block, and correlate the estimated extent of sympathetic blockade with any cardiovascular sequelae.

ABBREVIATIONS:

Airway

ETT - Endotracheal tube
LMA - Laryngeal mask airway

Breathing

IPPV - Intermittent positive pressure ventilation
PEEP - Positive end expiratory pressure
CPAP - Continuous positive airway pressure
ARDS - Adult respiratory distress syndrome
UWSD - Underwater sealed (chest) drain
SV - Self ventilating
SR - Spontaneous respirations

Circulation

CVP - Central venous pressure
VF - Ventricular fibrillation
VT - Ventricular tachycardia
ECC - External cardiac compression
GTN - Glyceryl trinitrate
SVT - Supra-ventricular tachycardia
SR - Sinus rhythm

Monitoring

$ETCO_2$ - End tidal carbon dioxide concentration
F_IO_2 - Oxygen fraction of the inspired gas
SpO_2 - Pulse oximeter saturation readout
BP - Blood pressure
ECG - Electrocardiogram
ICP - Intra-cranial pressure
BIS - Bispectral index (awareness) monitor

LAYOUT OF THE MANUAL: In this updated (2nd) Edition, the immediate sequences of thoughts and actions are shown on the left hand pages. The numbers therein cross-reference to ongoing care and further details on the respective right hand facing pages, so that all details may be viewed at once.

INDEX

SCAN as needed, or every 5 minutes

Circulation: Note the rate, rhythm and volume of the pulse and note the end tidal carbon dioxide concentration ($ETCO_2$) **(1)**.

Colour: Note the colour of the patient's mucous membranes and blood and note the saturation reading of the oximeter (SpO_2).

Oxygen: Note the rotameter settings and that the bobbins are spinning and calculate the inspired oxygen fraction (F_IO_2) **(2)**.

Oxygen Analyser: Note that the readout matches that expected in the inspiratory limb of the breathing circuit. Calibrate if necessary.

Ventilation: Note the patient's chest movements. Correlate these with the capnograph, breathing circuit pressures and tidal volumes.

Vaporisers: Note the vaporiser settings, the volatile agent liquid level on the vaporiser(s) in use and the vapour monitor readout.

Endotracheal tube or laryngeal mask airway: Note its position (distance marker at the lips), its orientation, the pilot bulb inflation for cuffed tubes, and its security **(3)**.

Eliminate: Note that in a crisis, you may need to remove machine, circuit, filter, ETT and its connections, e.g. the "catheter mount".

Review monitors: Note monitors in use and review all readings, waveforms and alarm settings. Update the anaesthetic record **(4)**.

Review equipment: Note all equipment in use, especially items in contact with the patient. Review its safety and function **(5)**.

Airway: Note the position of the head and neck, and the position, patency and security of any artificial airways or masks **(6)**.

Breathing: Note chest and abdominal movements and correlate these with the respiratory rate and pattern of spontaneous ventilation.

Circulation: Note trends in all cardiovascular parameters and correlate these with measured and estimated blood or other fluid losses **(7)**.

Drugs: Note drugs that have been given and correlate doses with effects. Note correct function of all IV lines and infusions **(8)**.

A: "Be **A**ware of **A**ir and **A**llergy". Be **A**ware yourself, think of possible **A**wareness in the patient, and of **A**ir (or other) embolism, **A**ir in the pleura (pneumothorax), **A**llergy or **A**naphylaxis **(9)**.

SWIFT CHECK: Note what the surgeon and other personnel are doing, check the patient's position on the table and that the physiological responses match the circumstances.

SCAN continued

(1) **Circulation:** Note the **volume** of the pulse. The $ETCO_2$ is used here as an index of venous return and cardiac output.

(2) **Oxygen:** If the source is not via an anaesthetic machine (e.g. direct **supply** from wall outlet, cylinder or oxygen concentrator), check the flowmeter and the integrity of supply from source to patient.

(3) **Endotracheal tube:** At insertion note and chart the distance marker at the **teeth** or gums when the tip is 3 cm (in an adult) past the vocal cords. Check this distance against the charted value, especially after the patient has been moved, the surgeon is working near the tube, or hammering or manipulation has taken place. If an LMA is in use, distance checks do not apply.

(4) **Review Monitors:** Note that all sensors are correctly placed, zeroed and **levelled** where appropriate, and note that they have been calibrated, if this is possible and practical. Note that **alarm** and alert settings are appropriate and are **turned on**.

(5) **Review Equipment:** Review all equipment in use by yourself and the surgical team **including** diathermy (electro-surgical apparatus), endoscopes, probes, retractors, heating blankets, humidifiers etc. Ensure that no physical, **thermal** or chemical damage can be done to the patient, and that the equipment is functioning as expected.

(6) **Airway:** Note any inappropriate use or pattern of the accessory muscles of respiration, any excessive retraction of the trachea or thyroid, and any uncoordinated or **paradoxical** movements of the chest or abdomen in relation to respiratory efforts.

(7) **Circulation:** In estimating blood or other fluid loss, suction bottle contents, swabs, drapes **and** floor should be checked (there is a very small margin for error in **babies and infants**). **Remember** that blood can pool under the patient on the table, and that considerable bleeding can take place into tissue spaces and body cavities. Note that venous return can be substantially influenced by retraction, pressure by the surgeon, by the gravid uterus lying on the inferior vena cava, or by manipulation of the heart, lungs or great vessels. Also, remember that traction, especially on eye muscles and peritoneum, can cause vagal stimulation.

(8) **Drugs:** Note that **all** syringes or infusions have been labelled in a standardised manner with the generic name of the drug (or fluid) and the dose (in mg/ml or mcg/ml as appropriate), and that the ampoules from which the ingredients have been taken are available for checking. Note that all IV lines are secure, labelled if multiple lines are in place and, if possible, visible from source to patient entry site.

(9) **Awareness, Air Embolus, Allergy : Always consider these** possibilities; each made up about 1% of AIMS reports.

CHECK: whenever you are worried

Circulation: Palpate a pulse. Correlate rate, rhythm and volume with the oximeter, ECG and BP monitor. Check capillary refill and $ETCO_2$ trace **(1)**.

Colour: If suspicious try the pulse oximeter on yourself. Take arterial blood for a lab check on saturation or blood gases.

Oxygen: Briefly increase the oxygen flow rate and calculate the new expected F_IO_2 in the breathing circuit (Caution: Patient awareness).

Oxygen Analyser: Check that the changes in the F_IO_2 are in line with the calculated changes in F_IO_2 in the breathing circuit.

Ventilation: **Ventilate by hand**. Check circuit including the catheter mount, connector and filter, scavenging, valves and visible moving ventilator parts.

Vaporisers: Check the vaporiser(s) are correctly seated, not empty, set, "locked in" and connected and that there are no gas or liquid leaks.

Endotracheal tube or laryngeal mask airway: Check position, orientation, patency and cuff. If ET tube is in use exclude endobronchial intubation **(2)**.

Eliminate: Check that an independent means of ventilating the patient (e.g. self-inflating bag) and an alternate supply of oxygen are available.

Review monitors: Check all monitors in use and compare current monitor values with those on the anaesthetic record **(3)**.

Review equipment: Check that all equipment in contact with or relevant to the patient is safe and functioning correctly.

Airway: Observe, palpate and auscultate the neck. If suspicious of airway obstruction, plan direct pharyngoscopy.

Breathing: Palpate and auscultate the chest whilst repeating SCAN. Review the $ETCO_2$ if a capnograph is in use.

Circulation: Cross check any abnormal BP readings where possible. Check the zero and scales of transducers.

Drugs: Check all ampoules, syringes, labels, infusion apparatus, connections & cannulae from fluid source to vein **(4)**.

A: Specifically consider the possibility of **A**wareness **(5)**, **A**ir (or other) embolism **(6)**, **A**ir in pleura (pneumothorax) **(7)**, **A**llergy or **A**naphylaxis **(8)**. See the relevant sub-algorithms for signs and high risk situations.

SWIFT CHECK: Correlate the monitored parameters with the clinical situation and risk factors. Specifically question the surgeon about what is being done, and check the pre-operative assessment, medical record and ward drug chart.

(1) **Circulation:** If possible, manually check a pulse other than the one being sensed by the oximeter. Beware - some oximeters automatically increase the size of the plethysmograph trace, if the pulse volume is small.

(2) **Endotracheal tube:** Endobronchial intubation must always be excluded. Palpation of the cuff above the sternal notch while squeezing the pilot balloon will confirm its position, and slight withdrawal may also resolve desaturation.

CHECK continued

Patency: Ventilate the tube directly (remove circuit, filter, all connections) with a separate system (see **E**liminate). The tip of the tube may have moved, the lumen become obstructed or the cuff herniated into the lumen or over the end of the tube. If there is any suspicion of regurgitation, aspiration or obstruction of a tube, perform direct laryngoscopy, suck out the pharynx, adjust the tube's position, consider adjusting the cuff and pass a suction catheter through the tube. Don't forget intra-oral swabs or packs.

(3) **Review monitors:** Always attempt to confirm correct siting, calibration, alarm settings and function:

Oximeter: Check the probe on yourself, try another site, try another probe, try another oximeter.

Capnograph: Breathe into the sensor yourself and check that the $ETCO_2$ reads 5% or 40 mmHg. Remember, a sudden fall in $ETCO_2$ may be due to entrainment of room air between the gas sampling site and the capnograph.

Blood Pressure: Confirm automated non-invasive blood pressure measurements manually before acting. Check zero and calibration of direct measurements.

ECG: Check the correct leads are in use, that waveforms are calibrated and that the monitor is in diagnostic mode before assessing ST segments.

(4) **Drugs:** Consider whether the problem might be the result of failure of drug delivery or of the wrong drug, wrong dose, wrong route, or wrong time of administration.

(5) **Awareness:** Consider previous drug/alcohol use. Look for signs of sympathetic activity. Check the anaesthetic is actually being delivered. If in doubt, deepen anaesthesia.

(6) **Air (and other) Embolism:** Always consider with a fall in $ETCO_2$, desaturation, hypotension and/or a sudden change in ECG rate or configuration, especially in a risky situation.

(7) **Air in pleura (pneumothorax):** If cardio-respiratory compromise remains undiagnosed after COVER ABCD, expose the chest and abdomen, and carefully compare left and right sides, using inspection, palpation and auscultation.

(8) **Allergy or Anaphylaxis:** Look for hypotension, a fall in $ETCO_2$ bronchospasm, desaturation and skin signs.

ALERT/READY Call for help/trolleys (1,2)

Circulation: If there is an impending arrest **allocate the "circulation" task (1)** and ask for the cardiac arrest trolley to be fetched.

Colour: If the oximeter is suspect, resite or replace it and/or do an arterial blood gas. Consider inserting an arterial line.

Oxygen: If adequate saturation cannot be confirmed, administer 100% oxygen. Plan how to provide analgesia and anaesthesia.

Oxygen Analyser: Confirm that the gas in the inspired limb of the breathing circuit is 100% oxygen.

Ventilation: **Allocate the "airway and breathing" task (1)**. Ventilate the lungs with a self-inflating bag. See **breathing** below. Exclude obstruction. **(3)**

Vaporisers: Turn the vaporiser off if there is cardio-respiratory compromise. Plan how to provide analgesia and anaesthesia.

Endotracheal tube or laryngeal mask airway: **Allocate the "equipment" task (1)**. If suspicious, prepare to remove and change the tube or LMA.

Eliminate: Prepare & check the correct function of an alternate breathing system and separate oxygen source.

Review monitors: Recheck, correlate and record all readouts and trends. Call for additional monitors as necessary. Don't forget body temperature in infants.

Review equipment: Remove or replace suspect equipment. Bring in additional emergency equipment as appropriate.

Airway: Adjust head and neck, attempt gentle chin lift. Prepare for pharyngoscopy; if suspicious, go to the **airway obstruction sub-algorithm**.

Breathing: Expose the chest and abdomen. Repeat SCAN and CHECK whilst comparing L & R sides. Consider causes.

Circulation: Check IV access. Secure additional access (venous & arterial) as necessary. Prepare to transfuse.

Drugs: **Allocate the "drugs" task (1)**. Check all drugs & infusions & the entire IV apparatus. Draw up, check & label drugs that may be needed.

A: Decide whether **A**wareness, **A**ir (or other) embolism, **A**ir in pleura (pneumothorax), **A**llergy and **A**naphylaxis are possible causes of the problem, and act accordingly (see sub-algorithms).

SWIFT CHECK: Make another assessment of the general situation, of the patient, of the activities of the surgeon and other personnel, and of the possible effects of the operation and/or any drugs or infusions.

ALERT/READY continued

(1) Call for Help - Allocate Tasks

TASKS: Airway **(A)**, Breathing **(B)**, Circulation **(C)**, Drugs **(D)**, Equipment **(E)**.

PERSON 1: Initially the anaesthesiologist - to look after **A**, **B**, overall coordination and cycling through **COVER** and the appropriate sub-algorithm(s). When skilled assistance is available the anaesthesiologist may delegate **A**, **B**, and concentrate on coordinating activities and checking algorithms.

PERSON 2: The anaesthetic assistant. This person should be primarily responsible for **D**, **E**, although may be deployed by the anaesthesiologist to other tasks.

PERSON 3: This person should look after **C**. If there is a cardiac arrest, this person should be responsible for ECC.

PERSON 4: To be deployed by the anaesthesiologist. If there is a cardiac arrest, this should be the second person looking after **C**, ensuring good intravenous access, injection of intravenous drugs, and ensuring they are flushed through.

PERSON 5: This person and any other available person should be deployed by the anaesthesiologist. It is most important that each person be given a specific task, e.g. “Can you independently assess the situation, go through COVER and sub-algorithms X and Y, and check that all is going to plan”? **OR** “Please help the anaesthetic assistant getting drug Z ready”, **OR** “Please help Person 3 (or 4) get the defibrillator ready”. Documentation is essential.

(2) Emergency Equipment & Drug Trolleys

Standard sets of equipment and drugs should be available on trolleys which can be brought in, or in drawers on the anaesthetic machine. The following should be available:

Airway Equipment I (Standard)
Airway Equipment II (Difficult intubation)
Breathing Equipment I (Standard)
Breathing Equipment II (Pleural drainage / bronchoscopy)
Circulatory Equipment I (Standard)
Circulatory Equipment II (Cardiac arrest)
Drugs - Emergency I (Standard)
Drugs - Emergency II (For unusual problems)
Equipment Extras I (Spare set of monitors)
Equipment Extras II (For unusual problems)

Emergency drugs with dosages guidance for adults and children are in **Appendices 1-3**. Suggested contents for a typical trolley are in **Appendix 4**.

(3) Ventilation

PERSON 1: Also exclude obstruction in the catheter mount, filter, or by or in any other airway path attachment.

EMERGENCY

Do not hesitate to declare an emergency. Allocate tasks, get trolleys (see previous page)

Circulation: If the pulse or $ETCO_2$ fails, **feel for a major pulse** and start **external cardiac compression (see next page)**.

Colour: If there is any question of cardiac, circulatory or respiratory compromise, give 100% O_2 regardless of the saturation.

Oxygen: Supply **100% oxygen** at a very high flow rate if necessary.

Oxygen analyser: Confirm the inspired gas in the breathing circuit is **100% oxygen**.

Ventilation: **Ventilate by hand** - use a self-inflating bag. Obtain appropriate chest movement, airway pressures and $ETCO_2$ (see **breathing** below).

Vaporisers: **Turn off all vaporisers** unless the problem is clearly unrelated or is hypertension or awareness.

Endotracheal tube or laryngeal mask airway: **Remove tube, catheter mount** and **filter** and **replace tube**, if there is any doubt whatsoever about their position and/or patency.

Eliminate: **The machine, circuit, filter and connections** unless the problem is clearly unrelated.

Review monitors: Frequently **scan**. Allocate someone to **review trends** and **keep notes** and ensure sensor integrity.

