

# PAEDIATRIC TRAUMA ANAESTHESIA MANUAL



DR JOSEPH HOBSON

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# INTRODUCTION

Version: 5.4

Major trauma in children is not common.

Anaesthetic management of trauma patients for surgery can have a significant impact on long-term outcomes. This document aims to assist anaesthetic practice for paediatric major trauma and to improve outcomes in high acuity, but low occurrence (HALO) events.

Each topic is a single page. It is divided into general considerations, induction, maintenance, and post-op, extubation, or Paediatric Intensive Care Unit (PICU) subheadings.

**Procedures outlined in this document are an *aide-mémoire* and are not intended to instruct an anaesthetist without prior experience. The anaesthetist should always work within their area of expertise.**

**Legal waiver: The information in this document is up to date as of 20.07.25 and is intended as a guide only. The final responsibility for patient management lies with the individual.**

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## Glossary

<b>ABG:</b> Arterial Blood Gas	<b>CVC:</b> Central Venous Catheter	<b>IOP:</b> Intraocular Pressure	<b>PPV:</b> Positive Pressure Ventilation
<b>APLS:</b> Advanced Paediatric Life Support	<b>CXR:</b> Chest X-Ray	<b>IPPV:</b> Invasive Positive Pressure Ventilation	<b>RA:</b> Regional Anaesthesia
<b>ARDS:</b> Acute Respiratory Distress Syndrome	<b>DGH:</b> District General Hospital	<b>KTS:</b> Knife to Skin	<b>ROSC:</b> Return of Spontaneous Circulation
<b>BE:</b> Base Excess	<b>DIC:</b> Disseminated Intravascular Coagulation	<b>LA:</b> Local Anaesthetic	<b>RSI:</b> Rapid Sequence Induction
<b>BIS:</b> Bispectral Index	<b>ETT:</b> Endo-Tracheal Tube	<b>LMA:</b> Laryngeal Mask Airway	<b>RV:</b> Right Ventricle
<b>BNF:</b> British National Formulary	<b>FBC:</b> Full Blood Count	<b>MAC:</b> Minimum Alveolar Concentration	<b>TBSA:</b> Total Body Surface Area
<b>CO:</b> Cardiac Output	<b>FONA:</b> Front of Neck Access	<b>MAP:</b> Mean Arterial Pressure	<b>TBV:</b> Total Blood Volume
<b>COETT:</b> Cuffed Oral Endo-Tracheal Tube	<b>GI:</b> Gastrointestinal	<b>NCA:</b> Nurse Controlled Analgesia	<b>TIVA:</b> Total Intravenous Anaesthesia
<b>CPR:</b> Cardio-Pulmonary Resuscitation	<b>HAS:</b> Human Albumin Solution	<b>NG/NJ:</b> Nasogastric/Nasojejunal	<b>TXA:</b> Tranexamic acid
<b>CPP:</b> Cerebral Perfusion Pressure	<b>HFNS:</b> High-Flow Nasal Specs	<b>ODP:</b> Operating Department Practitioner	<b>U+E:</b> Urea & Electrolytes
<b>CT:</b> Computerised Tomography	<b>HS:</b> Heart Sounds	<b>PCA:</b> Patient Controlled Analgesia	<b>VAE:</b> Venous Air Embolism
<b>CV:</b> Cardiovascular	<b>ICP:</b> Intracranial Pressure	<b>PPE:</b> Personal Protective Equipment	<b>VF:</b> Ventricular Fibrillation

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# TRAUMATIC BRAIN INJURY (TBI).

## Considerations

Consider NAI p23

**Aim is to prevent secondary brain injury with strict anaesthetic control**

**Heavily sedated & paralysed with an adequately maintained MAP**

**Outcome determining peri-anaesthetic risks:**

Hypotension | Hypoxia | Hyper/Hypocarbia | Hyperthermia | Seizures | ↑ICP (pain, coughing, Valsalva)

**Limit delay in surgical decompression**

**CPP = MAP – ICP (max. 20)**

## Induction

**Intubation in Cervical Spine Injury p5** | All imaging reviewed | Blood products available

30° head up tilt and consider 10ml/kg Plasmalyte preload

Opioid: Fentanyl (2mcg/kg) | Alfentanil (20mcg/kg) | Remifentanyl infusion (0.1-0.3ug/kg/min)

Propofol or Ketamine are suitable. Note: It is the limitation of hypotension that is crucial

**Polytrauma: Consider; Fluid resuscitation → Careful drug titration → Dilute Adrenaline**

Haemodynamically stable: **(2-2-2)** Fentanyl 2mcg/kg Ketamine 2mg/kg Rocuronium 2mg/kg (max. 150mg)

Haemodynamically unstable: **(1-1-2)** Fentanyl 1mcg/kg Ketamine 1mg/kg Rocuronium 2mg/kg

Haemodynamically critical: **(1-2)** Ketamine 1mg/kg Rocuronium 2mg/kg

RSI | Consider c-spine | Large IV access x2 | CVC not essential | Urinary catheter | Temperature probe | BIS monitoring | Arterial line (Not to delay KTS in an unstable patient)

## Maintenance

Avoid suction down ETT without sedation bolus

PEEP 5. Increase if neurogenic pul.oedema ↓SATs

Maintain paralysis and sedation (see infusions)

### Seizures

Prevent seizures if Hx suggestive or pupils change:

**Diazepam** IV 300-400mcg/kg (max. 10mg)

or **Lorazepam** IV 100mcg/kg (max. 4mg)

or **Midazolam** 150-200mcg/kg +/- infusion

+/- **Levetiracetam** 40mg/kg over 5 min (max. 2.5g)

Consult local guidelines

### Infusions

**Midazolam** 100-200mcg/kg/hr (bolus 1st)

**Remifentanyl** 0.1-0.3mcg/kg/min

**Atracurium** <1m 400mcg/kg/hr >1m 600mcg/kg/hr

**Dopamine** 5-15mcg/kg/min

**Noradrenaline/Adrenaline** 0.02-1mcg/kg/min

**Insulin:** consult local guidelines

### Refractory ↑ICP

Discuss with surgeons

Hyperventilation to PaCO<sub>2</sub> 4.0kPa (short term only)

3% Hypertonic Saline 3ml/kg over 10-20min

### ↓BP

Fluid boluses 10ml/kg & peripheral vasopressors

Noradrenaline (best α-agonist) / Early Dopamine

Adrenaline 1<sup>st</sup> choice inotrope for <5kg

### Targets for optimal cerebral perfusion

PaO<sub>2</sub> >12kPa

PaCO<sub>2</sub> 4-5kPa

etCO<sub>2</sub> 4.2-5.2kPa

SATs >95%

Temp <37°C

Na >140mmol/l

Glc 4-10mmol/l

**MAP (mmHg) <1yr >50 1-5yrs >60 5-10yrs >65 10-17yrs >70**

APLS SBP targets (mmHg): < 1year >80 1-5 years >90 5-14 years >100 >14 years >110

## Transfer to PICU

ICP protection measures

+/- Levetiracetam infusion



# PENETRATING EYE INJURY.

## Considerations

Aim is to prevent elevated IOP with deep anaesthesia & effective analgesia  
Normal IOP: 10-21mmHg  
Look for associated head injury

### Factors increasing the risk of ocular content extrusion

Coughing | Straining | Vomiting | Crying | Autonomic stimulation

## Induction

Ensure any head injury assessed	Consider RSI
Consider sedative premedication	Muscle paralysis. Avoid Suxamethonium
Avoid pressure from mask on injured eye	Deep intubation

### Additional considerations for IOP on induction

Decrease stimulation from Propofol and laryngoscopy

Fentanyl 2mcg/kg or Alfentanil 20mcg/kg  
Remifentanyl infusion 0.1-0.3mcg/kg/min

### Antibiotics

If not already on oral  
IV Ciprofloxacin 10mg/kg (max. 400mg) & IV Clindamycin 3-6mg/kg (max. 1.2g)  
Consult local policy

## Maintenance

TBI p2

Maintain $\text{etCO}_2$ 4 – 4.5kPa	Hyperventilate to decrease $\text{CO}_2$
Avoid $\text{N}_2\text{O}$	Antiemetics
Good analgesia. IV opioid usually required	Atropine 10-20mcg/kg (if oculocardiac reflex)

**Infusions:** Remifentanyl infusion 0.1-0.3mcg/kg/min

## Extubation

### Techniques to reduce coughing risk

Clonidine 1mcg/kg 30min prior to extubation	Remifentanyl 0.06-0.1mcg/kg/min
Dexmedetomidine 0.5-1mcg/kg 30min prior to extubation	Fentanyl 0.5-1mcg/kg 5min prior to extubation
Deep extubation or LMA exchange (if starved)	

# MAXILLOFACIAL TRAUMA.

## Considerations

Head Injury p2 | Penetrating Eye Injury p3 | Intubation in Cervical Spine Injury p5 | Neck Injury p7

**Expect bleeding & difficult BMV and intubation**

Continually reassess the airway for deterioration

Commonly associated with head & neck injuries

Consider NAI

## Upper face fractures

Higher incidence of intracranial haematoma and altered conscious level

Risk of basal skull fracture. Not absolute contraindication for nasal intubation. Caution advised

## Mid-face fractures

Bleeding can be significant and occult. Need large bore IV assess and a group & save

Potential for reflex bradycardia during surgical manipulation. Use Atropine 10-20mcg/kg if persistent

**Orbital fracture** → Risk of associated basal skull fracture

**Nasal fracture** → Most common fracture. Bleeding and difficult mask ventilation

**Zygoma fracture** → Risk of mechanical difficulty in opening the mouth

**Maxilla fracture** → Risk of difficult mask ventilation and bone, vomit or blood in the airway

## Lower face fractures

Rarer to cause airway compromise

**Mandibular condyle fracture** → mechanical difficulty in opening the jaw

**Bilateral anterior mandible fracture** → airway obstruction as tongue slides posteriorly in supine patient

Teeth often in the fracture line

## Risk factors for difficulty

Lefort type 2 (maxilla fracture) | Bilateral mandibular fracture | Facial with basilar skull fracture

Oedema, blood, loss of teeth

Possible bleeding reduction techniques → Manual reduction | Nasal balloons | Bite blocks | Hard collar

## Intubation considerations

See **Intubation in Cervical Spine Injury** p5 for options

From simple direct vision to surgical tracheostomy may be indicated as the first option

Full airway assessment needed prior to plan

Consider early intubation. ↑ bleeding/swelling

BMV may be difficult

FONA plan discussed and equipment available

Mark cricothyroid membrane

Maxillo-mandibular fractures → nasal ETT

Mouth opening >2cm needed for oral route

Large bore suction in airway to assist intubation

FOI can be challenging with blood in the airway

Intubate semi-upright or laterally

## Extubation considerations

Plan as carefully as intubation. Fully awake

Oedema may continue to get worse post-op

Mid-face fractures higher risk of complications

Suction airway thoroughly before extubation

Surgical team to be in attendance

May need HDU for observation

Wire cutters stay with patient if necessary

Post-op haematoma can be airway threatening

# INTUBATION IN CERVICAL SPINE INJURY.

## Considerations

Spinal Injury p6 | Neck Injury p7

### Guidance for intubation alone

**Technique will depend on clinical situation and experience of the anaesthetist**

Young children vulnerable to upper (C1-4) cervical injuries. May not have radiographic changes

Cervical collars and neck blocks are not standard practice in young children if not tolerated

Intubation or ↑ intra-thoracic pressure → Neurogenic shock → Unopposed vagal stimulation

### Bradycardia & Hypotension

Intubation after acute phase (typically >1 month) → Autonomic dysreflexia

### Risk of Hypertension / Stroke / Cardiac arrest

Prevention of 2° injury critical

Hypotension = cord ischaemia

## Intubation considerations

Strongly consider the use of a checklist

Emergency drugs for cardiovascular instability

High risk of aspiration (gastroparesis)

Flexion can be more dangerous than extension

Risk of respiratory deterioration

If respiratory effort is affected, diaphragmatic breathing is easier if the patient lies flat

Consider prophylactic Atropine & Ondansetron

FONA plan discussed and equipment available

## Intubation plan

3-4 assistants required for:

MILS (Manual In-Line Stabilisation) | Airway intervention | Managing anaesthesia | Calling for help

Remove any cervical collar and head blocks

Minimal jaw thrust/chin lift with mask ventilation

No evidence to avoid cricoid pressure

### Option 1

RSI & Video Laryngoscopy

This can be challenging. Consider hyperangulated blade

Low threshold for bougie/stylet

Consider using laryngoscopy to assist with an oral fiberoptic intubation

### Option 2

Asleep & spontaneously breathing nasal fiberoptic intubation

HFNS & TIVA

↓ Neck movement | Good if other difficult airway factors | Need time to plan | Need a stable patient

### Remember

LMA a useful rescue tool

Replace head blocks and tape after intubation

# SPINAL INJURY.

## Considerations

Injury above T6 = Neurogenic shock = Bradycardia / Hypotension / Hypothermia  
Intubation or ↑ intra-thoracic or bladder pressure = Unopposed vagal stimulation  
After acute phase = Autonomic dysreflexia (>T6) = Risk of cardiac arrest / hypertension / stroke  
Young children vulnerable to upper cervical injuries. Can be without radiographic changes  
Prevention of 2° injury critical  
Sudden loss of CO in surgery → ?VAE  
Hypotension = cord ischaemia  
Spinal surgery may incur large blood loss

## Induction

**Intubation in Cervical Spine Injury p5 | C-spine assessed | Blood products available**

Remove spinal board if applicable  
High risk of aspiration (gastroparesis)  
Note any neurological deficit prior to intubation  
Avoid Suxamethonium if injury >3 days old  
Anti-emetics for any supine immobilised patient  
Consider prophylactic Atropine  
Prepare for proning | RSI | Bite Block | Large IV access x2 | Arterial line | CVC | Consider cell salvage |  
Urinary catheter | Rectal temperature probe (once prone) | BIS monitoring | NG tube

## Maintenance

**Major Haemorrhage p14 | Acute & Chronic Pain p22**

TIVA if need for neurophysiology monitoring  
Active warming

Ventilate at 6ml/kg  
Prone position management

### BP management

Maximise spinal cord flow. Maintain MAP  
Noradrenaline 1<sup>st</sup> line (risk of reflex bradycardia)  
Goal-directed fluid therapy (risk of pul. oedema)  
Early vasopressor / inotrope support  
Injury above T6 may need inotropic support  
Hypotension is typically fluid resistant

### Infusions

Propofol TCI  
Remifentanyl 0.05-0.3mcg/kg/min  
TXA(p14)  
Noradrenaline 0.02-1mcg/kg/min (>0.2 add inotrope)  
Consider Dopamine or Adrenaline  
Consider dilution (e.g. 25% weight x 0.3mg in 50ml)  
Allows for stricter titration of vasopressors/inotropes

### Targets for optimal spinal cord perfusion

U/O <2yrs 0.75-1ml/kg/hr >2yrs 0.75-2ml/kg/hr	Temp >36°C	Glc 4-10mmol/l
Hb >80g/l	Hct: 0.3	pH 7.35-7.45
SATs >95%	PaO <sub>2</sub> 8-12kPa	etCO <sub>2</sub> 4.2-5.2kPa
<b>MAP (mmHg) &lt;1yr &gt;50 1-5yrs &gt;60 5-10yrs &gt;65 10-17yrs &gt;70</b>	PaCO <sub>2</sub> 4-5kPa	BIS <60

## Extubation

**Injury >T6. Coughing risks bradycardia. Consider:**  
LMA exchange  
Extubation with Remifentanyl 0.1mcg/kg/min  
Clonidine 1mcg/kg 30 minutes prior to extubation  
Dexmedetomidine 0.5-1mcg/kg  
30 minutes prior to extubation

## PICU

Poor respiratory function  
Unstable CV system  
Difficult intubation or airway oedema  
Massive transfusion



# NECK INJURY.

## Considerations

ENT consultant present | Maxillofacial Trauma p4 | Intubation in Cervical Spine Injury p5