Review equipment: Check, and **remove all non-essential equipment** in contact with patient (retractors, diathermy, etc.).

Airway: Go to **laryngospasm, airway obstruction**, or **aspiration** sub-algorithms as indicated. Consider intubation.

Breathing: Go to **bronchospasm, pulmonary oedema/ARDS**, hypo**ventilation**, **desaturation** sub-algorithms as indicated. Consider ventilation.

Circulation: Go to **tachycardia, bradycardia, hypotension, hypertension, myocardial ischaemia, or cardiac arrest**.

Drugs: Has there been **an error?** Ensure all drugs are **labelled** and keep a **record** of doses and times.

A: Go to **awareness, air** (and other) **embolism, air in pleura** (pneumothorax) and **anaphylaxis** sub-algorithms as indicated.

SWIFT CHECK: Go through as indicated when there is time.

CARDIAC ARREST - Basic and Advanced

– Also refer to the Cardiac Arrest sub-algorithm on page 42

CO-ORDINATION

Ensure people are allocated to tasks **A**, **B**, **C**1 (external cardiac compression), **C**2 (IV access and feeling the pulse), **D** and **E** (see page 11). As soon as possible, ensure that COVER, the Cardiac Arrest sub-algorithms (see also page 42) and any other relevant sub-algorithms are cycled through.

ENSURE CONTINUOUS BASIC LIFE SUPPORT

External cardiac compression (ECC) at 80-100 per minute.
Confirm a major (preferably femoral) pulse can be felt.
Ventilate with 100% oxygen every fifth ECC.
Confirm that ventilation is adequate (inspect, auscultate).
Minimise interruptions during therapeutic manoeuvres.

EMERGENCY MANAGEMENT

Follow the 2005 ILCOR ACLS Guidelines (BMJ 2005; 331: 1281 - 1282)

VF or pulseless VT

Adults: Defibrillate with 200 Joules, 200-300 Joules, then 360 Joules as needed. If VT/VF continues, vasopressin 40 iu once or adrenaline 1 mg q 3-5 mins). Defibrillate at 360J q 60s. Refractory cases consider amiodarone (4-5 mg/kg), lignocaine (1mg/kg), magnesium (0.1mmol/kg) and procainamide (20 mg/min up to 1000mg).

Children: Defibrillate starting at 2 Joules/kg, try twice, then increase to 4 Joules/kg (unsynchronised mode).

Asystole: Give adrenaline by IV bolus -1mg ***for an adult*** q 3-5 min (i.e. about 0.015 mg/kg ***for a child***). Consider atropine, 1mg IV ***in an adult*** (about 0.02 mg/kg ***in a child***), up to 0.04mg/kg. Consider cardiac pacing.

Pulseless Electrical Activity (PEA)

Give adrenaline by IV bolus -1mg ***for an adult*** q 3-5 min (***for a child***, initially 0.01 mg/kg IV/intra osseous bolus, up to 0.1 mg/kg; **OR** 0.1 mg/kg, either intra-orally or via ETT.) Consider atropine, 1mg IV ***in an adult*** (about 0.02 mg/kg ***in a child***), up to 0.04mg/kg in either. Consider causes of PEA: Hypovolaemia, hypoxia, hypo & hyperkalaemia, hypothermia, hydrogen ion-acidosis, tablets (OD), tension pneumothorax, thrombosis (coronary & pulmonary embolism), cardiac tamponade.

Basic life support should be continued until return of spontaneous circulation. Also see pages 42 and 43 for further management details.

NOTE: Calcium chloride 10% (5-10 mls in an adult) should only be used for hyperkalaemia, hypocalcaemia, or an overdose of calcium channel blockers.

NOTE: Sodium bicarbonate is **not** recommended by the Australian Resuscitation Council or the American Heart Association. There is no evidence for any benefit and considerable experimental evidence that it may be harmful.

NOTE: There is evidence that dextrose-containing solutions may be harmful after a cardiac arrest.

LARYNGOSPASM

SIGNS AND SYMPTOMS (1,2)

Inspiratory stridor/airway obstruction
Increased inspiratory efforts/tracheal tug
Paradoxical chest/abdominal movements
Desaturation, bradycardia, central cyanosis

PRECIPITATING FACTORS (1,2)

Airway irritation and/or obstruction
Blood/secretions in the airway
Regurgitation and aspiration
Excessive stimulation/"light" anaesthesia
Failure of anaesthesia delivery system

MANAGEMENT

Cease stimulation/surgery **(2)**
100% Oxygen **(3)**
Try gentle chin lift/jaw thrust **(4)**
Request immediate assistance
Deepen anaesthesia with an IV agent **(5)**
Visualise and clear the pharynx/airway
    If you suspect aspiration ➠ Regurgitation page 18 **(6)**
    If you **suspect airway obstruction** ➠ Airway Obstruction page 16 **(7)**
Try face mask CPAP/IPPV, if this is unsuccessful
    Give suxamethonium unless contraindicated **(8)**
    Give atropine unless contraindicated **(9)**
Again, try face mask CPAP/IPPV **(10)**
Intubate and ventilate **(11)**

FURTHER CARE:

Careful postoperative review of the patient to:
    confirm a clear airway
    exclude pulmonary aspiration **(6)**
    exclude post obstructive pulmonary oedema **(8)**
    explain what happened to the patient.
There is a risk of awareness: ➠ Awareness page 46
    go and see the patient in the ward
    explain again what happened
    reassure the patient

See After the Crisis ➠ pages 74-75.

LARYNGOSPASM continued

NOTES:

It was judged that correct use of this sub-algorithm would have led to earlier recognition of the problem and/or better management in 16% of 189 relevant incidents reported to AIMS.

(1) 77% of cases were clinically obvious, 14% presented as airway obstruction, 5% as regurgitation, 4% as desaturation.

(2) Causes and precipitating factors: Airway manipulation 44%; blood/secretions in the airway 12%; regurgitation/vomiting 9%; surgical stimulation 5%; moving the patient 4%; irritant volatile anaesthetics 2%; failure of anaesthesia delivery system 2%.

(3) 61% of reports documented desaturation.

(4) The cricothyroid muscle is the only tensor of the vocal cords. Gentle stretching of this muscle may overcome moderate laryngospasm. In applying jaw thrust, gentle pressure should be exerted on the angle of the mandible, and not on soft tissues.

(5) Try 20% of the induction dose; this may be all that is needed (5% of cases were managed in this way); for more details, and for advice about children see (8) and (9) below.

(6) 3% of cases were associated with aspiration.

(7) 23% of the cases initially presented clinically as airway obstruction.

(8) Suxamethonium: Delay in relieving severe laryngospasm was associated with post-obstructive pulmonary oedema in 4% of cases; 15% of cases were managed with suxamethonium without intubation.

0.5 mg/kg IV to relieve laryngospasm (50 mg adult dose)

1.0 - 1.5 mg/kg IV for intubation (100 mg adult dose)

4.0 mg/kg IM for intubation (if no IV access) (up to 400 mg adult dose).

(9) Atropine: 0.01mg/kg IV. Note that bradycardia occurred in 6% of all cases and in 23% of patients less than 1 year of age.

(10) 28% of cases were managed by face mask CPAP/IPPV

(11) 43% of cases were intubated

AIRWAY OBSTRUCTION

SIGNS AND SYMPTOMS

Noisy, poor or absent ventilation
Increased inspiratory efforts/tracheal tug
Paradoxical chest/abdominal movements

MANAGEMENT

Cease stimulation/surgery
100% oxygen **(1)**
Try chin lift/jaw thrust **(2)**
Request immediate assistance **(3)**
Consider allowing the patient to wake up, or
Ensure adequate depth of anaesthesia **(4)** and
Visualise and clear the pharynx/airway **(5)**
If you suspect Laryngospasm ➠ page 14
If you suspect Regurgitation ➠ page 18
Insert oral and/or nasal airways
Reposition head, apply chin lift/jaw thrust **(2)**
Try "team" mask CPAP/IPPV **(3)**

IF YOU CANNOT VENTILATE (6)

Have someone feel the pulse and call out the SpO_2 (1) (7)

If not already paralysed:
Consider suxamethonium 100 mg IV and atropine 0.6 mg IV,
see **(8)** and **(9)** under Laryngospasm ➠ page 14
Make one attempt at intubation under direct vision

IF YOU CANNOT INTUBATE

Consider a laryngeal mask **(8)**

IF THIS FAILS

Do an immediate cricothyrotomy
Ventilate with 100% oxygen

IF YOU CANNOT VENTILATE VIA AN ETT

Consider:

Misplaced/kinked/blocked ETT ➠ **C**HECK algorithm page 8
Bronchospasm ➠ page 24
Pneumothorax ➠ page 28

Consider possible obstruction distal to ETT:

Try pushing a small tube past it
or push the obstruction down one bronchus
and ventilate the other lung with a clean tube.

AIRWAY OBSTRUCTION continued

FURTHER CARE

Review the patient to:

confirm a clear airway
exclude pulmonary aspiration
exclude post obstructive pulmonary oedema
explain what happened

If there is a risk of awareness:

go and see the patient in the ward later on
explain again and reassure them **(9)**
advise them to warn future anaesthesiologists
See After the Crisis ➠ pages 74-75.

NOTES:

The figures reported here are based on an analysis of 62 of the first 4000 AIMS anaesthesia incidents. It was judged that correct use of the sub-algorithm would have led to earlier recognition of the problem and/or better management in 11% of the 62 relevant incidents reported to AIMS.

(1) Desaturation was documented in 65% of cases.

(2) This may relieve mild laryngospasm and some obstructions.
See (4) under Laryngospasm on page 15.

(3) Tasks for "team" include mask CPAP/IPPV and subsequent intubation or cricothyrotomy, if necessary. Ask for four people: Person I to hold mask and jaw with 2 hands and intubate
Person II to hold emergency oxygen and button squeeze the bag
Person III to ensure adequate anaesthesia and IV access
Person IV to find and pass equipment and help others.

(4) This will often relieve laryngospasm and is a prerequisite for pharyngoscopy and suction. 14% of cases of laryngospasm presented as airway obstruction.

(5) This is vital at this stage; half of the incidents reported had blood, secretions, a foreign body, or intrusive mass. Obviously, an intrusive mass cannot be cleared; care should be taken not to cause
bleeding. This step is also important before mask CPAP or IPPV to prevent aspiration.

(6) Get an assistant to have a scalpel and tube ready for you, as this will save time once the decision to proceed with cricothyrotomy is made.

(7) There were 4 cardiac arrests, 3 dysrhythmias and 1 death

(8) The LMA is easy to insert and works well in about 95% of cases. It **does not** provide airway protection (see: Caponas G. Intubating laryngeal mask airway. Anaesth Intensive Care 2002; 30 (5): 551 - 569). Consider also the ProSeal LMA (Brimacombe J, Keller C. The ProSeal laryngeal mask airway. Anaesthesiol Clin North America 2002; 20 (4): 871 - 891).

(9) Provide written advice and document this in the medical record.

REGURGITATION / ASPIRATION

1. REGURGITATION/VOMITING EMERGENCY MANAGEMENT

Inform the surgeon
Head down, lateral posture, if feasible
Apply cricoid pressure (release cricoid pressure if active vomiting occurs)
Try to clear and suction the airway; give 100% oxygen
Consider deepening anaesthesia **(1)** to visualise and clear the pharynx/airway
Try gentle mask CPAP/IPPV with cricoid pressure **(2)**
Ventilate the lungs with cricoid pressure
IF YOU CANNOT VENTILATE ➠ Laryngospasm page 14
Give suxamethonium 100mg IV and atropine 0.6 mg IV (adult dosages).
Intubate with cricoid pressure, expedite surgery.

2. ASPIRATION

SIGNS AND SYMPTOMS (3)

Laryngospasm / airway obstruction
Bronchospasm / wheeze / crackles
Hypoventilation / dyspnoea / apnoea
Reduced compliance (ARDS)
Desaturation / bradycardia / cardiac arrest.

EMERGENCY MANAGEMENT

Sedation, analgesia, IPPV via ETT
Suction airway, optimise F_IO_2 and PEEP
Bronchoscopy and lavage if necessary
Bronchodilators as necessary **(4)**
Chest X-ray. If normal, and saturation is adequate, extubate **(5)**
If stable after 2 hours in recovery, send to ward and arrange for follow up **(5)**
If unstable or saturation is inadequate **(5)**
    Maintain intubation and IPPV
    Admit to a high dependency area **(6)**

FURTHER CARE

Repeat chest X-ray and blood gases
Consider PEEP, bronchodilators, inotropes
Culture sputum. Antibiotics; not routine
Consider other causes **(7)**. Reassess daily **(8)**.
Explain what happened to the patient, his/her relations or friends.
Arrange follow up as necessary. See After the Crisis ➠ pages 74-75.

REGURGITATION / ASPIRATION continued

NOTES:

The figures reported here are based on an analysis of 183 of the first 4000 AIMS anaesthesia incidents. Aspiration was documented in 96. It was judged that the correct use of the sub-algorithm would have led to earlier recognition of the problem and/or better management in 19% of the 96 incidents of aspiration reported to AIMS.

(1) An alternative is to allow the patient to recover consciousness and to start again. Deepening anaesthesia may be necessary to properly visualise and clear the pharynx/airway without precipitating laryngospasm and/or further aspiration or vomiting.

(2) An alternative, if the patient's condition allows, and the appropriate equipment and assistance is at hand, is to proceed immediately with intubation.

(3) Diagnosis of regurgitation, vomiting or aspiration was clinically obvious in 70% of cases. However 15% of cases of aspiration presented as desaturation, 6% as laryngospasm, 3% as airway obstruction, 2% as bronchospasm, 1% occurred with difficult intubation, 1% presented with hypoventilation, 0.5% as pulmonary oedema and 0.5% as cardiac arrest.

(4) Salbutamol: 0.5% 1ml (5 mg) by mask nebuliser 4 hourly.

(5) "Stable": saturation 95% with F_IO_2 <0.5, heart rate <100, respiratory rate <20/ minute (adults), no bronchospasm, apyrexial.

(6) Major morbidity ensued in 50% of all cases of aspiration and death ensued in 4%.

(7) Bronchospasm, pulmonary oedema, ARDS, pulmonary embolism and other causes of ET tube obstruction may present a similar respiratory picture to aspiration.

(8) Steroids and antibiotics should not be used early or routinely.

DIFFICULT INTUBATION

REMEMBER, PATIENTS DO NOT DIE FROM FAILED INTUBATION - ONLY FAILED VENTILATION

Always have skilled assistance, preferably another anaesthetist, when difficulty is expected or the patient's cardiorespiratory reserve is low.

ANTICIPATE WITH

History of difficult intubation
Anatomical hallmarks at pre-operative assessment ➠ **Appendix 5**
Patho-physiological states involving head and neck region
Syndromes known to be associated with difficult intubation ➠ **Appendix 5**

MANAGEMENT

Call for skilled assistance
Call for the difficult intubation trolley
Maintain oxygenation at all times with 100% oxygen by mask
Have someone feel the pulse and call out the SpO_2.

If you cannot ventilate the lungs,

consider **Airway Obstruction** ➠ page 16

If you can ventilate by face mask, consider

waking up the patient OR
maintaining anaesthesia and trying to intubate **(1)**

If the latter choice is made, try basic manoeuvres first:

Optimise the head and neck position **(2)**
Try laryngeal manipulations such as "BURP" **(3)**
Try a well-lubricated gum elastic bougie or stylet (introducer) **(4)**
Try different laryngoscope blades

If these fail:

Consider inserting an LMA **(5)**
Consider other techniques:

Blind nasal / Retrograde / Lighted stylet.