Airway is precarious and can deteriorate rapidly

**Red flags** are dyspnoea, dysphonia and stridor. However, poor relation with signs and severity

Penetrating injuries can distort anatomy with a haematoma or subcutaneous emphysema

**Tracheostomy can be useful 1<sup>st</sup> line and effective in managing post-op airway oedema**

## Practical points for intubating

**Principles of management → maintenance of spontaneous ventilation, direct vision and an RSI**  
**Secure the airway based on the clinical scenario, not an algorithm**

**Non-time critical** → Consider CT (+/- angio), nasoendoscopy & fiberoptic intubation

Consider pre-induction nasoendoscopy | High flow nasal specs | Aspiration prophylaxis | Suction x2

Intubate the trachea under direct vision to avoid entering a tear (see below)

Use a smaller tube

Consider avoiding NMDB's in airway transections (muscle tone may be important for airway integrity)

Strict securing of ETT and an NG tube

ENT availability (use of a non-penetrating clamp for the distal trachea in partial/complete transection)

## Fiberoptic scope assisted direct/video laryngoscopy

1. Place ETT at the opening of the larynx under direct vision
2. Fiberscope is passed through the tube and into the trachea
3. The ETT can then be delivered past the lesion safely if the bevel is orientated to face the lesion.
4. Care must be taken when railroading the tracheal tube

## Laryngotracheal trauma

Difficult airway guidelines can make it worse

**Caution: Cricoid pressure, mask PPV (unless carefully) & percutaneous/surgical cricothyroidotomy**

**Plan A:** Fiberoptic intubation or fiberoptic scope assisted direct/video laryngoscopy

Consider tracheostomy if appropriate

RSI with a bougie or a rigid bronchoscopy & intubation is an alternative

**Plan B:** Emergency FONA or tracheostomy (use scope to identify lesions)

## Trachea and Bronchi trauma

May need double lumen tube or endobronchial intubation (OLV p10)

**Plan A:** Fiberoptic intubation or fiberoptic scope assisted direct/video laryngoscopy

Consider tracheostomy if appropriate

RSI with a bougie or a rigid bronchoscopy & intubation is an alternative

**Plan B:** Emergency FONA or tracheostomy

Percutaneous/Surgical cricothyroidotomy is an option

## Burns

Nasoendoscopy particularly useful

Full Difficult Airway Society guidelines apply

# THORACIC TRAUMA.

## Considerations

Major internal injuries in children may occur without any external chest wall injury

Rapid deceleration injuries are high risk for thoracic trauma

**Hypotension → Imminent CV collapse**

Pulmonary contusions most common injury

Cardiac/Aortic injury → Involve surgical team

40% TBV can be lost in each hemi-thorax

Rib fractures indicate significant force

May have large analgesia requirements

## Induction

Trachea-bronchial injury p7 | Avoid N<sub>2</sub>O

## One Lung Ventilation p10

**Consider: Fluid resuscitation → Careful drug titration → Dilute Adrenaline**

Haemodynamically stable: **(2-2-2)** Fentanyl 2mcg/kg Ketamine 2mg/kg Rocuronium 2mg/kg (max. 150mg)

Haemodynamically unstable: **(1-1-2)** Fentanyl 1mcg/kg Ketamine 1mg/kg Rocuronium 2mg/kg

Haemodynamically critical: **(1-2)** Ketamine 1mg/kg Rocuronium 2mg/kg

RSI | Large IV access x2 | Arterial line | Urinary catheter | Temperature probe

NG tube (if not contra-indicated) | BIS monitoring (limits MAC needed) | +/- CVC

### Pneumothorax present

Chest drain insertion should not delay intubation

Be aware PPV may cause tension → decompress

**Emergency:** Finger thoracostomy

**Definitive:** Chest drain insertion

### Cardiac tamponade present

Narrow pulse pressure | Shock | Quiet HS

Volume resuscitation (to ↓ RV collapse)

Surgeon for emergency drainage

**Clamshell thoracotomy p12**

## Maintenance

Traumatic Cardiac Arrest p11 | Major Haemorrhage p14 | Acute & Chronic Pain p22

Expect massive bleeding

Be aware of possible myocardial contusion

Follow APLS guidelines for management of arrhythmias

**TXA:** 15mg/kg bolus (max. 1g) → 2mg/kg/hr (8hrs). Check if given prior to theatre (max. 125mg/kg/hr)

### Targets during a major haemorrhage

PaO <sub>2</sub> 8-12kPa	PaCO <sub>2</sub> 4-5kPa	MAP normal	pH(art) >7.35	pH(cap) >7.25	Temp >35°C
Hb >80g/l	Hct >0.25	Plt >75 10 <sup>9</sup> /l	PT ratio <1.5	APTT ratio <1.5	Ca <sup>2+</sup> >1mmol/l
Fibrinogen >1g/l	Lactate stable	K <sup>+</sup> 3.5-5mmol/l	u/o present		Glc 4-10mmol/l

## Post-op

Aggressive multi-modal analgesia

Consider coagulation state of the patient (RA risk)

Paravertebral/Serratus anterior block +/- catheter

NCA/PCA +/- Ketamine infusion

## PICU

Flail chest

Significant pulmonary contusions

Diaphragmatic rupture

Oesophageal rupture

# THORACIC ULTRASOUND.

Higher sensitivity for detecting pneumothorax (ptx) than CxR

Diagnosing a pneumothorax can be challenging

Excluding pneumothorax is simple & reliable

**Lung sliding is the most important finding in excluding a pneumothorax**

**Remember pathology is a dynamic process. Scan may need repeating**

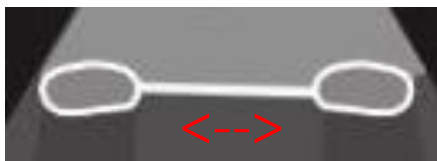
**Probe placement:** Longitudinally | Pointing up | Mid clavicular line | 2-4<sup>th</sup> intercostal space.

**Probe:** High frequency | Large | Linear

**Start medially:** Move laterally to posteriorly

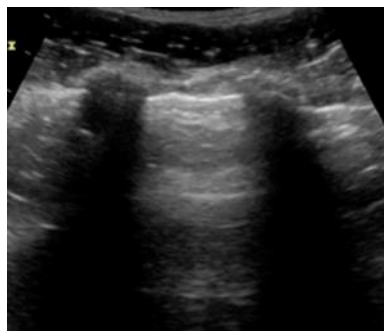
## Ultrasound findings on anterior chest wall

**'Lung sliding'**



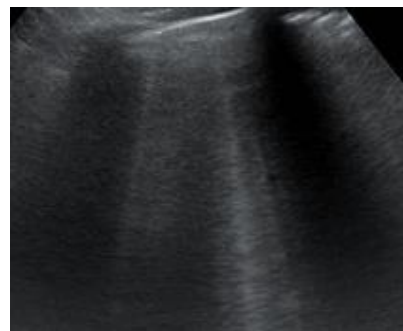
Viseral pleura slides to-and-fro under the parietal pleura

**Lost: Pneumothorax**



*A lines* are equidistant horizontal artifact lines below the pleura

**Increased: Pneumothorax**



*B lines/comet tails* are vertical artifact lines

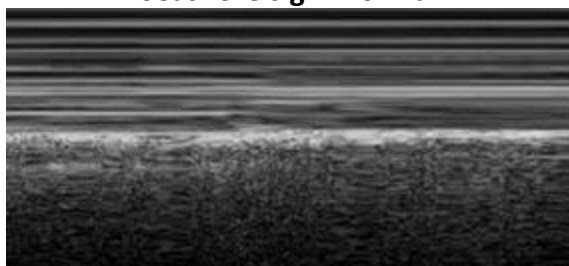
**Lost: Pneumothorax**

No sliding → move the probe lateral/posterior until sliding seen (edge of ptx) = **Lung point**

## Place the ultrasound in 'M' mode

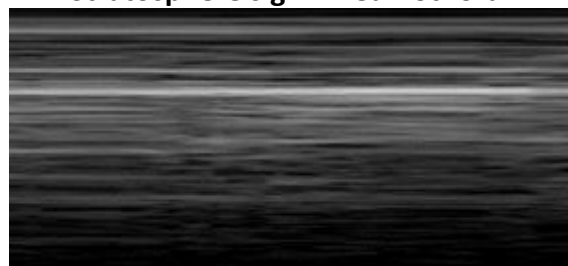
'M' mode = 'Motion' mode. It detects motion over time

**Seashore sign: Normal**



The moving pleura divides the image in half  
Motionless tissue above appear like waves  
Pleura causes granular pattern below like sand

**Stratosphere sign: Pneumothorax**



No divide in the image  
Appears like a barcode  
No sliding pleura

### Anterior chest wall

Lung sliding → **NO** → *B lines* seen → **NO** → 'M' mode seashore sign → **NO** → **Likely pneumothorax**

### Lateral/Posterior chest wall

Lung point seen → **YES** → **Likely pneumothorax**

## Pneumothorax identified

Be aware PPV may cause tension pneumothorax → decompress

**Emergency:** Finger thoracostomy

**Definitive:** Chest drain insertion

# ONE LUNG VENTILATION (OLV).

Does this need to be done?

For surgical access or to prevent lung contamination

Requires 2-3 people

## Selective endobronchial intubation

**1<sup>st</sup> choice in an emergency**

(suitable for all ages)

## Equipment

COETT

Bronchoscope port connector

Fibreoptic scope

The inner diameter of the ETT should be  $\geq 2$ mm larger than the diameter of the fibreoptic scope

\*Exception, 2.8 scope can fit in a 3.5 ETT, very tight. \*If 3.0 ETT, need 2.2 scope (lacks suction channel)

## Considerations

Unable to deflate unventilated lung

Oxygenation saturations will be low due to significant pulmonary shunting

Right upper lobe collapse if ventilating the right lung

Two lung ventilation requires significant manipulation

## Process

Intubate trachea

Insert scope through endotracheal tube

Advance scope into bronchus

Advance ETT over scope into bronchus

Inflate ETT tube cuff

## Additional options

Operator dependant

## Bronchial Blocker (BB)

Outer diameter bronchial blocker & scope should be  $< 0.7$  of the internal ETT diameter

$< 5.0$  COETT  $\rightarrow$  Extra luminal 5Fr BB

$> 5.0$  COETT /  $> 2$  yrs /  $> 15$  kg  $\rightarrow$  Intraluminal 5Fr BB

$> 6.0$  COETT /  $> 8$  yrs /  $> 25$  kg  $\rightarrow$  Intraluminal 7Fr BB

## Double Lumen Tube

8-10 years old  $\rightarrow$  28Fr

10-12 years old  $\rightarrow$  28-32Fr

12-14 years old  $\rightarrow$  32Fr

14-16 years old  $\rightarrow$  35Fr

$> 40$  kg as an advised minimum for 32-35Fr ( $> 50$  kg ideal)

# TRAUMATIC CARDIAC ARREST.

## Causes

**Hypoxia:** Standard APLS

**Isolated head injury:** APLS & vasopressors

**Non-trauma:** Standard APLS

**Spinal shock:** APLS & Adrenaline

## Blunt trauma / Penetrating trauma / Hypovolemia

Modified APLS

1° Address reversible causes (see below)

2° Chest compressions/cardioversion (deprioritised). Do not allow to hinder treating reversible causes

Use of routine Adrenaline is controversial. No evidence of benefit

## Traumatic cardiac arrest algorithm

**\*Reassess before proceeding to a thoracotomy**

Continue chest compressions but the **priority** is addressing the reversible causes

If resources allow, perform 1,2 & 3 simultaneously

### Arrest

**(call emergency paediatric surgical team)**

1. 100% O<sub>2</sub> / Check ETT / Check ventilation

2. Bilateral finger thoracostomies (5<sup>th</sup> intercostal space, anterior/mid-axillary line)

3. Massive transfusion protocol (warm products)  
Consider a pelvic binder

**\*Clamshell thoracotomy\***

### The reversible cause

**Hypoxia**

**Tension pneumothorax**

**Hypotension**

**Blood loss or Cardiac tamponade**

Fatal injury?

Guidance on the futility of continued resuscitation efforts

Persistently low CO<sub>2</sub> | Arrest >20minutes | Cardiac standstill on ultrasound scan

## Clamshell thoracotomy (p12)

**Consider immediately** in penetrating trauma to the chest or epigastrium

**Relative Contraindications:** Cardiac arrest >10mins | Evidence in **Blunt trauma** is limited

## During thoracotomy

Note if heart appears full or empty

Cardiac tamponade as 1° cause offers the best chance of survival

**ROSC** followed by **VF** → Have the coronary vessels been stapled/sutured in error? Release

## Post-thoracotomy

ROSC → Begin or continue sedation



# CLAMSHELL THORACOTOMY.

## Equipment

**Appropriate training needed**

**For thoracotomy:** Scalpel | Forceps | Heavy scissors

**For haemostasis:** Suture on needle size 1/0 | Foley catheter | Forceps x4

**PPE:** Gloves | Gown | Eye protection

## Aide mémoire for the surgeon

Skin preparation if immediately possible. Otherwise forego

Extend the thoracostomies posteriorly by ~3cm (helps with next steps)

Connect the thoracostomies with a deep skin incision following the 5th intercostal space

Insert two fingers to push lung down

With heavy scissors cut through all layers of the muscles and pleura towards the sternum on the L & R

Cut through the sternum with heavy scissors or a saw (Gigli saw if available)

Open the chest with retaining retractors/rib spreaders or manually by an assistant. Beware sharp injury from ribs

Always open the pericardium

Inverse T shaped incision. Stay in the midline to avoid phrenic nerves

Deliver the heart and inspect the back

## Cardiac tamponade

Evacuate any blood and clot present

Inspect the heart for wounds and manage

<1cm wound → seal with finger or gauze

If bleeding uncontrolled → suture or staple at 1cm 'bites' (risk of coronary occlusion)

Do not do this with wounds close to right AV groove or near the coronary arteries

## Massive bleeding distal to thoracic aorta

Compress the thoracic aorta onto the spinal column as distal as possible with a closed fist

Continue volume expansion with blood resuscitation

## Internal cardiac massage

One hand to the posterior surface of the heart and one to the anterior surface

Blood is 'milked' from the apex upwards

Avoid single handed massage. Risk of thumb perforating right ventricle

Ensure heart remains horizontal. Lifting the apex can impair venous filling

Defibrillation → **1J/kg** using internal paddles

ROSC may cause bleeding from internal mammary and intercostal vessels

May require sutures or artery forceps

# DAMAGE CONTROL LAPAROTOMY (DCL).

## Considerations

Aim of DCL: control bleeding, contamination and correct the physiological derangements  
To stabilise physiology not correct anatomy  
Surgery is limited to 1 hour

Good communication with the surgeon is vital  
"Restrictive & cautious resuscitation"

Patients die from intraoperative metabolic failure: **Coagulopathy** **Hypothermia** **Metabolic acidosis**  
Stage 1: DCL Stage 2: PICU Stage 3: Definitive repair

## Induction

Any head injury & imaging reviewed | Blood products available | Consider 10ml/kg RBC preload  
**In theatre in the cruciform position. Surgical team ready for KTS**

**Consider: Fluid resuscitation → Careful drug titration → Dilute Adrenaline**

Haemodynamically stable: **(2-2-2)** Fentanyl 2mcg/kg Ketamine 2mg/kg Rocuronium 2mg/kg (max. 150mg)  
Haemodynamically unstable: **(1-1-2)** Fentanyl 1mcg/kg Ketamine 1mg/kg Rocuronium 2mg/kg  
Haemodynamically critical: **(1-2)** Ketamine 1mg/kg Rocuronium 2mg/kg

RSI | Large IV access x2 (upper body) | Consider cell salvage | Urinary catheter | Temperature probe  
BIS monitoring (limits MAC needed) | Arterial line & CVC (Not to delay KTS in an unstable patient)

## Maintenance

**Major Haemorrhage p14 | ROTEM/TEG p15**

Expect massive bleeding  
Titrate anaesthesia to BIS  
Antibiotic cover  
BE important sign of shock. Under -6 → shock