If a LMA is in place consider whether to proceed and whether steps should be taken to secure endotracheal intubation **(5)**

Confirm correct placement of endotracheal tube

(**Do not** rely simply on chest auscultation)

DIFFICULT INTUBATION continued

FURTHER CARE

Review the situation

Exclude other complications **(6)**

There is a risk of awareness:

Go and see the patient in the ward

Explain the full circumstances and reassure them **(7)**

Advise them to warn future anaesthesiologists **(7)**

NOTES:

(1) Techniques will vary with the experience and familiarity with the techniques of the individual anaesthesiologist.

Avoid multiple attempts at laryngoscopy/intubation, as this may cause bleeding and laryngeal oedema, worsening the situation.

(2) This may require 2 assistants:

one to apply pressure to the larynx and/or the back of the neck,

the second to lift the head up.

(3) BURP refers to **B**ackward **U**pward **R**ightward **P**ressure, as described by Knill. Knill, RL. Difficult laryngoscopy made easy with a “BURP”, Can J Anaesth 1993;40:279-82.

(4) The most common aid to facilitate successful intubation in the AIMS series was the gum elastic bougie (46%), followed by a stylet (23%).

(5) The LMA is easy to insert and works well in about 95% of cases. It **does not** provide airway protection.

(6) Airway trauma

Pulmonary aspiration

Post-obstructive pulmonary oedema

Cardiovascular signs and symptoms

(7) Document the problem in the case notes and give the patient a letter to warn future anaesthetists. If a particular precipitating event was significant, or a particular action was useful in resolving the crisis, this should be clearly explained and documented.

HYPOVENTILATION

SIGNS

Desaturation
Rising $ETCO_2$
Change in heart rate

PRECIPITATING FACTORS

Coughing / breath holding / light anaesthesia **(1)**
Airway obstruction
Distended abdomen
Lithotomy, Trendelenberg position
CNS depression **(2)**
Loss of integrity of chest wall or diaphragm
Muscle weakness
Pre-existing conditions **(3)**
Drugs **(4)**
- Relaxants
- "High spinal" blockade

Equipment related problems **(5)**

EMERGENCY MANAGEMENT

Complete COVER ABCD - A SWIFT CHECK

GET CONTROL OF THE AIRWAY
VENTILATE THE LUNGS

The primary cause may be obvious; if so, treat it

If Laryngospasm ➠ page 14

If Airway obstruction ➠ page 16

If inadequate depth of anaesthesia is allowing coughing, bucking or breath holding; rapidly deepen anaesthesia with an IV agent **(1)**

Consider other precipitating factors listed above.

HYPOVENTILATION continued

NOTES:

The guidance here is based on an analysis of the first 4000 AIMS anaesthesia incidents.

(1) This was a common cause of desaturation, secondary to hypoventilation. Rapid control of the situation may be gained by deepening anaesthesia with 10-20% of the initial induction dose.

(2) All anaesthetic induction and maintenance drugs, opioids and sedatives, depress ventilation in the spontaneously breathing patient.

(3) Numerous conditions cause muscle weakness.

Broadly speaking they consist of:

- Primary muscle conditions (myopathies)
- Secondary muscle weakness (electrolyte disturbances/ drugs etc.)
- Conditions affecting innervation (trauma / neuropathy / CVA / myasthenia gravis etc.)

(4) Several drug related causes of hypoventilation were reported to AIMS, including:

- Relaxant anaesthesia without commencing IPPV
- Residual or recurrent paralysis in the recovery phase
- Paralysis/weakness associated with high spinal blockade

(5) Any problem resulting in a lack of circuit continuity

disconnections
misconnections
leaks
obstructions

BRONCHOSPASM

SIGNS AND SYMPTOMS (1)

Increasing circuit pressure
Desaturation
Wheeze (auscultate)
Rising $ETCO_2$ and prolonged expiration
Reduction in tidal volumes

THINK OF (2)

Anaphylaxis/allergy to drugs / IV fluids / latex
Airway manipulation / irritation / secretions / soiling
Oesophageal/endobronchial intubation
Pneumothorax
Inadequate anaesthetic depth or failure of anaesthetic delivery system

EMERGENCY MANAGEMENT

100% Oxygen
Cease stimulation/surgery
Request immediate assistance
Deepen anaesthesia **(3)**
If intubated exclude endobronchial or oesophageal position **(4)**
If mask/LMA in use consider early:

Laryngospasm/Airway obstruction ➠ pages 14 & 16
Regurgitation/vomit/aspiration ➠ page 18 **(5)**

Give adrenaline or salbutamol (see next page)
If you cannot ventilate via an ETT consider:
Misplaced/kinked/blocked ETT or circuit ➠ **C**HECK page 8
Pneumothorax ➠ page 28
Aspiration ➠ page 18
Anaphylaxis ➠ page 50
Pulmonary oedema ➠ page 26
Consider possible obstruction distal to ETT
Try pushing a small tube past it, **or** push the obstruction down one bronchus and ventilate the other lung.

CONSIDER ANAPHYLAXIS ➠ page 50

CONSIDER PULMONARY OEDEMA ➠ page 26

BRONCHOSPASM continued

FURTHER CARE:

Depends on patient's condition, and cause.
Bronchodilators as necessary
Chest X-ray
Admit to HDU/ICU if necessary

NOTES:

(1) 30% of 103 relevant incidents described increased peak inflation pressures, and a further 31% described "bronchospasm"/wheeze as the initial sign.
21% reported desaturation as the first sign.
3% reported rising ETCO2 and 1% revealed a flat capnogram indicating no gas flow.

(2) Allergy/anaphylaxis - 22/103 (21%) of incidents.
Of the remaining 81 cases of bronchospasm:
- 44% occurred at induction and of these:
  - 64% were due to airway irritation
  - 17% were due to ETT misplacement
  - 11% were due to aspiration
  - 8% were due to other causes.
- 36% occurred during maintenance and of these:
  - 31% were due to ETT problem
  - 14% were due to aspiration with an LMA
- 20% occurred during emergence/recovery and of these:
  - 38% had no specific cause identified
  - 25% were due to pulmonary oedema
  - 18% were due to aspiration.

(3) 55% were of cases of bronchospasm at induction were idiopathic or presumed to be due to airway irritation from laryngoscopy and/or intubation.

(4) 12% were associated with oesophageal intubation and 2.5% with endobronchial intubation.

(5) 12% of cases were associated with aspiration

Recommended dosages: ➠ **Appendices 1 - 3**

Adult salbutamol: 0.5% 1ml (5mg) solution nebulised or aerosol puffer, 2 puffs (0.1 mg/puff), or 0.5% 0.1ml in 1 ml, injected down ETT (0.5mg)
Child salbutamol nebuliser: 1 year – 1.25mg; 5-10 years – 2.5mg.
Adrenaline IV: 1 mcg / kg bolus (0.01 ml/kg of 1:10,000 soln.) slowly.
Repeat bolus, or commence infusion 0.15 mcg / kg / min.
Titrate to heart rate, blood pressure, and bronchodilator effect.

PULMONARY OEDEMA / ARDS

SIGNS AND SYMPTOMS (1)

Respiratory distress/tachypnoea
Desaturation
Increased inspiratory pressure
Pink frothing sputum up ETT / LMA (diagnostic)
Crepitations or bronchospasm ➠ page 24

PRECIPITATING FACTORS

Fluid overload **(2)**
Non cardiogenic:
- Post airway obstruction **(3)**
- Anaphylaxis
- Neurogenic
- Sepsis
- Pulmonary aspiration
- Multiple organ failure

Cardiogenic **(4)**

EMERGENCY MANAGEMENT

Titrate inspired oxygen concentration against SpO_2
Head up tilt / sit up if possible
If breathing spontaneously apply CPAP **(5)**
Intubate if necessary
IPPV and PEEP if intubated
Consider drug therapy: - morphine / GTN / frusemide **(6)**

FURTHER CARE

Consider and investigate likely cause.
Chest X-ray
Review peri-operative fluid balance/renal function
Non-cardiogenic: consider following airway obstruction
- Allergy/anaphylaxis ➠ page 50
- Aspiration ➠ page 18
- Sepsis ➠ page 68
- Multiple organ failure, e.g. major trauma, pancreatitis
- Renal - renal function tests

PULMONARY OEDEMA/ARDS continued

FURTHER CARE continued

Cardiogenic:

ECG

Fractionated cardiac enzymes

Echocardiogram

Consider admission to high dependency area / ICU

NOTES:

The figures reported here are based on an analysis of 35 of the first 4000 AIMS anaesthesia incidents. It was considered that the COVER ABCD - A SWIFT CHECK algorithm plus the specific sub-algorithm would be required once the initial diagnosis was made.

(1) Hypoxia 46%; pink frothy sputum 23%; increased airway pressures 14%; respiratory distress 14%; crepitations or wheeze 9%.

(2) Fluid overload was judged to be the cause in 46% of incidents. 81% of these had pre-existing conditions making them more susceptible to over-hydration: age > 70, cardiovascular disease or hypertension, renal failure and chronic airflow limitation.

(3) 23% of incidents were judged to be post upper airway obstruction.

(4) 14% were judged to be cardiogenic in origin, e.g. valvular heart disease, ischaemia/infarction, cardiac failure, arrhythmia.

(5) CPAP is important specific therapy for pulmonary oedema (in addition to treatment for hypoxia).

(6) Preload reduction:

Morphine 0.02 mg/kg IV doses, titrating response

GTN infusion 50 mg in 500 ml 5% dextrose (glass)

Commence at 0.1ml/kg/hr

Fluid reduction:

Frusemide 0.5 mg/kg IV if fluid overload (place urinary catheter)

If hypotensive:

Adrenaline infusion: start with 0.00015mg/kg/min.

Adrenaline: for easy dosing (adult and child)

see **Appendices 1-3**.

Titrate against heart rate and blood pressure

PNEUMOTHORAX

SIGNS AND SYMPTOMS (1)

Difficulty with ventilation/respiratory distress
Desaturation
Hypotension
Heart rate changes
Unilateral chest expansion
    Expose, inspect, palpate **(2)**
    Auscultate, percuss
Abdominal distension
Distended neck veins, raised CVP
Tracheal deviation

PRECIPITATING FACTORS (3)

Any needle or instrumentation, even days previously **(4)**
    In or near the neck or chest wall
    Down the trachea / bronchial tree
External cardiac compression
Fractured ribs, crush injury
Blunt trauma / deceleration injury
Problem with pleural drain already sited
Airway overpressure, obstructed ETT
Emphysema or bullous lung disease

EMERGENCY MANAGEMENT

Inform the surgeon
Inspect the abdomen, or the diaphragm from below if visible
Insert an IV cannula into the affected side **(5)**
Turn off the nitrous oxide
Insert a pleural drain at the same site **(6)**
Continuously observe the bottle for bubbling and/or swinging
Be vigilant for further deterioration in the patient, it may be due to:
    Increased or continuing air leak
    Kinked / blocked / capped / clamped underwater seal drain
    Contralateral pneumothorax
    Misplaced pleural drain tip
    Trauma caused by drain insertion
    Misconnection of drain apparatus

PNEUMOTHORAX continued

FURTHER CARE

If the problem persists, consider cardiac tamponade

Consider pericardiocentesis and/or opening the chest.

Arrange a chest X-ray **(7)** and look for:

state of re-expansion of the lung, mediastinal shift,

position of the tip of the drain.

Explain the nature of the problem to the patient before discharge from the recovery ward. See After the Crisis ➠ page 74 - 75

NOTES:

The figures reported here are based on an analysis of 24 confirmed cases of pneumothorax reported in the first 4000 AIMS anaesthesia incidents.

(1) The diagnosis is one of exclusion. In 63% of 65 incidents where the diagnosis was considered, it was not the cause. 71% of confirmed pneumothoraces occurred under general anaesthesia: detection in this sub-group was aided by hypotension 47%, desaturation 41%. Note: clinical observation is **NOT** reliable. See **(2)**. The commonest cause of unilaterally decreased breath sounds is endobronchial intubation.

(2) A sign for tension pneumothorax described in the Russian literature should be specifically sought. This involves detection by palpation of widening of the intercostal spaces on the affected side. Demonstration of the sign requires that the patient be positioned symmetrically. The tips of one or two fingers are then inserted in the mid-axillary line and a comparison is made from one side to the other at an identical level. The wider side has the pneumothorax. Ref: Tsarev NI, Pugachev AF, Shelest AI. Diagnosis and treatment of spontaneous pneumothorax. Voen Med Zh 1987; 8: 51 - 52.

(3) Following chest wall/clavicular region blocks 25%. Whilst under general anaesthesia 53%. Of the GA sub-group: Post CVC insertion 41%. Associated with tracheostomy/base of neck procedures 24%.

(4) Cronen MC, Cronen PW, Arino P, Ellis K. Delayed pneumothorax after subclavian vein catheterisation and positive pressure ventilation. Br J Anaesth 1991; 67: 480 - 482.

(5) Do not wait for confirmation by chest X-ray if the patient is rapidly deteriorating. Insert the cannula just cephalad to the third rib in the midclavicular or midaxillary line, and swiftly withdraw the needle as its tip may lacerate a moving lung.

(6) Early management of severe trauma (EMST) recommends underwater seal drain placement just anterior to the midaxillary line, as this avoids the internal mammary artery which may be punctured using the mid-clavicular approach, and allows drainage of blood.

Always use blunt dissection to penetrate the parietal pleura. Use a finger to sweep away structures near the opening and then insert drain.

(7) It should be noted that a chest x-ray may not detect a non-tension pneumothorax in a supine patient. Inspiratory AP and lateral views are preferable; a CT scan is the definitive test.

DESATURATION

EMERGENCY MANAGEMENT

Complete COVER ABCD - A SWIFT CHECK **(1)**
Hand ventilate with 100% oxygen
Confirm the F_IO_2 is appropriate
Confirm the $ETCO_2$ is appropriate, if it is low consider:
Anaphylaxis ➠ page 50
Pneumothorax ➠ page 28
Air (or other) embolism ➠ page 48
Auscultate again, specifically exclude endobronchial intubation **(2)**

REVIEW AND TREAT OTHER POSSIBLE CAUSES

Underlying cardiopulmonary problems

If bronchial secretions or plugs are suspected **(3)**
- Posture and suction ETT/bronchi
- Give a “long slow blow” especially in children
- If cardiovascularly stable consider PEEP/CPAP

If acute shunt is suspected **(4)**
- Ensure the patient is supine and level
- If a pneumoperitoneum is present, deflate the abdomen

Consider gas embolism **(5)**

Pulse oximeter malfunction (6)

Consider: polycythaemia, methaemoglobinaemia, acute tricuspid incompetence, probe sited distal to an AV fistula.

FURTHER CARE

Reassess the situation

If persistent/unstable desaturation consider:
- Completing/abandoning surgery
- Chest X-ray, blood gases

If stable and well saturated as at **(5)** of Aspiration ➠ page 19
- Wake the patient up and extubate

If unstable or desaturated, and not as at **(5)** of Aspiration ➠ page 19
- Admit to ICU/HDU

DESATURATION continued

NOTES:

It was judged that correct use of the sub-algorithm would have led to earlier recognition of the problem and/or better management in 16% of 584 relevant incidents reported to AIMS.

(1) The use of COVER ABCD accounted for 89% of applicable incidents reported to AIMS. Use of the desaturation sub-algorithm accounted for a further 9% of applicable incidents.

(2) Endobronchial intubation was the commonest cause of desaturation in anaesthetised patients reported to AIMS. It should be specifically excluded early. Further details may be found in **(6)** below.

(3) 2% of incidents were due to bronchial plugs or excessive bronchial secretions, which can produce marked desaturation, especially in young children. A shunt effect is produced, which may be unmasked by abolition of hypoxic pulmonary vasoconstriction with induction of anaesthesia.