**Infusions:** TXA(p14)

### Blood pressure

Radial pulse = adequate BP until bleed controlled  
Fluid volume replacement first line  
Surgical manoeuvres for massive bleeding:  
- Four quadrant packing  
- Occlude the aorta at the diaphragmatic hiatus

### Once bleeding controlled

Fentanyl boluses 1mcg/kg (max. 10mcg/kg)  
Allows vasodilation → further resuscitation

### STACK Update

With surgeon. Every 15-30min

**S** Systolic BP  
**T** Temperature  
**A** Acidosis  
**C** Coagulation  
**K** Kit used (e.g. blood products)



**Change strategy? Laparotomy → DCL → PICU**

**Reasons to change strategy:**

Massive transfusion	Temperature <35°C
pH <7.30	Surgery >90min
Coagulopathy	Lactate >5mmol/l

### Inotropes/Vasopressors

Avoid pure α agonists if possible  
1<sup>st</sup> line: dilute Adrenaline if needed

### Targets during damage control surgery

PaO <sub>2</sub> 8-12kPa	PaCO <sub>2</sub> 4-5kPa	pH(art) >7.35	pH(cap) >7.25	Lactate stable	Temp >35°C
Hb >80g/l	Hct >0.25	Plt >75 10 <sup>9</sup> /l	PT ratio <1.5	APTT ratio <1.5	
Fibrinogen >1g/l	Ca <sup>2+</sup> >1mmol/l	K <sup>+</sup> 3.5-5mmol/l	u/o present	Glc 4-10mmol/l	

## PICU

Will need re-look laparotomy

# MAJOR HAEMORRHAGE.

## Considerations

Blood volume: Neonate 90ml/kg Infant 80-85ml/kg Child 75-80ml/kg Adult 70ml/kg

### Outside assistance

Activate major haemorrhage pathway  
Transfusion lab  
Haematologist on-call via switchboard

Tachycardia = bleeding until proven otherwise  
Hypotension = late sign. >40% TBV loss  
Surgical source control vital:  
Tourniquet | Splint | Pressure | Clamp | Packing

## Induction

In theatre with surgical team ready for KTS

DCL p13 for induction and monitoring

## Maintenance

2-3 Anaesthetists & ODPs | Injury dependant | DCL p13 | ROTEM/TEG p15

Patients die from intraoperative metabolic failure: **Coagulopathy** **Hypothermia** **Metabolic acidosis**

Anaesthetic task allocation: Phone | Blood products | Patient

## BP management

No permissive hypotension | Maintain MAP in the low-normal range | Titrate anaesthesia to BIS  
Use Plasmalyte if needed | Volume before  $\alpha&\beta$  agonist | Adrenaline 1<sup>st</sup> line  $\alpha&\beta$  agonist

**Coagulopathy** → ROTEM/TEG | Blood products | Calcium

**Hypothermia** → Core temp monitoring | Active warming | Fluid warmer | Warm blood products

**Metabolic acidosis** → BP management | Source control | BE important sign of shock. Under -6 → shock

Antibiotics (consider repeating if EBL >30%)

Does patient need Damage Control Surgery?

**TXA:** 15mg/kg bolus (max. 1g) → 2mg/kg/hr (8hrs). Check if given prior to theatre (max. 125mg/kg/hr)

## Blood products 1<sup>st</sup> line

RBC, FFP (Octaplas), Cryoprecipitate: 5ml/kg. Platelets: 10ml/kg (1 adult dose if >200ml)

Use a fluid warmer. Ideally a rapid infuser

Reassess after every bolus

ROTEM/TEG (p15) for coagulation guidance

Different lines for plts and cryo. (Same cannula is ok)

10%  $\text{Ca}^{2+}$  gluconate 0.5ml/kg (guided by the ABG)

Monitor  $\text{K}^{+}$  (See Crushed Limb p16 for Tx)

?Fibrinogen low → consider fibrinogen concentrate (Fibryga) 70mg/kg (max. 2g)

**Blood transfusion should be balanced & goal-directed. See targets below**

**Once bleeding controlled:** Fentanyl boluses 1mcg/kg (max. 10mcg/kg)

Allows vasodilation → further resuscitation

## Targets during a major haemorrhage

$\text{PaO}_2$  8-12kPa

$\text{PaCO}_2$  4-5kPa

pH(art) >7.35

pH(cap) >7.25

Hb >80g/l

Hct >0.25

Plt >75  $10^9$ /l

Fibrinogen >1g/l

PT ratio <1.5

APTT ratio <1.5

$\text{K}^{+}$  3.5-5mmol/l

$\text{Ca}^{2+}$  >1mmol/l

u/o present

Lactate stable

Temp >35°C

Glc 4-10mmol/l

## Post-op | PICU

Massive transfusion → consider PICU

# ROTEM/TEG.

## Considerations

Reference ranges are normal values not transfusion thresholds

ROTEM: A5/A10 good predictors of MCF

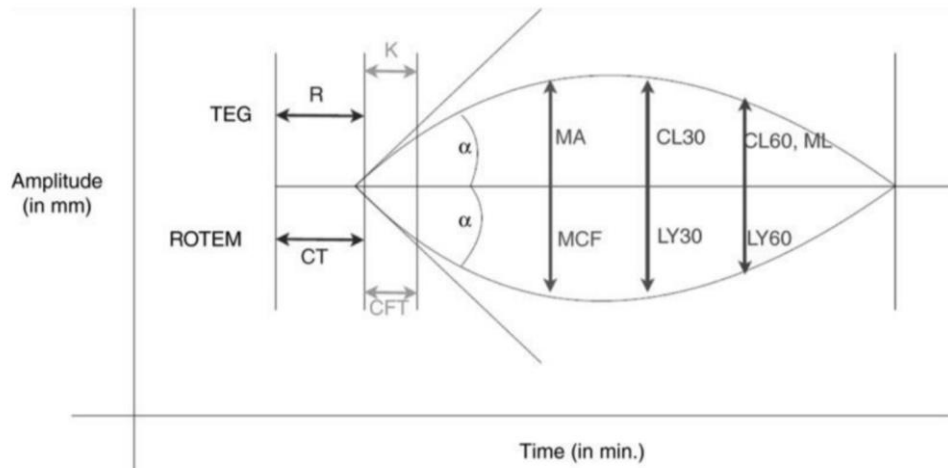
'10 & 10' Aim for A10 above 10 on FIBTEM

FIBTEM (ROTEM) and FF (TEG) specifically measure fibrinogen function

Consider TXA 15mg/kg bolus & 2mg/kg/hr infusion for all moderate to severe bleeding (p14)

Point in time test only. **Repeat**

**Tests inadequate without:** Sufficient volume resuscitation & temperature / pH / Ca<sup>2+</sup> control



### ROTEM Reference ranges

CT INTEM 161-204s EXTEM 50-80s

CFT 62-130s EXTEM 46-149s

MCF INTEM 51-69mm EXTEM 55-72mm FIBTEM 6-21mm

A5 INTEM 33-52 EXTEM 32-52

A10 INTEM 43-62 EXTEM 43-63

LY/CL30 INTEM 98-100 EXTEM 100-100

### TEG Reference ranges

R TIME 4-8min

K time 1-4min

MA 55-73mm

FF citrated blood 11-24mm

LY/CL30 0-8%

Consider use of AI to assist with interpretation

## Clots

How fast	How strong	How long
Long CT or R time	Low MCF or MA	High CL or LY
Factor deficiency or anticoagulation	Normal FIBTEM/FF = ↓Plts Low FIBTEM/FF = ↓Fibrinogen	Increased clot lysis
Adjust/reverse anticoagulation FFP NovoSeven	Platelets Cryoprecipitate Fibrinogen conc. (Fibryga)	TXA

Fibryga. 1g into 50ml water (20mg/ml). Injection rate no faster than 5ml/min:

FIBTEM MCF <3 = 100mg/kg (max. 4g) MCF 3-9 = 70mg/kg (max. 2g) MCF >9 = 35mg/kg (max. 2g)

NovoSeven. 90mcg/kg. Round ⬆ to nearest No. whole vials except in small infants. Repeat after 1hr

# BLAST INJURIES.

## Considerations

Greater chance of major trauma than adults

Highest mortality: 1<sup>st</sup> Burns 2<sup>nd</sup> Head injury

High incidence of PTSD

Higher risk of coagulopathy

Whole body CT as part of primary survey

**Never** close a blast injury

**Shock, compensated shock, peritoneal or retroperitoneal breach, evisceration or peritonitis = Surgery**

## Induction

Any head injury assessed | All imaging reviewed | Blood products available | Any hearing loss?