(4) "Obesity syndrome" refers to the rapid desaturation which may be seen at induction when anaesthetising obese patients, or those with tightly distended abdomens, and accounted for 2% of relevant incidents. Drug-induced abolition of hypoxic pulmonary vasoconstriction and an acute reduction in functional residual capacity resulting in sudden V/Q mismatching is thought to be the cause. The lithotomy and Trendelenberg positions, spontaneous ventilation and hypovolaemia all may exacerbate the problem, resulting in sudden desaturation at the start of a case and progressive desaturation during the maintenance phase.

(5) 0.8% of incidents involved suspected gas embolism.

(6) 1% of incidents involved unusual causes of pulse oximeter malfunction, including acute tricuspid incompetence, polycythaemia and methaemoglobinaemia. Acute tricuspid incompetence may lead to the oximeter sensing the venous pulse. A large plethysmographic wave form and a saturation of 70-75% is commonly seen. Arterial saturation, when directly measured, may be quite adequate. Polycythaemia may lead to artefactually low saturation readouts with high directly measured arterial oxygen saturations or tensions. Methaemoglobinaemia, depending on its extent, will cause the saturation to approach 85%.

BRADYCARDIA

EMERGENCY MANAGEMENT

Complete COVER ABCD - A SWIFT CHECK

Do not hesitate to treat as Cardiac Arrest ➠ Page 42 **(1)**

Ensure adequacy of oxygenation and ventilation **(2)**

If hypotensive **(3)**

Inform and interrogate the surgeon, stop retraction/stimulation
Turn off vaporiser
Crystalloid 500 ml bolus (10 ml/kg adult dose) and repeat if necessary
Atropine 0.012 mg/kg (that is 0.6 mg for an adult)
Consider adrenaline 0.001 mg/kg slow IV bolus (50 mcg **in an adult**)
Followed if necessary by an infusion of adrenaline starting at 0.00015mg (0.15mcg)/kg/min (1 ml/min of 1mg in 100mls **in an adult**)
Increase monitoring - ECG, arterial line, CVP
Consider external pacemaker (trans-venous or transcutaneous)

REVIEW AND TREAT PROBABLE CAUSES: (4)

Drugs (5)

Inhalational agent overdose. Consider also suxamethonium, induction agents, neostigmine, and opioids. Check drugs given by surgeon.

Airway (2)

Hypoventilation ➠ page 22
Hypoxia see Desaturation ➠ page 30

Vagal Reflexes (6)

Cease stimulation

Regional Anaesthetic (7)

Consider: Vasodilation, respiratory failure.

Ensure: Volume loading, vasopressors (early adrenaline), airway support, left lateral displacement during pregnancy.

Surgical Factors (8)

Consider: IVC compression, pneumoperitoneum, retractors position.
Ensure: Surgeon aware.

Undetected Blood Loss (9)

Improve IV access, fluid replacement, cross match.

Cardiac Event (4)

Consider: Tension pneumothorax, haemothorax, tamponade, embolism (gas, amniotic or thrombus), sepsis, myocardial depression (from drugs, ischaemia, electrolytes, trauma).

Ensure: Review of appropriate sub-algorithms.

BRADYCARDIA continued

FURTHER CARE

If the situation warrants:

Continue the adrenaline infusion, titrate against heart rate and blood pressure. For dose guide ➠ **Appendices 1 - 3**

Consider transvenous or transcutaneous pacing

Consider an urgent cardiology consult

NOTES:

It was judged that correct use of the sub-algorithm would have led to earlier recognition of the problem and/or better management in 4% of 265 relevant incidents reported to AIMS

(1) 25% presented as cardiac arrest.

(2) Airway problems were a factor in 19% of cases.

(3) 51% of cases were associated with hypotension.

(4) See previous page for the most common causes. Other important causes include myocardial events (particularly inferior ischaemia / infarction), anaphylaxis, pneumothorax and air/other embolism. At least one of these factors was responsible in 5% of cases. Multiple causes occurred in 22% of cases.

(5) Drugs were a factor in 40% of cases. Those most commonly implicated were inhalational agents (26%), opioids (16%), intravenous anaesthetics (14%) and suxamethonium (9%). Other drugs included muscle relaxants, anticholinesterases, metaraminol and phenytoin.

(6) Vagal reflexes were a factor in 14% of cases, usually following a surgical stimulus. The stimulus should be ceased and the problem usually resolves.

(7) Regional anaesthesia was a factor in 9% of cases.

(8) Surgical factors were present in 4% of cases.

(9) In addition to intraoperative losses, preoperative blood loss and occult losses (i.e. into the chest cavity) were also reported. Hypovolaemia was a factor in 3% of cases.

TACHYCARDIA

EMERGENCY MANAGEMENT

Complete COVER ABCD - A SWIFT CHECK

Do not hesitate to treat as Cardiac Arrest ➠ page 42 **(1)**

If hypertensive ➠ Hypertension ➠ page 38 **(2)**

If hypotensive ➠ Hypotension ➠ page 36 **(3)**

Confirm change in blood pressure is real **(4)**

Recheck that vaporiser(s) are off

Crystalloid 10 ml/kg bolus and repeat if necessary.

DIAGNOSE RHYTHM

If sinus tachycardia ➠ Hypotension ➠ page 36 **(5)**

If not sinus tachycardia choose treatment based on severity of hypotension **(6)**

If severe, use synchronised cardioversion

Start at 100 J for adults (0.5 J/kg for pulseless SVT in children);

if unsuccessful, 200 J (1.0 J/kg for pulseless SVT in children)

Consider antiarrhythmic drugs (see below)

If mild, use appropriate antiarrhythmic drugs **adult doses**:

VT: Lignocaine 1 mg/kg IV over 10 mins (or Amiodorone 5mg/kg over 10 mins) **(7)**

AF: Digoxin 0.125 - 0.5mg IV over 10 mins (or Amiodorone 5 mg/kg in adults over 10 mins); Digoxin 0.03 – 0.15 mg IV in children **(8)**

SVT: Adenosine 6-12 mg IV in adults (**for children** 0.05mg/kg increasing to 0.25mg/kg by rapid IV or intraoral bolus);

or titrated ß-blocker: atenolol 1 mg boluses **in adults (9)**

REVIEW AND TREAT PROBABLE CAUSES

Hypovolaemia (10) Consider: Blood loss, dehydration, diuresis, sepsis.

Ensure: Adequate IV access, fluid replacement, cross match and check haematocrit.

Drugs (11) Consider: Induction and inhalation agents, atropine, local anaesthetic toxicity, adrenaline, cocaine, vasopressors.

Airway (12) Hypoventilation ➠ page 22

Hypoxia ➠ Desaturation page 30

Anaphylaxis (13) ➠ page 50

Reflex Stimulation (14) Consider: Laryngoscopy, CVC insertion, surgical manipulation.
Ensure: Adequate anaesthesia.

Cardiopulmonary Problems (15)

Consider: Tension pneumothorax, haemothorax, tamponade, embolism (gas, amniotic or thrombus), sepsis, myocardial irritability (from drugs, ischaemia, electrolytes, trauma), pulmonary oedema.

Ensure: Review of appropriate pages in manual.

TACHYCARDIA continued

FURTHER CARE

Monitor for myocardial ischaemia
Consider further drug therapy

NOTES:

The figures reported here are based on an analysis of 123 of the first 4000 AIMS anaesthesia incidents. A correct use of the sub-algorithm would have lead to earlier recognition of the problem and/or better management in 3% of 123 relevant incidents reported to AIMS.

(1) 17% presented as cardiac arrest.

(2) There was associated hypertension in 26% of cases.

(3) There was associated hypotension in 33% of cases.

(4) Use sphygmomanometer and auscultate the blood pressure. When using an arterial line check the zero and calibration.

(5) With sinus tachycardia, treatment is that of the primary cause. In the vast majority of cases this alone will result in resolution. If it is persistent and associated with hypotension, refer to hypotension (page 36).

(6) Non sinus tachycardia was present in 46% of cases including ventricular tachycardia in 13%, paroxysmal supraventricular tachycardia in 9%, atrial fibrillation in 8% and atrial flutter in 1%.

(7) Ventricular tachycardia 100-200/min slightly irregular, broad complexes IV lignocaine 1mg/kg (or amiodarone 5 mg/kg) slowly, in adults Also, see pulseless VT (➠ page 13).

(8) Atrial fibrillation/flutter 100-200/min, irregular narrow complexes, no P waves (flutter: P waves 250-300/min, ventricular rate 100 or 150), IV digoxin 0.01 mg/kg (or amiodarone 5 mg/kg)

(9) Paroxysmal supraventricular tachycardia 150-250/min, regular narrow complexes, obscured P waves, IV adenosine 6-12 mg (or atenolol 1mg IV boluses) in adults.

(10) Hypovolaemia was associated with 3% of cases; however it is the commonest cause of tachycardia and hypotension. It is so common it is not usually regarded as an incident.

(11) Drugs were associated in 33% of cases. The most commonly implicated were induction and volatile agents, atropine, local anaesthetic toxicity, adrenaline, cocaine and vasopressors.

(12) Airway problems were often one of multiple contributing factors but were specifically reported in 4% of cases: hypoventilation/hypoxia occurred in the setting of difficult intubation and circuit problems, and caused secondary light anaesthesia in some instances.

(13) Allergy/anaphylaxis was a factor in 11% of cases.

(14) Autonomic reflex stimulation was reported in 9% of cases.

(15) Cardiopulmonary problems as causes were reported in 8% of cases.

HYPOTENSION

EMERGENCY MANAGEMENT

Complete COVER ABCD - A SWIFT CHECK **(1)**
Confirm the blood pressure change is real **(2)**
Don't hesitate to treat as Cardiac Arrest ➠ page 42
Inform and discuss with surgeon
Recheck vaporisers are off **(3)**
Improve posture: lie flat, elevate legs if possible
IV fluids: crystalloid bolus - 10ml/kg, and repeat as necessary
Give vasopressor: metaraminol 0.005 - 0.01 mg/kg IV bolus **(4)**
If severe give adrenaline 0.001 mg/kg IV bolus;
Followed if necessary by an infusion of adrenaline
starting at 0.00015mg/kg/min
If erythema, rash or wheeze is evident ➠ Anaphylaxis ➠ page 50
If bradycardic give atropine and see Bradycardia ➠ page 32
If pulseless go to Cardiac Arrest ➠ page 42
If desaturated or cyanosed see Desaturation ➠ page 30
Increase monitoring – ECG if not already present, Arterial pressures, CVP, filling pressures

REVIEW AND TREAT PROBABLE CAUSES (5)

Hypovolaemia (6)

Consider: Blood loss, dehydration, diuresis, sepsis.
Ensure: Adequate IV access, fluid replacement, cross match

Drugs (3)

Consider: Induction and inhalational agents, opioids, suxamethonium, anticholinesterases, local anaesthetic toxicity, vancomycin, protamine, vasopressor/vasodilator infusion problem, drug ampoule or syringe error and drugs given by surgeon.
Ensure: Agent ceased, support circulation

Regional Anaesthesia (7)

Consider: Vasodilation, bradycardia, respiratory failure.
Ensure: Volume loading, vasopressors (early adrenaline), airway support, left lateral displacement during pregnancy.

Surgical Events (8)

Consider: Vagal reflexes, obstructed venous return, pneumoperitoneum, retractors and position. Ensure: Surgeon aware.

Cardiopulmonary Problems (9)

Consider: Tension pneumothorax, haemothorax, tamponade, embolism (gas, amniotic or thrombus), sepsis, myocardial depression (from drugs, ischaemia, electrolytes, trauma)
Ensure: Review of appropriate pages in manual.

HYPOTENSION continued

FURTHER CARE

Review and treat probable cause(s)

See precipitating factors, and **(3)** to **(9)**
Consider further fluid/drug therapy
Consider invasive haemodynamic monitoring
- Arterial pressures
- Filling pressures

NOTES:

It was judged that correct use of the sub-algorithm would have led to earlier recognition of the problem and/or better management in 6% of 438 relevant incidents reported to AIMS.

(1) COVER ABCD accounted fully for 12% of hypotension incidents.

(2) Use a sphygmomanometer and auscultate the blood pressure. When using an arterial line, check the zero and calibration.

(3) Drugs were a factor in 26% of causes (inhalational and intravenous anaesthetic agents 7% each, opioids 5%, suxamethonium 2%). Other drugs implicated included vasodilators, inotropes (pump malfunction), IV local anaesthetics, vancomycin, protamine and dilantin. Vaporiser problems made up 32% of inhalational agent induced hypotension. 2% of all drug related hypotension was related to syringe or ampoule errors.

(4) Options include IV boluses of ephedrine 0.05mg/kg (especially with pregnancy).

(5) Based on all reported incidents timely and effective management was best achieved by using specific sub-algorithms in 85% of cases (cardiac arrest 25%, desaturation 21%, bradycardia 31%, anaphylaxis 5%, non sinus tachycardia 3%). The remaining 15% required review of further possible specific causes. Multiple causes were involved in 23% of cases.

(6) Hypovolaemia was a factor in 2% of cases, but is often unreported. It is such a common cause of hypotension that it is not usually reported as an incident.

(7) Regional anaesthesia was a factor in 14% of cases

(8) Surgical events were a factor in at least 5% of cases. Reflex stimulation was induced by anaesthetic procedures (laryngoscopy, CVC placement) as well as surgical manipulations (mesenteric traction, eye surgery).

(9) Cardiopulmonary problems were a factor in 6% of cases.

HYPERTENSION

PRECIPITATING FACTORS (1)

Give particular consideration to:

- Drug errors **(1)**
- Awareness or light anaesthesia **(2)**
- Pre-existing hypertension **(3)**
- Airway problems **(4)**
- Surgical factors **(5)**
- Hypercarbia **(6)**
- Less common/unusual conditions
  - Fluid overload
  - Raised intracranial pressure
  - Hyperthyroidism
  - Phaeochromocytoma/carcinoid
  - Malignant hyperthermia

EMERGENCY MANAGEMENT

Complete **COVER ABCD - A SWIFT CHECK (7)**

Confirm the blood pressure change is real **(8)**

Deepen anaesthesia/assess depth

Cease any vasopressor therapy **(9)**

Inform and interrogate the surgeon; cease stimulation

Recheck for drug errors and delivery of anaesthesia

Consider an appropriate dose of opioid **(10)**

Consider antihypertensive therapy:

BE CAUTIOUS USING HYPOTENSIVE AGENTS IF THE POSSIBILITY OF LIGHT ANAESTHESIA EXISTS

Consider glyceryl trinitrate 50 mg in 500 ml 5% Dextrose and start at 5 - 10ml/hr for adults (0.1ml/kg/hr in children)

If tachycardia is troublesome:

- Give atenolol 0.015mg/kg by slow IV bolus injection **(11)**

Titrate all drugs against effect

HYPERTENSION continued

FURTHER CARE

Review and treat probable cause(s)

See precipitating factors and **(1)** to **(9)** below
Resolution will usually follow
Consider invasive blood pressure monitoring

NOTES:

It was judged that correct use of COVER ABCD followed by the hypertension sub-algorithm would have identified the specific cause in 79% of 70 relevant incidents reported to AIMS. In 21% no obvious cause was apparent, but was assumed to be a combination of light anaesthesia and/or excessive surgical stimulation and in all cases was effectively treated by rapidly deepening anaesthetic depth.

(1) Drug errors, secondary to drugs being given - 40%, or following drugs unintentionally not being given - 14%.

(2) Presumed light anaesthesia - 21% of reports. Due to inter-individual variation, failure to deliver agents: vaporiser, nitrous oxide, syringe driver failure.

(3) Preoperative hypertension - 61% of the 252 reports received by AIMS

(4) Causes included hypoventilation ➠ page 22, hypercarbia and hypoxia (see desaturation ➠ page 30)

(5) Surgical stimulus, water intoxication, aortic cross clamping.

(6) Hypercarbia in 11%. Due to hypoventilation, soda lime exhaustion, sticking valve in circle system, inadequate fresh gas flows in non- rebreathing circuits.

(7) Use of the COVER ABCD - A SWIFT CHECK algorithm identified 73% of incidents reported to AIMS.

(8) Use a sphygmomanometer and auscultate the blood pressure. When using an arterial line, check the zero and calibration. In 4% of such cases the hypertension was spurious.

(9) Inadvertent vasopressor administration was the commonest reported cause - 40%.

(10) After reviewing the drugs administered to date, give opioids if judged appropriate, e.g. fentanyl 0.25 - 0.5 mcg/kg aliquots, titrated to effect.

(11) Esmolol, a ß blocker with a rapid onset and short duration of action, in a dose of 0.25 - 0.5 mg/kg may be a better choice if available.

MYOCARDIAL ISCHAEMIA

SIGNS AND SYMPTOMS (1)

ST changes - elevation or depression
T wave flattening or inversion
Ventricular dysrhythmias

PRECIPITATING FACTORS

Pre-existing cardiovascular disease
Haemodynamic instability
Tachy- or bradycardia
Hyper- or hypotension
Desaturation ➠ page 30
Pulmonary oedema ➠ page 26
Awareness / light anaesthesia / intubation **(2)**

EMERGENCY MANAGEMENT

Inform the surgeon
Defer, or rapidly complete, surgery
Ensure adequate oxygenation
Correct any haemodynamic derangement **(3)**

If Hypotension ➠ page 36
If Hypertension ➠ page 38
If Tachycardia ➠ page 34
If Bradycardia ➠ page 32

If ischaemia does not resolve rapidly (4)

Commence glyceryl trinitrate (50mg in 500ml 5% dextrose) and start at 0.1ml/kg/hr

Titrate against clinical response
Consider multi-lead ECG monitoring **(5)**
Monitor ECG continuously
Aim for haematocrit - 30%
If the myocardial ischaemia is significant, consider short-acting
ß-blocker to cover emergence **(6)**

MYOCARDIAL ISCHAEMIA continued

FURTHER MANAGEMENT

Obtain a 12 lead unfiltered ECG as soon as possible to assist in the diagnosis.
Admit to HDU/ICU/CCU
Consider invasive monitoring:
- Blood pressure
- Cardiac filling pressures

Further investigation - serial ECG/cardiac enzymes
Continue oxygen therapy for at least 2 days.

NOTES:

The figures reported here are based on an analysis of 40 reports considered to demonstrate myocardial infarction or ischaemia, of the first 4000 AIMS anaesthesia incidents. It was judged that correct use of the sub-algorithm would have led to appropriate management in 90% of cases, and would have led to earlier recognition of the problem and/or better management in 47% of the reported cases. The remaining 10% would have required the use of other sub-algorithms (e.g. air embolism).

(1) In all cases, ECG changes were reported as the means of detection. The diagnosis should be confirmed where possible by comparing monitor changes to a pre-operative trace. In 73% of cases there were associated cardiorespiratory abnormalities:
- 43% - hypotension;
- 25% - tachycardia/hypertension;
- 5% - desaturation.

(2) 15% of cases were judged secondary to light anaesthesia and 50% of these occurred with intubation.

(3) Resolution of ischaemia followed correction of cardiorespiratory abnormalities alone in 35% of cases.

(4) In the incidents reported, it was considered that in 40% of cases coronary vasodilator treatment, or more rapid treatment was indicated.

(5) It is well recognised that Standard 3 lead monitoring for ischaemia is very insensitive. Use the CM5 configuration to maximise the detection of ischaemia if multi-lead monitoring is not in use.

(6) Esmolol, a ß-blocker with a rapid onset and short duration of action, at a dose of 0.25 – 0.5 mg/kg IV, may be a suitable choice if available. Otherwise use atenolol 0.015 mg/kg as a slow IV bolus.

CARDIAC ARREST

- Go to Page 13 for Basic and Advanced Life Support

PRECIPITATING FACTORS

Pre-existing disease states **(1)**
- Cardiac
- Respiratory
- Renal

Consequent upon surgical manoeuvres **(2)**

Error or fault in anaesthetic technique
- Inadequate ventilation
- Essential monitoring not in use **(3)**

Drug problems (4)
- Overdose
- Induction/reversal drugs
- Anaphylaxis ➠ page 50
- Opioid overdosage

EMERGENCY MANAGEMENT

Complete COVER ABCD - A SWIFT CHECK

Inform the surgeon

Stop surgery / blood loss

Place patient supine and expose the chest

Praecordial thump (in witnessed and/or monitored adult arrest only)/
- external cardiac compression

Intubate and ventilate with 100% oxygen

ECG, for rhythm clues **(5)**

Delegate tasks as on page 11

Basic life support as on page 13

FURTHER CARE

Confirm and correct the cause

Ensure correct adrenaline dosage **(6)** ➠ **Appendices 1- 3**

If Anaphylaxis ➠ page 50

If septicaemia see Sepsis ➠ page 68

Correct/prevent hypothermia

Arrange admission to ICU

Accurately document events as soon as possible

See After the crisis ➠ pages 74-75

CARDIAC ARREST continued

NOTES:

Of the 129 arrests reported to AIMS, there were 25 fatalities; of these 129:
30% occurred outside the operating room
11% occurred in the recovery ward
6% occurred in the induction room
Bradycardia and asystole predominated.

(1) Pre-existing disease was judged to be the sole contributing factor in 23%, and was one of several contributing factors in another 40%

(2) 22% of arrests were directly associated with surgical manoeuvres:
CO_2 insufflation
autonomic stimulation
femoral prostheses

(3) Essential monitoring: disconnect alarms, circuit oxygen analyser, pulse oximetry, capnography, spirometry, circuit pressure.

(4) Arrests were closely associated with drug injection in 25% of cases:
Induction drugs 10%
Anaphylaxis 8% ➠ page 50

(5) Bradycardia 23% ➠ page 32
Asystole 22%,
Tachycardia/VT/VF 14% ➠ Tachycardia page 34

(6) Adrenaline: ➠ **Appendices 1-3**
Adults 1mg IV bolus
Paediatrics 10 mcg/kg IV/intra osseous bolus **OR**
0.1mg/kg intra-orally or via ETT

DRUGS / VASCULAR ACCESS

EMERGENCY CHECK

Review all ampoules / syringes / bags / burettes / cassettes **(1-3)**

Review all drug, cannulae and intravascular line labels

Systematically review all vascular access equipment, working from fluid source via the cannula/skin interface to the tip

Check vehicles/dilutions/rates/routes are correct

Correlate doses with effects

ALWAYS CONSIDER

Drug administration problems may be interrelated with vascular access problems **(4-8)**

Wrong patient

Wrong drug **(3)(6)**

- Ampoule or syringe swap
- Known allergy

Right drug **(3)(6)**

- Wrong dose/rate **(2)**
- Wrong diluent/dilution
- Wrong time
- Wrong route/site

Failure of intended delivery **(4)(5)**

- Malpositioned cannula tip **(4)**
- Bag/syringe/burette empty
- Cannula disconnected/blocked/kinked
- Line disconnected/blocked/kinked
- Back flow (up a Y–piece)

Unintended delivery **(6)**

- Drug flushed from dead space **(7)**
- Drip/pump delivering drug inadvertently **(8)**
- Flushing syringe containing drug
- Someone else giving a drug **(3)**
- Check for any recognized cannulae in situ **(8)**

BEWARE

Any syringe containing relaxant

Haematoma / extravasation

Inadvertent intra-arterial placement

Pneumothorax, haemothorax, hydrothorax

Nerve damage

Dysrhythmias (cannula tip in heart)

Cannula dead space

DRUGS / VASCULAR ACCESS continued

(1) Problems with drug administration comprised 30% of all 4,000 reports to AIMS. Incidence of errors rises markedly with polypharmacy.

(2) Major morbidity in 25% of drug reports. Death in 1.25%.
Causes of major morbidity - drug overdosage 33%;
side-effects 20%; allergic reactions 17%.

(3) Contributory factors:
error of judgement 13%
inattention 11%
haste 10%
communication problem 9%
drug label problem 5%
fatigue 3%

(4) Approach the diagnosis of vascular access problems from a "geographical perspective":

- infusion device/fluid
- fluid line/equipment
- line deadspace
- catheter/skin interface
- peripheral vascular tree
- central vascular space
- staff and environment

51% of the 128 vascular access cases involved a fault at the catheter/skin interface. In 15% of these the cannula was inserted by someone other than the anaesthesiologist. 18% involved central venous lines.

(5) Incorrect manufacture or assembly of arterial / central / peripheral lines 8%. Disconnection resulting in unrecognized blood loss 6%.

(6) Errors included:
connection of wrong drug infusion pump 3%
over/under dosage fluid/ drugs 2%
drug precipitation in the line dead space 2%
anaphylaxis to infusions 2%.

(7) Suxamethonium remaining in the dead space caused late paralysis upon subsequent line flushing in 6 case reports.

(8) Unrecognised cannulae may be the source of disconnections or be the route of an unknown delivery of drugs/fluids.

AWARENESS

SIGNS AND SYMPTOMS

There may be no obvious signs (1)

Hypertension
Tachycardia
Reflex activity: Withdrawal/movement
Coughing/straining
Pupillary dilation
Sweating/tears

HIGH RISK SITUATIONS (2)

Patient factors: History of drug/alcohol abuse
Highly anxious patient
Previous awareness

Equipment problems **(3)**

- Vaporiser leaking/empty/malpositioned
- Incorrectly calibrated vaporiser
- Nitrous oxide run out
- Failure of drug delivery with TIVA

Drug errors **(4)**

- Syringe swap causing paralysis before induction
- Syringe swap causing non-delivery of opioid/sedative

Anaesthetic technique

- Deliberate light anaesthesia during crisis management or caesarean section
- Opioid based anaesthesia
- Regional/local anaesthetic techniques
- Anaesthesia with paralysis **(5)**

Other problems

- Laryngospasm ➠ page 14 or
Airway obstruction ➠ page 16
Difficult/prolonged intubation ➠ page 20 **(6)**
- Delayed extubation

EMERGENCY MANAGEMENT

Stop painful stimuli
Verbally reassure the patient
Rapidly deepen anaesthesia
Consider amnestic drugs: e.g. benzodiazepine
Plan follow-up:

- In the recovery ward and the next day **(7)**
- As often as necessary, before discharge

AWARENESS continued

FURTHER CARE

Interview the patient post operatively as soon as possible, and several days later **(7)**

Reassure the patient
Explain what has happened
Be honest and sympathetic
Arrange for follow up

Go through After the crisis ➠ pages 74-75

NOTES:

21 cases of awareness under general anaesthesia were reported to AIMS. In 43% of these, the conduct of the anaesthetic appeared unremarkable, and was only discovered post-operatively by an unsolicited patient complaint. The COVER ABCD algorithm would have detected almost all causes of awareness where it was actually suspected but would be ineffective in patients who were aware but lacked physical signs to indicate its presence.

(1) **There may be no signs to indicate awareness**. In 43% of 21 cases of awareness under general anaesthetic, there were no remarkable changes to alert suspicion.

(2) Commonest causes under general anaesthesia included:

low concentration of volatile agent	38%
in association with a crisis	23%
failure to check equipment	19%
justified risk taking	10%

(3) The most frequently identified cause of awareness under general anaesthetic was a low concentration of volatile agent. The commonest preventable cause was secondary to a failure to check equipment, specifically the vaporiser. There were 2 reports related to total intravenous anaesthesia, caused by failure to deliver the drug to the patient. Failure to deliver nitrous oxide was also reported.

(4) There was another group of 20 incidents involving accidental paralysis whilst awake. The majority involved syringe swaps immediately prior to induction, particularly suxamethonium for opioids.

(5) If full paralysis is avoided except where absolutely necessary there is a greater chance that a patient will be able to indicate that they are aware.

(6) There were 2 reports of awareness during difficult intubations.

(7) Awareness may not manifest for several days after the incident.

AIR (AND OTHER) EMBOLISM

SIGNS AND SYMPTOMS (1)

A sudden fall in $ETCO_2$
Desaturation and/or central cyanosis
Air in surgical field or vascular line
Hypotension
A sudden change in spontaneous breathing pattern
A change in the heart rate
A change in the ECG configuration
Raised CVP or distended neck veins
A cardiac murmur or mottled skin

EMERGENCY MANAGEMENT

Inform the surgeon **(2)**
Prevent further entrainment/infusion of gas **(3)**
Flood the field with fluid
Aspirate central venous line if already in situ
100% oxygen and hand ventilate
Consider valsalva or PEEP
Level the patient

Do not hesitate to treat as a Cardiac Arrest ➠ page 42

Turn the vaporiser off
If hypotensive:
Volume expansion with crystalloid 10 ml/kg

Consider adrenaline 0.1 mg IV bolus for adults (**adult dose** 1 ml of 1:10,000, **child dose** of 0.002 mg/kg IV bolus) followed if necessary by an adrenaline infusion starting at 0.00015 mg/kg/min (1 ml/min of 1 mg in 100 ml = 10mcg/min) **(4)**. (➠ **Appendices 1-3**)

AIR (AND OTHER) EMBOLISM continued

FURTHER CARE

Careful postoperative review of the patient to:

Confirm nature/source of embolism **(3)**

Stabilise long bone fractures

Consider admission to ICU

If there is confirmed cerebral gas embolism

Give IV lignocaine at 0.06 mg/kg/min

Early hyperbaric oxygen therapy (within the first 6 hours)

NOTES:

It was judged that correct use of the sub-algorithm would have led to earlier recognition of the problem and/or better management in 41% of the 38 relevant incidents reported to AIMS.

(1) The following changes were documented in the AIMS reports: A fall in $ETCO_2$ 68%, desaturation - 60%, hypotension - 36%, a change in heart rate - 24%, a change in ECG configuration - 27%.

(2) In the AIMS reports, in 22% the source of embolus was via intravascular lines. The remainder (78%) were from the surgical field, most commonly: intracranial, hepatobiliary and maxillofacial.

(3) Sources of embolism include:

- **(a)** Entrainment of air, from venous sinuses or large veins, high risk procedures include those where the operative site is above the level of the right atrium. Procedures most commonly implicated included neurosurgical and maxillofacial; spinal, intrathoracic, and hepatic procedures may also be implicated.
- **(b)** Infusion of air or carbon dioxide; from “unprimed” vascular lines such as warming coils or infusion devices, insufflation of body cavities, “pressure” operated dissection devices and re-use of part empty blood bags.
- **(c)** Thrombotic embolism; most commonly from pelvic veins.
- **(d)** Fat embolism; occurring after any trauma, or long bone surgery.

(4) In some reported embolism cases, noradrenaline has been effective (P. Mackay, personal communication)

ANAPHYLAXIS/ALLERGY

SIGNS AND SYMPTOMS

Cardiovascular changes **(1)**

- Hypotension, circulatory collapse
- Tachy - **OR** bradycardia **(2)**

Respiratory changes

- Bronchospasm **(3)**
- Pulmonary oedema

Erythema / skin rash / pruritus **(4)**

Oedema of the face and lips

Nausea and vomiting in awake patients **(5)**

PRECIPITATING FACTORS (6)

Allergic reaction to drugs, colloids, blood products, latex allergy

EMERGENCY MANAGEMENT

Complete COVER ABCD - A SWIFT CHECK

Do not hesitate to treat as Cardiac Arrest ➠ page 42

Inform the surgeon

Request immediate assistance

Cease all drugs/plasma expanders/blood products

Immediate and aggressive volume expansion **(7)**

Maintain ventilation with 100% oxygen

Elevate the legs, if practical

Give adrenaline bolus IV 0.001mg/kg (**adult dose** 1 ml of 1:10,000) **(8)**

Start adrenaline infusion 0.00015mg/kg/min (**adult dose** 1 ml/min of 1 mg in 100 ml), and increase as necessary (➠ **Appendices 1-3**)

Administer slowly and titrate against heart rate and blood pressure

FURTHER CARE

The patient may relapse

Continue the adrenaline infusion, for days if necessary

Consider other drugs **(9)**

Admit to HDU/ICU

Take bloods for testing as soon as possible **(10)**

Counsel the patient/relatives.