**In theatre with surgical team prepared**

Consider 10-20ml/kg RBC preload

**Consider: Fluid resuscitation → Careful drug titration → Dilute Adrenaline**

Haemodynamically stable: **(2-2-2)** Fentanyl 2mcg/kg Ketamine 2mg/kg Rocuronium 2mg/kg (max. 150mg)

Haemodynamically unstable: **(1-1-2)** Fentanyl 1mcg/kg Ketamine 1mg/kg Rocuronium 2mg/kg

Haemodynamically critical: **(1-2)** Ketamine 1mg/kg Rocuronium 2mg/kg

RSI | Consider c-spine | Large IV access x2 | Cell salvage | Urinary catheter | Temperature probe

BIS monitoring (limits MAC needed) | Arterial line & CVC (Not to delay KTS in an unstable patient)

## Maintenance

**Injury dependent | TBI p2 | DCL p13 | Major Haemorrhage p14 | ROTEM/TEG p15 | Major Burn p17**

### Antibiotics

Refer to local policy

Considerations: Penicillin allergy | Penetrating CNS injury | Need for anti-fungal treatment

### 1° Shockwave injuries

**Major haemorrhage** (without penetrating wounds)

**Air embolism (CV collapse)**

**Pulmonary haemorrhage**

**Pneumothorax**

**Great vessel injury**

**GI perforation or Traumatic amputation**

**Pelvic disruption**

**Major Haemorrhage p14 | ROTEM/TEG p15**

100% O<sub>2</sub> / Fluids / Vasopressors / CPR

Early intubation / Suction

Decompress / Chest drain / Avoid N<sub>2</sub>O

CT thorax in 1° survey / Specialist surgeon

**DCL p13 | Crushed Limb p18**

Pelvic binder / Proximal control

### Blast lung

Lung protective strategies as per ARDS:

Permissive hypercapnia | Low TV 4-6ml/kg | Adequate PEEP | Peak pressure <30cmH<sub>2</sub>O

Not suitable for extubation

### 2° Fragmentation injuries

Consider injuries along missile's path

Face and eye injury incidence high (27-48%)

Consider antifungal cover in abdominal/thorax injury → Fluconazole 6mg/kg (max. 400mg)

Tetanus immunoglobulin & Hep B vaccination

Vascular injury incidence high (3-12%)

### 3° Blast wind injuries

Polytrauma from being thrown: e.g. HI / fractures: See relevant chapter

Burn injury. See **Major Burn p17**

Inhalational injury: Lung protective strategies

## Post-op | PICU

Needs observation for delayed lung/GI pathology

May need re-look laparotomy



# MAJOR BURN >10-15%TBSA.

## Considerations

Profound cardiovascular and metabolic changes  
>48hrs old risks Toxic Shock Syndrome

Expect a Systemic Inflammatory Response  
Fire: Smoke inhalation | CO or cyanide poisoning

**Patient must be fluid resuscitated**

**%TBSA x weight (kg) x 3 = fluid volume (ml) for the first 24 hours of resuscitation**  
(Half the volume over 8hr from time of injury, the remainder over the following 16hr)  
Resuscitation fluid volume is separate to maintenance fluid requirements

## Induction

Access for inhalational injury | Access volume and electrolyte state | Blood products available  
Continue NJ feeds | Tetanus immunoglobulin

Hypotension at presentation → Assume bleeding in the trauma patient

**<48hrs old. Burn Shock**

↓CO ↓BP ↑HR ↑SVR

**>48-72hrs old. Hyperdynamic phase**

↑Fluid losses ↑CO ↑HR ↓SVR ↓Coag

**Consider: Fluid resuscitation → Careful drug titration → Dilute Adrenaline**

Haemodynamically stable: **(2-2-2)** Fentanyl 2mcg/kg Ketamine 2mg/kg Rocuronium 2mg/kg (max. 150mg)

Haemodynamically unstable: **(1-1-2)** Fentanyl 1mcg/kg Ketamine 1mg/kg Rocuronium 2mg/kg

Haemodynamically critical: **(1-2)** Ketamine 1mg/kg Rocuronium 2mg/kg

Avoid Suxamethonium

Expect hypovolaemia. Strongly consider fluid bolus prior to transfer even if fluid balance is neutral  
Drug doses vary. Cautious if unstable. Higher doses may be needed >72hrs. Titrate to effect  
Volatiles and Remifentanyl can cause profound hypotension during shock phase

RSI | Large IV access x2 | Urinary catheter | Temperature probe | BIS monitoring (limits MAC needed)  
>20% burn or repeated debridement: NG tube | Consider a long-line  
>30 % burn: Arterial line | CVC | NJ tube

## Maintenance

Myocardial depression and hypovolaemia risk  
Antiemetics & analgesia to promote early feeding  
Regional block → check coagulation

Vasopressor / inotrope infusions ready  
Cautious with opioids in shock phase  
IV access consideration for post-op needs

Infection risk high: Strict ANTT. Antibiotics only if needed. High risk of resistance

**Blood loss can be insidious. 1% deep debridement → 3.4% total blood volume loss**

### Fluid management

Goal-directed  
U/O: 0.5-1ml/kg/hr  
<20kg: Glucose containing maintenance fluid  
Burn >16hrs: Consider HAS to ↓ 3<sup>rd</sup> space losses

### Temperature control

Warm theatre to >28 °C  
Active body heaters  
Fluid warmer  
Cover all possible patient areas

## Post op

PCA/NCA or continuous infusion (Fentanyl 1<sup>st</sup> line)  
Consider low dose Ketamine infusion  
Consider starting Gabapentin in all >20% burns  
Nutritional support is vital

## PICU

Burn >40% TBSA  
Pain issues  
ARDS | Protection of sensitive grafts  
Invasive monitoring | Deep burns | Airway burns

# CRUSHED LIMB.

## Considerations

Significant risk to patient on reperfusion of the crushed limb

### Crush syndrome & reperfusion injury

Hypovolemia / Hypotension / Rescue cardioplegia /  
Electrolyte and acid-base abnormalities /  
Rhabdomyolysis / Acute renal failure / Thrombotic  
event / DIC (rare)

Avoidance of acute renal failure is crucial

### Rescue cardioplegia (cardiac arrest)

Uncontrolled limb re-perfusion in shocked patient  
Rapid return of blood to the right atrium that is:  
cold, acidotic,  $\uparrow\text{Ca}^{2+}$ ,  $\uparrow\text{K}^+$ ,  $\uparrow\text{CO}_2$   
in an already shocked system

All Tx needs to be in the context of other trauma

## Induction

FBC, Coag, U+E | Blood products available | Avoid Suxamethonium

Consider: Fluid resuscitation → Careful drug titration → Dilute Adrenaline

Haemodynamically stable: (2-2-2) Fentanyl 2mcg/kg Ketamine 2mg/kg Rocuronium 2mg/kg (max. 150mg)

Haemodynamically unstable: (1-1-2) Fentanyl 1mcg/kg Ketamine 1mg/kg Rocuronium 2mg/kg

Haemodynamically critical: (1-2) Ketamine 1mg/kg Rocuronium 2mg/kg

RSI | Large IV access x2 | Arterial line | CVC | Cell salvage | Urinary catheter | Temperature probe  
BIS monitoring (limits MAC needed)

## Maintenance

Major Haemorrhage p14 | ROTEM/TEG p15 | Acute & Chronic Pain p22

Use **STACK** updates with the surgeon. (p13)

Inotropes & blood transfusion may be required

### Fluid management

Prepare circulation for reperfusion  
20ml/kg 0.9% Saline fluid bolus. Not Plasmalyte  
Further fluid depends on clinical response  
**Maintain urine output >2ml/kg/hr**  
If normovolaemic consider Mannitol 20%  
1-2g/kg over 4hrs