See After the Crisis ➠ page 74-75

Provide written advice and document this in the medical record

Arrange for allergy testing at 1 month

ANAPHYLAXIS/ALLERGY continued

NOTES:

The earliest signs of anaphylaxis are hypotension, bronchospasm and integumentary signs. More than one sign manifested in 51% of cases. 65% of patients were ASA grades I-II. It was judged that correct use of the sub-algorithm would have led to earlier recognition of the problem and/or better management in 30% of 122 relevant incidents reported to AIMS.

(1) Over half of all reactions were judged as severe, and 89% of these involved circulatory decompensation.
There was hypotension in 68% of all cases.

(2) Heart rate changes were documented in 28% of reports, being equally split between tachy- and bradycardia. **Bradycardia invariably heralded circulatory collapse**.

(3) Bronchospasm was documented in 42% of cases.

(4) Erythema/urticaria/rash was documented in 48% of cases. Facial/airway oedema was an uncommon sign

(5) Nausea and vomiting occurred in 45% of awake patients.

(6) 35% of cases involved polydrug therapy at induction.
Drugs or agents commonly implicated were:
Cephalosporins 24%
Haemaccel 9%
Non-depolarising relaxants 8%
Penicillin 5%
Thiopentone 5%
Blood products 2%.
Other drugs implicated include: suxamethonium, propofol, protamine, amide-type local anaesthetics.

(7) Immediate crystalloid bolus of 10ml/kg. Review and repeat as necessary. Haemaccel and blood products should be avoided.

(8) For dosing of adrenaline ➠ **Appendices 1-3 on pages 76-78**.
Great vigilance is required to ensure that the correct strength of adrenaline is used.

(9) Consider hydrocortisone IV 5 mg/kg.

(10) In the course of an allergic response to foreign antigens, immunoglobulins are consumed and mast cell tryptase (and other acute phase reactants) are released. Serial samples are required after the reaction immediately after treatment, and at one and six hours after the reaction); post mortem sampling is also possible. Blood samples, frozen at 4°C, should be dispatched with a full description of the anaesthetic and the clinical events.

TRAUMA/BLEEDING

CONSIDER WITH

Any unexplained change in the patient's condition

HIGH RISK SITUATIONS

After high velocity motor vehicle accidents
With any neck/head/chest/abdominal injury, no matter how trivial the external signs
With multiple injuries
Patients with pre-existing systemic disease
Elderly patients

PRECIPITATING FACTORS (1)

Breathing:	Pneumo/haemothorax
	Pulmonary contusion
	Ruptured larynx/bronchus
Circulation:	Ongoing haemorrhage (overt or occult)
	Intracranial hypoperfusion from any cause
	Cardiac tamponade
	Myocardial contusion

Hypothermia
Rapidly evolving clinical problems **(2)**
Especially before systematic assessment
Hyperkalaemia from suxamethonium

EMERGENCY MANAGEMENT

Complete COVER - A SWIFT CHECK
Check if the EMST protocol is complete **(3)**
If not, go through it systematically
Treat all cervical spines as unstable until cleared
Inform the surgeon about any concerns
If there is cardiovascular instability, consider:
Haemorrhage. Many blood volumes may disappear:
- Into a pelvis
- Into the retroperitoneal space
- Into extensive soft tissue damage

Myocardial contusion
Haemo/pneumothorax
If you suspect an intracranial problem:
- Assess for focal signs
- Inform a neurosurgeon immediately

List continued on next page

TRAUMA/BLEEDING continued

Get a CT scan as soon as practicable
Check arterial line, measure filling pressures
Be prepared to completely expose and examine the patient, **including** top to toe, front and back.
Check haemoglobin, electrolytes and clotting regularly.

IF THE SITUATION IS STILL UNRESOLVED, RECHECK FOR:

Airway injury
Cervical spine injury
Pulmonary contusion
Bronchopleural fistula
Unexplained blood loss / hypovolaemia
Cardiac tamponade
Hyperkalaemia after suxamethonium
Undiagnosed intracranial collection
Hypothermia

FURTHER CARE

Maintain vigilance
Continuously reassess the situation
Consider admission to ICU/HDU post operatively.

NOTES:

The COVER-ABCD algorithm detected (82%), diagnosed (68%) and corrected (66%) a high proportion of relevant incidents reported to AIMS.

(1) Commonest modes of presentation were: hypoxia/desaturation 53%, airway obstruction/laryngospasm 8%, aspiration 8%, cardiac arrest 8%, air embolus 6%, hypotension 3%.

(2) 39% of incidents were sequelae of "cutting corners" in an effort to save time. Retrospectively, in 73% of these incidents the urgency was judged to be perceived rather than real. Failure to check the machine resulted in equipment related problems in 5% of cases.

(3) EMST - Early Management of Severe Trauma protocol (Australia). USA/UK equivalent is ATLS - Acute Trauma Life Support protocol.

SEE: EARLY MANAGEMENT OF SEVERE TRAUMA (EMST)

PROTOCOL on the next pages

EARLY MANAGEMENT OF SEVERE TRAUMA (EMST) PROTOCOL

As many incidents in trauma patients involve “corner cutting” such as failure to check due to perceived urgency, it is essential to recheck everything carefully. The best way to do this is to start again with COVER ABCD. If not successful consider possible missed diagnoses - follow the **EMST** system - repeat primary survey, review results to date, and look for missed injuries.

A airway injury

look for — failure to secure airway, failure to ventilate with tube in airway

manage — failed intubation drill, consider surgical cricothyrotomy early with facial injury

cervical spine injury

look for — priapism, areflexia, trauma above clavicles, history of neck pain or tenderness

manage — immobilise neck, review cervical spine X-ray (radiologist if possible), further films as required

B tension pneumothorax

look for — distended neck veins, decreased air entry on ipsilateral side, hyperresonance on ipsilateral side, mediastinal shift away

manage — immediate needle thoracostomy, formal UWSD insertion

relevant algorithm pneumothorax sub-algorithm ➠ page 28

massive haemothorax

look for — distended or flat neck veins, decreased air entry on ipsilateral sided dullness to percussion on ipsilateral side, mediastinal shift away

manage — volume load ++, formal UWSD insertion, beware increased bleeding on UWSD insertion, consider early involvement of thoracic surgeon

relevant algorithms hypovolaemia/pneumothorax sub-algorithms

pulmonary contusion

look for — desaturation in presence of chest injury

manage — desaturation sub-algorithm ➠ page 30

bronchopleural fistula

look for — continuous air leak via UWSD

manage — consider UWSD piercing lung, consider inserting additional large UWSD consider isolating lung with ETT down other bronchus or double lumen tube

relevant algorithm desaturation sub-algorithm ➠ page 30

C unexplained blood loss/hypovolaemia

look for	sites of concealed bleeding: chest/abdomen/pelvis, sites of visible bleeding
manage	consider chest xray, consider pelvis xray, consider diagnostic peritoneal lavage or if severe urgent laparotomy, view operative site, examine known wounds. If MAST suit in use: ensure correct inflation consider removal using standard method
relevant algorithm	hypotension sub-algorithm ➠ page 36

cardiac tamponade

look for	distended neck veins, decreased heart sounds, unexplained hypotension, equalisation of cardiac pressures
manage	consider pericardial tap/may need open drainage

myocardial contusion

look for	unexplained dysrhythmias, ST/T wave changes on ECG, hypotension with adequate filling
manage	bradycardia ➠ page 32, tachycardia ➠ page 34, hypotension ➠ page 36

hyperkalaemia after scoline

look for	patient after head injury, spinal injury or burns, widened QRS, cardiac arrest
manage	consider taking blood for K estimation, CPR as required, give glucose and insulin, consider giving calcium, consider giving $NaHCO_3$, do not discontinue CPR for at least 30 minutes
relevant sub-algorithm	cardiac arrest ➠ page 42, hyperkalaemia ➠ page 59

D undiagnosed intracranial collection

look for	dilating pupil under GA, unexplained bradycardia and hypertension in presence of known or suspected head injury, raised ICP if monitored, failure to waken
manage	urgent CT scan if available, urgent neurosurgical consultation

E hypothermia

look for	temperature fall during long cases
manage	cover as much of patient as possible, active heating methods, warm theatre measure core temperature

WATER INTOXICATION

SIGNS AND SYMPTOMS

In the awake patient - CNS symptoms **(1)**

- Drowsiness and confusion
- Nausea and vomiting
- Coma
- Convulsions

In the anaesthetised patient - CVS symptoms **(2)**

- Circulatory overload
- ECG changes
- Delayed emergence from anaesthesia

PRECIPITATING FACTORS

High risk procedures:

- closed cavity irrigation
- prolonged operating time

Anaesthesia:

- administering large volumes of hypotonic fluids.

EMERGENCY MANAGEMENT

Inform surgeon

Cease irrigation/surgery

Increase F_IO_2, monitor blood gases

URGENT, Na^+, K^+, Osmolarity (blood)

If symptomatic:

- 0.9% saline and frusemide 0.5 - 1.0 mg/kg IV (25 mg for adults)
- mannitol 0.25g/kg may be considered if not hypovolaemic

If severe CNS depression/convulsions:

- hypertonic saline **(3)**
- anticonvulsants

FURTHER CARE

Continue ECG /SpO_2 monitoring

Attention to fluid balance

Monitor electrolytes, osmolarity, blood gases

Mild symptoms - fluid restriction may suffice

Consider central venous line or pulmonary artery catheter

Consider HDU/ICU admission

WATER INTOXICATION continued

NOTES:

In the first 4000 anaesthesia reports, 10 reports of water intoxication were made, 8 involving male urological procedures and 2 involving endometrial ablation. The COVER algorithm deals poorly with this uncommon event and it requires a simple specific management sub-algorithm.

It was judged that correct use of the sub-algorithm would have led to earlier diagnosis of the problem and/or better management in 80% of the 10 relevant incidents reported to AIMS.

(1) CNS symptoms appear early but are not specific, therefore a high index of suspicion is required.

(2) Circulatory overload may manifest early as desaturation during general anaesthesia. ECG changes - CM5 position is useful as it enables ST segment analysis.

(3) Over-rapid correction, especially with hypertonic saline, has been implicated in causing neurological problems such as central pontine myelinolysis.

ELECTROLYTE DISTURBANCES

SODIUM

HYPONATRAEMIA

SIGNS AND SYMPTOMS

Confusion, convulsions, coma

PRECIPITATING FACTORS

Excessive IV with 5% dextrose, water toxicity ➠ page 56
Elderly patients, cardiac and renal failure, diabetics, hypothyroidism
Diuretics, vomiting, ileus, diarrhoea

EMERGENCY MANAGEMENT

Exclude factitious cause: hyperglycaemia, mannitol, ethanol, methanol, ethylene glycol
Correct hypovolaemia with colloid or N Saline
Correct hypervolaemia (CCF, water overload) with diuretic and fluid restriction
Consider effects of posture, oxygen
Symptomatic hyponatraemia - fitting or coma:
- Resuscitation
- Slow correction of Na^+ over 24-36 hours with 0.9% Saline
- Hypertonic saline rarely to correct if Na^+ <120mmol/L and patient severely symptomatic
- Frequent monitoring of electrolytes

HYPERNATRAEMIA

SIGNS AND SYMPTOMS

Pyrexia, confusion, coma
Dehydration, hypovolaemia, tachycardia, hypotension

PRECIPITATING FACTORS

Burns, pyrexia, polyuric renal failure
Vomiting, diarrhoea, mannitol, diuretics
Hypoadrenalism, thyrotoxicosis
Overuse of intravenous sodium bicarbonate

ELECTROLYTE DISTURBANCES continued

EMERGENCY MANAGEMENT

Restore hypovolaemia with IV colloid or 5% dextrose
1L water deficit will increase Na by 4mmol/L above 145mmol/L
Correct deficit with 5% dextrose or 4% dextrose saline
Slow correction of Na over 24 hours
Adjust fluid regime for insensible losses
Frequent monitoring of urine output and electrolytes

Consider thromboprophylaxis

POTASSIUM

HYPOKALAEMIA

SIGNS AND SYMPTOMS

Tachyarrhythmias: AF, SVT, VT, Torsade
ECG changes: prolonged PR, flat T waves, U waves
Ileus, constipation, muscle weakness, ventilatory failure
Metabolic alkalosis

PRECIPITATING FACTORS

Diuretics, vomiting, ileus, diarrhoea, polyuric states
Steroids, bronchodilators, catecholamines, TPN, insulin
Hypovolaemia, dehydration

EMERGENCY MANAGEMENT

Treat underlying cause
If hypovolaemic, give IV colloid 10ml/kg
Give IV KCl if symptomatic (max rate 40 mmol/hr)
Consider $MgSO_4$ 5-10mmol IV
Measure electrolytes and blood gases hourly

HYPERKALAEMIA

SIGNS AND SYMPTOMS

Bradycardia, “sine wave”, QRS asystole
ECG changes, peaked T waves, prolonged PR interval
Hypotension, muscle weakness

PRECIPITATING FACTORS

Anuric renal failure, burns, crush injury, spinal injury
Acute myotoxicity
Acidosis, haemolysis
Suxamethonium in above patients

ELECTROLYTE DISTURBANCES continued

EMERGENCY MANAGEMENT

Exclude artefact: (drip arm, tourniquet, haemolysis)
Determined by ECG changes / haemodynamics
Give, in the following order, as necessary:

- $CaCl_2$ 10ml IV stat (if ECG signs present)
- $NaHCO_3$ 50ml IV stat
- 25ml 50% dextrose + 25u insulin
- Continuous nebulised salbutamol (➠ **Appendices 1 & 2**)
- Consider dialysis in anuretic patients or if persistent

CALCIUM

HYPOCALCAEMIA

SIGNS AND SYMPTOMS

Tetany, laryngospasm, Chvostek's and Trousseau signs
Confusion, convulsion
ECG: prolonged QTc interval

PRECIPITATING FACTORS

Parathyroidectomy
Early rhabdomyolysis
Massive transfusion

EMERGENCY MANAGEMENT

Treat only if symptomatic
Measure ionised Ca^{++}
$CaCl_2$ 10ml IV push
Check acid base and electrolytes

HYPERCALCAEMIA

SIGNS AND SYMPTOMS

Muscle weakness
Drowsiness, coma

PRECIPITATING FACTORS

Hyperparathyroidism
Rhabdomyolysis
Renal failure
Malignancy

EMERGENCY MANAGEMENT

Usually none, treat underlying cause
Maintain adequate hydration and normovolaemia
Diuretics once normovolaemia assured

METABOLIC DISTURBANCES

GLUCOSE

HYPOGLYCAEMIA

SIGNS AND SYMPTOMS

Sweating, tachycardia
Confusion, aggression
Reduced level of consciousness

PRECIPITATING FACTORS

Diabetics (both insulin and non insulin dependent)
Septic patients
Patients on insulin infusions
Patients on TPN: especially those where TPN is ceased
Alcoholic patients
Patients presenting with coma of unknown aetiology
Fasting, dehydration, pre or post ileus/vomiting

EMERGENCY MANAGEMENT

Give 50ml 50% dextrose IV bolus injection
Measure blood sugar with finger prick
Continue to give IV dextrose until blood sugar level (BSL) > 7mmol/L
Cease insulin infusions if applicable
Measure electrolytes (especially K^+)

HYPERGLYCAEMIA

SIGNS AND SYMPTOMS

Tachypnoea, air hunger
Confusion, aggression, reduced consciousness
Dehydration, hypotension, inappropriate polyuria

PRECIPITATING FACTORS

Diabetics (both insulin and non insulin dependent)
Septic patients, elderly patients, patients on TPN
Fasting, dehydration, pre- or post-op ileus/vomiting

EMERGENCY MANAGEMENT

Restore euvolaemia: Give colloid 500ml then reassess
0.9% Saline: 1L over first hour, 500 ml/hr thereafter
Measure BSL, biochemistry and blood gases
If ketoacidosis: (pH < 7.1, BSL > 20mmol/L): Call for help
Insulin infusion: 50u actrapid / 50ml saline: start 5 u/hr
Measure BSL, biochemistry and blood gases hourly
No routine indication for sodium bicarbonate
Urinary catheter in all patients, consider CVC, arterial line
Reduce insulin infusion, change to 5% dextrose when BSL < 10mmol/L

METABOLIC DISTURBANCES continued

ACID-BASE BALANCE

METABOLIC ACIDOSIS
SIGNS AND SYMPTOMS

Tachypnoea, air hunger
Shock, hypotension, oliguria

PRECIPITATING FACTORS

Any prolonged shock state: cardiogenic, hypovolaemic, septic, distributive shock
Septic patients, ICU patients, multiple trauma
Diabetic emergencies
Intra-abdominal sepsis, ischaemia
Hepatic, renal failure
Ureterosigmoidostomy, acetazolamide
Catecholamine (esp. adrenaline) or salbutamol infusions
Methanol, alcohol, ethylene glycol ingestion

EMERGENCY MANAGEMENT

Treat underlying cause
Ensure adequate ventilation
Support the circulation with: volume, inotropes
Measure biochemistry: calculate anion and osmolal gap
IV $NaHCO_3$ only indicated in bicarbonate losing states with normal anion gap, e.g. renal tubular acidosis

METABOLIC ALKALOSIS
SIGNS AND SYMPTOMS

Tachyarrhythmias:
    AF, SVT or VT
ECG changes: prolonged PR interval, flat T waves, U waves
Ileus, constipation, muscle weakness, ventilatory failure
Dehydration, hypovolaemia

PRECIPITATING FACTORS

Diuretics, vomiting, ileus, diarrhoea, polyuric states
Steroids, bronchodilators, catecholamines, TPN, insulin
Hypovolaemia, dehydration
Post massive blood transfusion
Post hypercapnoeic alkalosis (ventilated ICU patients)

EMERGENCY MANAGEMENT

Treat underlying cause
If hypovolaemic, give colloid 500ml (10ml/kg) and reassess
Measure electrolytes and blood gases hourly
Consider $MgSO_4$ 5-10mmol IV
Consider IV KCl, phosphate
Consider IV or oral acetazolamide in euvolaemic patients

METABOLIC DISTURBANCES continued

THYROID

HYPOTHYROIDISM

SIGNS AND SYMPTOMS

Hypothermia, hypoglycaemia, hypotension, cold intolerance
Dry skin ('crazy pavement') changes (chronic)
Bradycardia, confusion, coma, delayed awakening

PRECIPITATING FACTORS

Elderly patients
Previous thyroidectomy, fasting
Sepsis, infections

EMERGENCY MANAGEMENT

Maintain normotension with fluid, inotropes if required
Discontinue anaesthesia as soon as possible
Normothermia: Actively warm if required
ECG monitoring, consider arterial line
Give IV T3 5-20 mcg slowly, 12 hourly
Check baseline thyroid function tests
Admit to HDU/ICU postoperatively

HYPERTHYROIDISM

SIGNS AND SYMPTOMS

Fine tremor, pyrexia, tachycardia, AF, SVT
Hypercarbia, metabolic acidosis
Dehydration, hypovolaemia, hypotension

EMERGENCY MANAGEMENT

Consider malignant hyperthermia ➠ page 66
Maintain hydration, colloid 500ml and reassess
Cool patient actively
Adequate sedation and analgesia
Baseline thyroid function test, frequent monitoring of electrolytes
Urinary catheter, consider CVC, arterial line
∂ blockade (phentolamine), ß blockade if required and patient haemodynamically stable
Consider oral carbimazole or propylthiouracil
Admit to HDU/ICU postoperatively

PARATHYROID

HYPERPARATHYROIDISM See hypercalcaemia ➠ page 60

HYPOPARATHYROIDISM See hypocalcaemia ➠ page 60

METABOLIC DISTURBANCES continued

PHAEOCHROMACYTOMA

SIGNS AND SYMPTOMS

Paroxysmal hypertension
Tachycardia, AF, SVT, VT
Peripheral ischaemia
Hypercarbia, metabolic acidosis

PRECIPITATING FACTORS

Confirmed diagnosis
Retroperitoneal or abdominal vascular procedures

EMERGENCY MANAGEMENT

Central venous and arterial lines
Phentolamine 5-10mg IV or by infusion as required
Nitroprusside (50 mg/250ml) titrate to 0.5mg/kg/24hrs
Consider $MgSO_4$ 4g bolus prn
Control the timing of surgical manipulations of the tumour
Do not give ß blockers until vasodilatation achieved
Patients undergoing elective removal may require adrenaline infusion post operatively
High dependency post operatively

ADDISONIAN CRISIS

SIGNS AND SYMPTOMS

Hypotension, bradycardia, hypoglycaemia
Unresponsive to catecholamines
Low Na^+, high K^+

EMERGENCY MANAGEMENT

CVC, arterial line
Baseline serum cortisol
Hydrocortisone 100 mg IV, then 6 hourly
Adrenaline infusion to maintain haemodynamics
Frequent monitoring of electrolytes
High dependency post operatively

METABOLIC DISTURBANCES continued

CARCINOID CRISIS

SIGNS AND SYMPTOMS

Flushing, especially head and neck
Bronchospasm
Sweating
Hyper/hypotension
Electrolyte disturbances

EMERGENCY MANAGEMENT

Ketanserin, aprotinin
H1 and H2 receptor blockers
Somatostatin or octreotide
Avoid catecholamines
? steroids

MALIGNANT HYPERTHERMIA (MH)

SIGNS AND SYMPTOMS (1)

Early signs:

- Skeletal muscle rigidity (e.g. masseter spasm)
- Tachycardia and hypertension
- Elevated $ETCO_2$
- Dysrhythmias
- Acidosis (metabolic and respiratory)

Late signs:

- Hyperpyrexia (may be >42ºC)
- Central cyanosis despite high F_IO_2
- Electrolyte abnormalities
- Elevated CPK (>20000)
- Myoglobinuria
- Coagulopathy
- Cardiac failure/pulmonary oedema

HIGH RISK PATIENTS

Family history of MH **(2)**
Use of suxamethonium and halothane **(3)**
Certain musculo-skeletal syndromes

EMERGENCY MANAGEMENT

Cease volatile agent **(4)**
Hyperventilate with 100% oxygen - use high flow rates
Inform the surgeon
Cease surgery as soon as possible
Request immediate assistance
Obtain Dantrolene from the emergency trolley or on-site **(5)**
Monitor body temperature
Take sample for arterial blood gas (ABG)
Consider sodium bicarbonate 50mEq if ABG unavailable
Give dantrolene 200mg (4 mg/kg) IV **(6)**
Cool patient by all available routes:

- Surface
- Body cavity irrigation (i.e. nasogastric/rectal lavage)
- Cold IV fluids

Change anaesthetic tubing and soda lime
Consider invasive monitoring

MALIGNANT HYPERTHERMIA continued

FURTHER CARE

F_IO_2 = 1.0 at all times until condition resolved

Titrate further dantrolene against the clinical response

Place intra-arterial cannula for frequent blood sampling:

- Blood gases
- Electrolytes (K^+ Ca^{++})
- Clotting studies

Place a urinary catheter, aim for urine output ≥ 1ml/kg/hr

There is a chance of relapse:

- Observe in HDU/ICU for at least 24 hours
- Continue dantrolene for at least 48 hours **(7)**

Arrange for MH testing in the future

NOTES:

(1) Early signs are often nonspecific. Diagnosis of MH is often delayed as more common conditions are initially considered. Muscle rigidity may not occur.

(2) The genetics of MH are complex, involving 2 or 3 genes or alleles. The pattern of inheritance may vary from dominant to recessive.

(3) The reported incidence of suspected MH varies from:

- 1:16000 anaesthetics without the use of triggering agents
- 1:4200 anaesthetics using triggering agents

Suxamethorium and halothane (where still in use) in combination is generally regarded as the most potent trigger

(4) If administration of the triggering agent was brief, discontinuation may abort the attack

(5) The Emergency Trolley (➠ **Appendix 4**) should have dantrolene, and there should be extra stock on-site.

(6) Dantrolene will be required for all fulminant cases, i.e. those with rapidly rising $PaCO_2$ and falling PvO_2, a base deficit of >5 mEq/L and/or rapidly rising temperature. A 24 hour dantrolene infusion of 10 mg/kg may also be required following the initial bolus administration(s).
Preparation for IV administration requires the full attention of at least one person

(7) Few hospitals stock adequate quantities of dantrolene for ongoing care after the initial crisis, due to cost and limited shelf life. This must be anticipated and further supplies sent for as soon as the diagnosis of MH is suspected; 18 vials should be available, re-stocked monthly.

SEPSIS

SIGNS AND SYMPTOMS (1)

Confusion/tachypnoea
Hypotension and/or tachycardia
Unexplained desaturation or hypercarbia
Spiking fever and rigors, or hypothermia
Unexplained metabolic acidosis
Oliguria
Elevated creatinine
Thrombocytopaenia
Evidence of disseminated intravascular coagulopathy
Postoperative respiratory failure
Failure to reverse

EMERGENCY MANAGEMENT (2)

Complete COVER ABCD - A SWIFT CHECK
Call for help
100% oxygen
Bolus of crystalloid or colloid 10ml/kg IV for cardiovascular instability
Consider placing an arterial line
Consider an adrenaline infusion, start at 1mg in 100 ml burette (1 ml/min of 1 mg in 100 mls), 0.00015mg/kg/min (➠ **Appendices 1-3**)
Titrate to achieve a mean blood pressure >70mmHg

FURTHER MANAGEMENT (3)

Consider placing a central venous line
Aim for a CVP of >8mmHg
Place a urinary catheter
Take samples for microscopy and culture of:
    Blood, urine
    Any other fluids (e.g. bile, pus, ascites, CSF)
Record any prior antibiotics
Give appropriate empirical antibiotics (seek advice if unsure)
Check haematology, coagulation status, biochemistry, blood gases

SEPSIS continued

FURTHER CARE

Continue vigorous fluid resuscitation throughout
Continue the adrenaline infusion
If there is continuing instability ➠ ICU

NOTES:

The figures reported here are based on an analysis of 13 of the first 4000 AIMS anaesthesia incidents. The use of the **COVER ABCD** algorithm plus the specific sub-algorithm provides a series of check lists to deal successfully with the complex multiple and interrelating problems that septic patients present.

(1) Cardiorespiratory compromise presenting as desaturation 77%, hypovolaemia 46%, and hypotension 30% were the commonest presentations.
Postoperative respiratory failure was common - 62% of reported incidents: 31% requiring re-intubation.

(2) Sepsis was generally reported in high risk patients:
70% were ASA III or above
- Diabetics
- Intensive Care patients
- Immunocompromised patients
- Instrumental urological procedures
- Instrumental enteric and biliary procedures
- Orthopaedic infections

(3) Active infection/sepsis:
- Urological sepsis
- Gynaecological sepsis
- Biliary sepsis
- Pancreatitis
- Abscesses
- Cellulitis/fasciitis

REGIONAL ANAESTHESIA I

EPIDURAL/SPINAL

EMERGENCY MANAGEMENT

Question the patient, reassure, and sedate if appropriate.
Inform the surgeon as to the nature of the problem.
Complete AB COVER CD – A SWIFT CHECK.
If Hypotension ➠ page 36 **(1)**
If Bradycardia ➠ page 32 **(1)**
Do not hesitate to treat as Cardiac Arrest ➠ page 42 **(1)**

Review and treat probable causes: (2).

Inadequate fluid loading, blood loss.
High block (aspirate CSF from epidural?)
Drug errors
- Wrong drug, concentration or volume
- Wrong site
- Incorrect infusion rate.

Ensure: fluid, drug and infusion rates and route are correct.

For suspected local anaesthetic toxicity (3)

Give phenytoin 15 mg/kg over 30 minutes for CNS irritability.
Control seizures with 1-2 mg/kg of thiopentone IV but beware of cardiovascular compromise.
For cardiovascular collapse, treat as Cardiac Arrest ➠ page 42.

Assess the block (2,4,5)

If inadequate consider general anaesthesia, local infiltration or further local anaesthetic down the epidural catheter **(2,4).**
If excessive, administer oxygen and assist ventilation if required **(3,5).**

Consider needle/catheter problem (6-8)

Wrong site
- Inadvertent intravascular placement/injection
- Inadvertent intrathecal placement/injection
- Inadvertent intrapleural placement/injection.

Trauma
- Haematoma.
- Nerve damage.
- Pneumothorax.
- Pain.

Beware of tourniquet failure with Bier's blocks.

REGIONAL ANAESTHESIA I

EPIDURAL/SPINAL continued

FURTHER CARE

Confirm and correct cause
Review patient to determine delayed events **(5)(6)**
Counsel the patient, arrange follow up.

NOTES:

There were 252 reports of incidents involving regional anaesthesia reported to AIMS. Of these 78% were either epidural or spinal anaesthesia related.

(1) Hypotension and arrhythmia in spinal/epidural incidents reported accounted for 30% of all regional anaesthesia incidents, and the deaths in 2%. They involved a combination of high block and or hypovolaemia.

(2) Common precipitants included:
- Inadequate time for assessment
- Elderly patients with multiple medical problems
- Usual dosages of local anaesthetics having a more profound effect in the elderly
- Error in judgement of level of block and or blood loss.

(3) Local anaesthetic toxicity was reported in 10% of all cases with fitting in one third of these.

(4) Failed blocks - 5% of all regional anaesthesia incidents.

(5) Overdose/total spinal - 10% of all regional anaesthesia incidents.
Most common problems cited included:
- Dural puncture - 13% of all reports.
- Post dural puncture headache - 52% of dural punctures, with 75% of these requiring a blood patch.
- Miscellaneous problems of epidurals: abscess, hematoma, subarachnoid migration, and prolonged recovery.

(6) Trauma, infection or pain was reported in 6% of cases.

(7) Intravascular injection was reported in 4% of the spinal/epidural blocks.

(8) Inadvertent epidural injection of IV drugs in 3 reports (metaraminol 2, ranitidine 1) without sequelae.

REGIONAL ANAESTHESIA II

OTHER NERVE BLOCKS

PROBLEMS

Arrhythmias **(1)**
Signs of intravascular injection of local anaesthetic **(2)**
Equipment malfunction with the use of tourniquets **(3)**
Pneumothorax with blocks near the thoracic cage **(4)**
With patient and operative site identification **(5)**

EMERGENCY MANAGEMENT

Reassure the patient and sedate if appropriate
Inform the surgeon
Stop the procedure, especially for vagal response
For tourniquet failure, reinflate and prepare to treat for intravascular injection of LA
If intravascular injection is suspected:

- Stop injection of local anaesthetic
- Administer oxygen
- Prepare to support airway, breathing and circulation
- Prepare anticonvulsant, (thiopentone/midazolam) and give if fitting does not resolve within 15 seconds
- Do not hesitate to treat as Cardiac Arrest ➠ page 42
- If bradycardic consider atropine 0.6 mg

If pneumothorax is suspected, go to Pneumothorax ➠ page 28

If intra-arterial injection of adrenaline containing LA is suspected, observe closely for local ischaemia. Consider a vasodilator.

For block failure, convert to a general anaesthetic or use supplementary local infiltration (beware of overdosage).

REGIONAL ANAESTHESIA II

OTHER NERVE BLOCKS continued

FURTHER CARE

Confirm and correct cause
Review patient in the ward to assess delayed events **(6,7)**
Counsel the patient, and explain what happened.