### Analgesia

Consider Ketamine  
Consider regional block  
**Epidural:**  
Consider injuries, coag & CV stability  
Limit infusion rate to 0.1-0.15ml/kg/hr  
**Risk with compartment syndrome (p22)**

### $\text{K}^+ > 6.5$

**Salbutamol** IV 4mcg/kg (max. 250mcg). Dilute to 50mcg/ml. **Give slowly ( $\downarrow$ BP)**. Repeat 2 hourly  
**Calcium Gluconate 10%** IV 0.5ml/kg over 5min (max. 20ml). Repeat in 10min if needed  
**Calcium Chloride 10%** IV 0.2ml/kg over 10min (max. 10ml). repeat in 10min if needed  
Follow local guidelines for an **Insulin** infusion  
**Beware of drug error** | Avoid Frusemide in rhabdomyolysis | Check Glucose and  $\text{K}^+$  after 15min

### Staged tourniquet release (>1hour)

Release 30sec → re-apply 3min → release 30sec →  
re-apply 3min → release  
Do not gradually release tourniquet  
"Fully on or fully off"

### Acidosis $\text{pH} < 7.34$ or $\text{HCO}_3^- < 18\text{mmol/L}$

Sodium bicarbonate 8.4% (1mmol/ml) 1ml/kg  
Dilute 1 in 10 with Dextrose 5% (1 in 5 if CVC)  
Give slowly over 10min  
**Beware of extravasation & hypernatraemia**

## Post-op

Ketamine infusion (or local protocol):  
5mg/kg (max. 250mg) in 50ml with 0.9% NaCl  
0.5-2ml/hour (start at 1ml/hour)(50-200mcg/kg/hr)

## PICU

Insulin infusion  
Alkalisiation of urine

# FLAP RECONSTRUCTION.

## Considerations

Prolonged anaesthesia & surgery

Blood loss | Fluid loss | Heat loss

**Peri-anaesthetic risks for flap failure:**

**Hypothermia | Vasoconstriction | ↑Sympathetic tone | Hypovolaemia | Oedema | Acidosis**

No evidence for volatile vs IV anaesthesia for flap success

## Induction

FBC, U+E | Blood products available | Consider pre-med (multiple GA's)

## Regional Block

Important for increasing flap survival

↓Catecholamines / Vasodilation / Pain control

Epidural if appropriate

Consider inserting a regional catheter

ETT cuff pressure monitor | Large IV access x2 | Arterial line | CVC | Cell salvage | Urinary catheter

Peripheral & Core temperature probe

## Maintenance

Major Haemorrhage p14 | ROTEM/TEG p15

**Prolonged Surgery:** Repeat ABGs | Pressure areas | Repeat antibiotics | DVT prophylaxis as required

**Goal-directed anaesthesia is crucial for adequate microcirculation perfusion to the flap**

### BP target ↔

Avoid hypotension

Use vasopressors with caution

### Volume state ↔

Avoid hypo/hypervolaemia

Monitor all losses

### Vasomotor tone ↓

Anaesthesia & analgesia

Remifentanyl 0.1-0.3mcg/kg/min

### Monitor Hct

Avoid excess crystalloids

Avoid haemodilution (↓O<sub>2</sub> delivery)

Avoid haemoconcentration (↓ flow)

### Temperature

Peripheral within 1°C of core

Warm theatre to >28°C

Active body heater & fluid warmer

## Targets for optimal microvascular perfusion

Hb >80g/l

Hct ~0.3

Temp >36°C

Glc 4-10mmol/l

etCO<sub>2</sub> 4.2-5.2kPa

PaCO<sub>2</sub> 4-5kPa

PaO<sub>2</sub> 8-12kPa

SATs >95%

U/O <2yrs 0.75-1ml/kg/hr >2yrs 0.75-2ml/kg/hr

CVP <8 mmHg

pH 7.35-7.45

**End of surgery:** Patient 'warm and wet': Normothermic | Vasodilated | Slightly hypervolaemic | ↑ CO

## Extubation

**Avoid ↑sympathetic tone:**

Deep extubation or LMA exchange (if starved)

Remifentanyl 0.06-0.1mcg/kg/min

Fentanyl 0.5-1mcg/kg 5 minutes prior to extubation

Clonidine 1mcg/kg 30 minutes prior to extubation

Dexmedetomidine 0.5-1mcg/kg 30 minutes prior to extubation

## PICU/HDU

PICU/HDU admission for flap monitoring

PCA for flap site or donor site if applicable

+/- Continuous analgesia infusion

Post-op fluids if epidural in-situ

Consider PRN Diazepam 0.1mg/kg 6°

# PREGNANCY AND TRAUMA.

## Considerations

**Does the patient need transfer to a DGH with maternity services?**

**Involve Neonatal & Obstetric teams**

Management priorities for resuscitation the same      Resuscitate mother → mother resuscitates foetus

Uterine fundus > umbilicus = >20 weeks gestation = Aortocaval compression

**>27 weeks = 3<sup>rd</sup> Trimester**

Hypervolaemic & haemodiluted (Hb >105)

Utero-placental injuries risk massive bleeding

40% blood loss before signs of shock

Abdominal organs 1-2 ribs spaces higher

Utero-placental perfusion = MAP

'Chest trauma' could be abdominal trauma

**Does a caesarean section need to be performed before surgery?**

**Peri-mortem C-section (>20weeks) is a life-saving part of the obstetric ALS algorithm**

**Ideally within 4 minutes of maternal cardiac arrest and by the most capable member of the team**

## Induction

Blood products available

Is regional anaesthesia an option?

Potential difficult airway

30° left tilt or manual displacement (>20weeks)

Consider 10ml/kg Plasmalyte preload

Aspiration risk. Consider Ranitidine

**Discuss with Obstetric team:**

**Does this patient need: A Kleihauer test | Prophylactic glucocorticoids | Anti-D immunoglobulin**

**Consider: Fluid resuscitation → Careful drug titration → Dilute Adrenaline**

**Haemodynamically unstable: (1-1-2) Fentanyl 1mcg/kg Ketamine 1mg/kg Rocuronium 2mg/kg (max. 150mg)**

Note. Ketamine causes uterine contraction in early pregnancy

RSI | Large IV access x2 | Cell salvage if appropriate | Urinary catheter | Temperature probe

BIS monitoring (↓MAC needed in pregnancy) | Arterial line & CVC if appropriate

## Maintenance

**Major Haemorrhage** p14

30° left tilt with pillow (>20weeks)

Avoid NSAIDs or N<sub>2</sub>O

Give antiemetic

Target etCO<sub>2</sub> 4-4.4kPa

PEEP >5

Slight respiratory alkalosis (↑foetal O<sub>2</sub> delivery)

BNF for concern over drug administration

**Hypotension poorly tolerated**

**Amniotic fluid embolism**

Restrict vasopressors unless fluid unresponsive

Sudden CV collapse & DIC

Placental abruption common even in minor trauma

Supportive management

**Blood product transfusion & targets different in pregnancy**

ABO-, RhD- and K- (Kell-) compatible red cell units should be transfused

In an extreme situation and when the blood group is unknown, use group O RhD- red cells

Platelets >100x10<sup>9</sup> | Fibrinogen >2g/l

Early/Repeated **ROTEM/TEG** (p15) (DIC risk ↑)

Discuss with transfusion lab & Haematologist

Use cell salvage where appropriate

Will the patient need Anti-D immunoglobulin?