NOTES:

The figures reported here are based on an analysis of 56 of the first 4000 AIMS anaesthesia incidents (22% of 252 regional anaesthesia incidents). These 56 included: Ophthalmic blocks 9%, brachial plexus blocks 8%, local nerve blocks 3%, and Biers blocks 2%.

(1) Bradycardia was reported in 5 reports of ophthalmic blocks that all resolved spontaneously

(2) Intravascular injection of local anaesthetic reported in 8% of AIMS reports of all regional anaesthesia incidents with symptoms from dizziness to seizures reported.

(3) 4 reports of tourniquet failure in Bier's blocks; beware the assistant who may inadvertently deflate tourniquet.

(4) 3 reports, 1 confirmed pneumothorax, 2 suspected from patient clinical signs of chest pain, and not requiring drains.

(5) 4 reports of the incorrect side blocked. **In 2 of these reports the patients identified the incorrect side as the site for operation**. One report of an epidural inserted in the wrong patient. In all but one case the consent form was correct.

(6) Intravascular instead of interneural in 13 ophthalmic blocks.

(7) Corneal abrasion reported after cataract surgery under peribulbar block from inappropriate use of mercury weight; pneumothorax after supraclavicular block.

AFTER THE CRISIS: A PRÉCIS

IF THE PATIENT SURVIVES

Talk to the patient at the earliest opportunity

- Explain what has happened
- Keep it simple and stick to the facts
- Avoid guesswork
- Do not admit liability but do apologise for the mishap

For incidents with risk of psychiatric trauma / awareness / disability / pain, involve a psychiatrist/psychologist

If it was a minor mishap (e.g. superficial corneal or dental damage)

- Arrange for the problem to be corrected as soon as possible at no expense to the patient.

IF THE PATIENT DIES

Contact a senior colleague who will:

- Advise you to stop working that day/night
- Help you with the tasks ahead
- Liaise with medical/hospital administration

Arrange cover of your duties

Make a factual account as soon as possible referring to the medical record

Do not alter or erase any part of the anaesthetic record

You **may** annotate the medical record with a separately timed, dated and signed postscript

Leave all tubes, cannulae, drains, lines, catheters etc. in situ

If there is any doubt at all about what happened, isolate the theatre/ equipment/drugs for future examination by an appropriate person who can document the checks performed.

Contact the family personally as soon as possible

Arrange an interview in a suitable room

DO NOT let others (eg. surgeon) conduct the interview alone

Give the bad news first; show empathy and say sorry

Explain the facts as known at the time

Do not offer opinions lightly

Make yourself available to the family (e.g. contact numbers)

Debrief the staff involved

Seek a good friend/family member for support

Contact the Head of Department

Contact the relevant Medical Defence Organisation

AFTER THE CRISIS – THE POST MISHAP PROTOCOL

(An Action Card)

1. **Contact a mentor/senior colleague**: to come and assist in the protocol.
2. **The patient**: should be informed as soon as possible if he or she has survived. The Coroner's office is responsible for the body of a dead patient; the surviving patient usually needs intensive care and the anaesthetist must be seen to be there and to be a part of the team.
3. **The relatives**: need to be informed promptly and accurately of what has occurred. THE SURGEON MUST NEVER CONDUCT THE INTERVIEW ALONE. This interview should be unhurried, run as a team effort, and may be divided into two parts - first the bad news, and then after a pause, the facts as known. Start with the need for the operation, what the plan was for the anaesthetic and build the basic medical history of the patient. If an opinion is to be offered, make it clear that it is an informed guess, not fact, the autopsy may prove you wrong. Ongoing support and communication channels of a surviving patient and of their friends and relatives should be established.
4. **The next patient** deserves a fresh team and equipment. The unthinkable sequel to an unexpected death is that the next patient also dies because of an undetected equipment fault or overstressed personnel.
5. **The equipment and drugs used**, if implicated, must be isolated for examination.
6. **The medical staff involved** need a debriefing session to state what they think occurred, to ventilate their feelings and to learn from the mishap. Critical Incident Stress Debriefing (CISD) may be appropriate after two or three days.
7. **The nursing and paramedical staff** should attend an end of shift defusing session to allow immediate reactions to be revealed, and a factual and concise "take away" statement to be given out in order that the hospital staff have information that is appropriate and accurate. The situation may also require a formal CISD. Special consideration should be given to any anaesthesia nurse involved.
8. **Administrative details**: Check the medical record for accuracy and completeness, prepare formal statements, hospital or departmental incident reports, AIMS and TGA reports. The ICU record should be examined frequently. Never alter or destroy the record, but you may annotate with a separate timed, dated and signed postscript.
9. **The anaesthetist**, as well as the anaesthetist's family, should be supported and assisted in the immediate post-catastrophe period.
10. **The courts**: Copy, review and understand all relevant records. Notify medical defence and hospital administration. Prepare a personal statement of events for medical defence even if no court action follows.

APPENDIX 1

USEFUL ADULT DRUG DOSES

(1) Adrenaline for cardiac arrest - IV bolus
1ml of 1:1000 (1mg) slowly

(2) Adrenaline for cardiac arrest - IV infusion
Make 1mg up to 20ml in a syringe
Start at 1-2ml/min

(3) Adrenaline - for other indications* - IV bolus
Make 1mg up to 20ml in a syringe
Give 1ml bolus injections, repeat as necessary
Remember, with bolus injections there is a chance of:
- VT, VF
- Severe hypertension
- Pulmonary oedema

Use an infusion if time allows - see **(4)**

(4) Adrenaline - for other indications* - infusion
Make 1mg up to 100ml in a burette
Start infusing at 1ml/minute
Increase to 10ml/min, feeling the pulse
Titrate against heart rate and blood pressure
Use more if the problem is life-threatening

(5) Atropine: For cardiac arrest or bradycardia - 0.6mg IV bolus
For other indications - 0.1mg IV increments

(6) Suxamethonium: 100-200mg for intubation

(7) Salbutamol
0.5% - 1ml by nebuliser (5mg)
0.5% - 0.1ml in 1ml, inject down ETT (0.5mg)

***Indications for adrenaline other than arrest**
- Anaphylaxis
- Bronchospasm
- Hypotension
- Angioneurotic oedema

APPENDIX 2

USEFUL PAEDIATRIC DRUG DOSES♦

(1) Direct Current (DC) Defibrillation for cardiac arrest/pulseless states:

- **for VF and pulseless VT** start at 2 Joules/kg, try twice, then increase to 4 J/kg (unsynchronised mode)
- **for SVT 0.5** – 1 J/kg (synchronised mode)

(2) Adrenaline for cardiac arrest – IV or IO* bolus:
Make up 1 mg into 10 ml with isotonic saline (100 µg/ml);
Give 10 µg/kg IV or IO* initially, up to 100 µg/kg subsequently.
Endotracheal doses (via ETT**) are up to 100 µg/kg.

(3) Adrenaline for cardiac arrest – IV infusion:
Make up 1 mg into 1000ml of isotonic saline (1 µg/ml)
Give a continuous IV infusion in the range. 0.1 – 1.0 µg/kg/min.

(4) Lignocaine for VF, VT, ventricular ectopy:
Initially 1 mg/kg IV or IO* or via ETT**.
Subsequent IV infusion (suppression of ventricular ectopy)
20-50 µg/kg

(5) Atropine for cardiac arrest or bradycardia:
20 µg/kg IV or IO* or via ETT**

(6) Suxamethonium for intubation:
1-2 mg/kg; 2 mg/kg in infants.
- may be given IV,
or infra-lingually by submucous resection in absence of IV access.

(7) Salbutamol for nebulisation:
1 year of age – 1.25 mg; 5-10 years – 2.5 mg

(8) Other indications for adrenaline administration:
Severe bradycardia (with or without hypotension)
Anaphylaxis
Severe bronchospasm

♦ Guidance taken from paediatric clinical anaesthetists and from the Australian Resuscitation Council published recommendations.

*** IO = intra-osseus.**

**** ETT = via endotracheal tube. The endotracheal route is an alternative for administration of adrenaline, atropine and lignocaine, if intravenous (IV) or intra-osseus access is unavailable.**

NOTE: Take great care with dilution calculations and dosages.

APPENDIX 3

ADRENALINE DOSAGE CALCULATIONS

Usual Abbreviations:

"ml" = "millilitre" (1/1000 [10^{-3}] of a litre)
"mg" = "milligram" (1/000 [10^{-3}] of a gram)
"µg" = "microgram" (1/1,000,000 [10^{-6}] of a gram)
(NOTE: "µg" may also be written "mcg")
"kg" = "kilogram" body weight
"IV" = "intravenous"

One ampoule of 1:1000 adrenaline in 1 ml volume.

- This equals 1mg in 1 ml
- This equals 1000 µg/ml

If one ampoule is diluted to 10ml

- This equals 0.1 mg/ml
- This equals 100 µg/ml
- This is 1:10,000 adrenaline

If one ampoule is diluted to 100ml

- This equals 0.01 mg/ml
- This equals 10 µg/ml
- This is 1:100,000 adrenaline

If one ampoule is diluted to 1000ml

- This equals 0.001 mg/ml
- This equals 1.0 µg/ml
- This is 1:1,000,000 adrenaline

Maximum slow intravenous (IV) Injection rates, but only when indicated

Adult: 500 µg over 5 minutes
This equals 5ml of 1:10,000 adrenaline, which is 100 µg/ml
(Dilute 1 ampoule of 1mg to 10ml with water and draw up 5 ml)

Child: 10 µg/kg, which is 0.01 mg/kg, over 5 minutes
This equals 0.1 ml/kg of 1:10,000 adrenaline

NOTE: A useful preparation for either (1) an adrenaline, (2) a noradrenaline or (3) an isoprenaline infusion is to mix 6 mg (6 mls of 1:1000) in 100 ml. This dilution will contain 60 µg / ml, and when infused, ml / hour = µg / minute. Any one of these three different infusion preparations may be started at 3 ml / hour (3 mcg / min).

****NOTE: Take great care to distinguish the different adrenaline (or other) dilutions before calculating the volume and rate of IV administration.***

(Go to adult adrenaline dosages ➠ page 76) (Go to paediatric adrenaline dosages ➠ page 77)

APPENDIX 4

A TYPICAL EMERGENCY TROLLEY

CONTENTS (RESTOCK MONTHLY)

DRAWER 1

Drugs
Sterile water (1000ml)
Mannitol (25% - 2 bottles)
Dantrolene (18 vials) for malignant hyperthermia
Dextrose (50% - 2 bottles)
Dantrolene (18 vials)
Frusemide (10 vials)
Procainamide (1 vial)
Heparin (10 ml – 3 vials)
Sodium Bicarbonate (2 adult, 2 paediatric)
Insulin (1 bottle)
Hydrocortisone (100mg – 10 vials)
Potassium Chloride (20 ml – 2 vials)

DRAWER 2

60 ml syringes
18G blunt drawing up cannulae (10)
Temperature probes (2)
Specimen containers for:
- haematology
- coagulation studies
- electrolytes

CVP catheters

DRAWER 3

Peripheral venous cannulae
Arterial catheter kit and transducer
Nasogastric tubes 12, 16, 18
Rectal tubes

DRAWER 4

Airway equipment
A variety of sizes of masks for adults and children

APPENDIX 5: PREDICTING DIFFICULT INTUBATION

1. ANATOMICAL HALLMARKS AT PRE-OPERATIVE ASSESSMENT

THYROMENTAL DISTANCE

Measures the infra-mental distance anterior to the larynx, which determines how easily the laryngeal and pharyngeal axes will fall into line with atlanto-occipital extension. A distance of <6 cm (approximately 3 fingerbreadths) suggests laryngoscopy may be difficult.

WILSON SCORING SYSTEM

Wilson and colleagues found five useful risk factors, measured at 3 levels of severity that could be used to predict difficulty with intubation (Wilson ME. Predicting difficult intubation. Br J Anaesth 1993;71:333-4).

Depending on the threshold chosen, a high percentage of truly difficult intubations can be detected, however this is at a cost of increasing the false positive rate.

The risk factors identified were as follows:

- weight
- head and neck movement
- jaw movement (mandibular protrusion, inter-incisor gap)
- prominent maxillary teeth (“buck teeth”)
- receding mandible

MALLAMPATI TEST

Mallampati and colleagues described clinical signs to predict difficult intubation in 1983 (Mallampati SR, Gatt SP, Gugino LD, et al. A clinical sign to predict difficult tracheal intubation: a prospective study. Can Anaesth Soc J 1985; 32: 429-34):

1. The patient sits upright, head in the neutral position.
2. The mouth is opened as widely as possible and the tongue is maximally protruded, without phonating.
3. The observer sits opposite at eye level and inspects the pharyngeal structures.

The airway is classified according to the structures seen.

Mallampati et al described 3 grades, but the commonly used assessment consists of 4 grades, as modified by Samsoon and Young (Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. Anaesthesia 1987;42:487-90). The 4 grades* are as follows:

Class I	soft palate, fauces, uvula, pillars
Class II	soft palate, fauces, uvula
Class III	soft palate, base of uvula
Class IV	soft palate not visible at all

*It should be noted that a Class I view nearly always predicts easy intubation, and a Class IV view a difficult intubation. Intermediate classes (II and III) are associated with a wide range of degrees of difficulty with intubation.

2. PATHOPHYSIOLOGICAL STATES

Infections: epiglotitis, abcesses

Endocrine/ Metabolic: thyromegaly, acromegaly

Inflammatory: ankylosing spondylitis, rheumatoid arthritis, temporomandibular joint ankylosis

Neoplastic: upper airway tumours, post surgery/irradiation

Trauma: facial fracture, oedema; airway, head and neck burns

3. SYNDROMES KNOWN TO BE ASSOCIATED WITH DIFFICULT INTUBATION

Down's, Goldenhaar, Pierre Robin, Klippel-feil, Treacher Collins

APSF AIMS Anaesthesia

The development and compilation of the information in this 2nd Edition of the Manual are the result of the wide anaesthesia, intensive care, trauma medicine, emergency medicine, medical science and nursing clinical experience, knowledge, skill and commitment, and the sheer hard labour of many people. Some of these folk also contributed to the development of the first "draft" edition of this Manual in 1996.

This 2nd Edition team is made up of some 25 specialists and consultants in various parts of Australia, New Zealand and the United Kingdom. (No doubt there were also a number of "ghost" advisors to these people, other consultants and registrars, in their respective departments and practices.) The work was achieved in their spare time, unpaid and out of altruistic motivation towards the improvement of anaesthesia safety for our patients.

Deep gratitude is therefore expressed to Monika Bullock RN, and Drs Andrew Bacon, Charles Bradfield, Marianne Chapman, Lyn Currie, Mary-Ann Fox, Bill Griggs, Stephen Helps, Ross Kerridge, Steve Kinnear, Michal Kluger, Professor Guy Ludbrook, Drs Pat Mackay, Richard Morris, Associate Professor John Myburgh, Drs Andrew Paix, Rob Singleton, Suzie Szekely, Thava Visvanathan, Leonie Watterson, Bob Webb and Rod Westhorpe.

Much updating and collation of data, co-ordination of effort, and the review controls necessary to bring all this information together have been carried out by an APSF Editorial team of Professor Bill Runciman, Dr Klee Benveniste, Dr John Williamson and Mr Peter Hibbert.

We would like sincerely to thank AstraZeneca for their financial and technical support and encouragement, which has enabled the printing of this Edition. We hope more editions may follow.

The initial impression from the first 2000 reports that the use of a structured approach to anaesthesia crises results in their better handling, has been supported by these additional data. For example, of the 584 reports of desaturation among these first 4000 AIMS Anaesthesia incidents (see page 30 in the Manual), it was judged that earlier recognition and/or better management would have resulted from use of the relevant sub-algorithms in 16% of cases.

We would anticipate the potentially useful role of anaesthesia simulators in the on-going evaluation and improvement of anaesthesia crisis management protocols.

APSF **Bill Runciman** **Klee Benveniste**
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