## Post-op | PICU

Discuss thromboprophylaxis. Patient is high risk

# SEDATION FOR TRAUMA.

## Considerations

**Sedation in trauma can be difficult and carries significant risk**

Sedation by the anaesthetist should be considered only if GA is contraindicated (e.g. airway concern)

Procedure painful = add analgesia

Appropriate environment & staff

Majority of complications are 2° to airway or respiratory events

Caution with multi-sedative technique

↑co-morbidities = ↑risk

## Preparation

### Fasting for sedation

Trauma delays gastric emptying

Fasting state vs urgency of the procedure

Fasting not required for N<sub>2</sub>O alone

### Pre-sedation checklist

Suction

Airway equipment

Monitoring

Oxygen / Nasal specs

Emergency drugs

Other staff/Equipment

## Techniques

It is highly dependent on patient suitability & anaesthetist experience

“Deep sedation” does not exist. There is conscious sedation and then general anaesthesia

Fully prepared to start before sedation given → Limits total doses

### Minimal

IV Midazolam

(+/- N<sub>2</sub>O)

### Moderate

Ketamine only or

IV Midazolam + Fentanyl/Ketamine

### GA

Ketamine or Propofol

RSI

## Ketamine sedation

0.5-1mg/kg IV bolus +/- 0.25mg/kg boluses | 4mg/kg IM | 5-10mg/kg Oral (bitter taste)

Preserves airway reflexes | CV stable | Analgesic

No evidence for pre-emptive Midazolam/Atropine

Experience in use is required

↑HR, ↑BP, ↑secretions, **laryngospasm**

Non-starved is not a contraindication

Avoid <1yr

**Painless e.g. imaging** = Midazolam or Chloral hydrate (<15kg) (no Anaesthetist required)

### Drug options & 1<sup>st</sup> dose

N<sub>2</sub>O 50-70%

Dexmedetomidine. Intranasal 1-4mcg/kg max. 200mcg

Midazolam Oral 0.5mg/kg max. 20mg

Midazolam IV 25-50mcg/kg max. 6mg

Fentanyl IV 1mcg/kg max. 100mcg

Fentanyl Intranasal 1.5mcg/kg max. 100mcg

Diamorphine Intranasal 0.1mg/kg max. 5mg

Local block 2mg/kg Levobupivacaine

### Considerations & Contraindications

Eye/ear injury, pneumothorax, bowel obstruction

Avoid in cardio or cerebrovascular instability

↓RR, apnoea, ↓BP

↓RR, apnoea, ↓BP

↓RR, apnoea, ↓RR, ↓HR

↓RR, apnoea, ↓RR, ↓HR

↓RR, apnoea, ↓BP, ↓HR

LA toxicity, severe liver abnormalities

### Naloxone

10mcg/kg max. 400mcg

See BNF for repeat doses

### Flumazenil

10 micrograms/kg every 1min max. 200 mcg

Repeat as needed max. 50mcg/kg in total

## Post-sedation

Half-lives of the reversal agents are shorter than the sedation drugs

Monitor in a quiet and darkened recovery room

Reversal agents given → extended recovery stay



# ACUTE & CHRONIC PAIN.

## Considerations

Unrelieved acute pain related to trauma is a risk factor for chronic pain development  
Acute pain following major trauma is associated with PTSD in childhood/adolescence  
Negative psychological states can have a profound impact on pain perception

### Risk factors for chronic pain

**Injury-related** → Thoracic injuries & thoracotomies | Major orthopaedic injuries | Lower limb injuries  
Spinal cord injuries | High-intensity pain | TBI  
**Psychological** → Anxiety | Depression | Catastrophising | PTSD

**Concepts of good analgesia → Early | Effective | Sustained**

### Regional anaesthesia (RA)

Could be important in the prevention of chronic pain  
Strongly consider placing a tunnelled catheter for continuous infusion. Use 0.125% Levobupivacaine  
Can use multiple peripheral nerve catheters → careful of total LA dose  
**Benefits** → Peri-operative analgesia | Decreased stress response | Reduced opioid need | Sympathetic block for limb perfusion | Chronic pain protection | Post-op care | Repeat procedures  
**Cautions** → Infection risk higher in trauma patients (immunocompromised, unsterile procedures)  
Additional central blockade risks with major transfusion, coagulopathy or ↑ICP

### Acute compartment syndrome (ACS)

Evidence of harm is lacking in the use of RA in patients at risk of ACS  
Theory suggests that ACS will cause break-through pain with low dose regional anaesthesia  
Consider a low dose block and infusion using 0.125% Levobupivacaine  
*Attention to ACS better directed at → careful observation, pressure monitoring and vigilance*

### Intra-op analgesia options

Use a multi-modal approach including RA when appropriate

Ketamine → 0.2-0.5mg/kg boluses. Consider post-op continuous infusion  
Paracetamol → Regular. Caution with liver or kidney trauma/impairment  
NSAIDs → PR Diclofenac / IV Parecoxib. Caution in Active bleeding | Hypovolaemia | Coagulopathy  
Tramadol → Used in acute and chronic pain management  
Gabapentin → Discuss with pain team  
Fentanyl → Useful for RSI and as cardio-stable intra-op analgesia  
Morphine → Caution in trauma patients: Respiratory depression | Delirium | Hypotension | Vomiting  
Remifentanyl → To support anaesthesia, not as analgesia. >0.2mcg/kg/min risks post-op hyperalgesia

## Post-op

Aggressive pain management

Use age-appropriate pain scales  
Continuous re-evaluation  
PCA/NCA  
Gabapentin post-op (discuss with pain team)

Early referrals vital  
Pain team | Psychology | Physiotherapy

**Analgesia and chronic pain prevention is maximised if a holistic support system is in place**

# NON-ACCIDENTAL INJURY (NAI).

## Considerations

TBI p2

Significant proportion of paediatric trauma

Most common trauma in under 1-year-olds

NAI Patients with minor trauma often re-present with more significant injuries

**Traumatic brain injury is the most common serious insult in NAI**

Refer all suspicions to the appropriate safe-guarding team or lead

Be aware of the different types of abuse: Physical | Emotional | Sexual | Neglect

**The Anaesthetist is in a privileged position to identify abuse in the trauma patient**

## Risk factors

### Child

Chronic disability  
Learning difficulties  
Premature  
Unwanted

### Parental

Stepparents  
Young parents  
Mental health issues  
Substance abuse

### Social

Single parent  
Poverty  
Isolation  
Known to social services

## Pre-induction signs

### Behavioural

Inappropriate behaviour  
Aggression  
Withdrawn  
Inappropriate relationship with parent

### Physical

Poor hygiene  
Evidence of failure to thrive

### History

Inconsistent or inadequate history regarding current trauma  
Any traumatic injury in a non-ambulant child  
History of neglectful/abusive actions  
History of patient drug abuse  
Parental inattention to health needs  
Evidence of marked lack of supervision

## Maintenance signs

**General anaesthesia allows for easier physical observations of the patient**

Poor hygiene  
Slap or bite marks  
Signs of previous injuries  
Unexplained burn injury or cigarette burns

Anogenital injuries  
Intra-oral injuries in a non-ambulant child  
Suspicious bruising pattern  
Bruising in inaccessible areas (ears/buttocks)

## Post-op

Appropriate referrals made to the safe-guarding team or lead  
Ensure all documentation complete

# MAJOR INCIDENT ACTION.

## Considerations

**Action plans will vary between hospitals. Check your own hospital's plan**

Switchboard may be overwhelmed  
Large scale strategic organisation needed

Vital to limit telephone and communication traffic  
Obey chains of communication

### Strategic Commander

Deliver the 'strategic aim' and consider the incident in the wider context  
Not involved in directly managing the tactical or operational detail

### Tactical Commander

Responsible for directly managing the response by allocating resources and coordinating tasks  
Oversee and support but not be directly involved in the operational response to the incident

### Operational Commander

Those responsible for managing the main response to the incident  
Will lead a team carrying out specific tasks within a ward/department e.g. Emergency department (ED)

## Theatre cascade

**Switch board** announce 'Major Incident has been declared' once authorised by Strategic Commander

**ED** set up a Major Incident Control Room for the Operational Commander and team

**Theatre** set up a Theatre Incident Room (TIR) to manage theatres and liaise with ED control room

**Theatre Team leader** will notify theatre staff of the Major Incident

## All theatre communication

Theatre staff ↔ Team leader / TIR ↔ ED control room

## Action cards

**Anaesthetic Consultant on-call | Anaesthetic Register on-call | ODP on-call**

Collect your card. Follow instructions

## Emergency theatre

Will stop if able

If unable, the next available theatre will be identified as the emergency theatre

All emergency case bookings must be put to TIR

## Anaesthetists/ODPs on elective lists

Stay in your theatre continuing your normal duties

Communicate with your theatre team when current operation could be stopped if needed

Do not send for a new patient without permission from TIR

Ensure your theatre & anaesthetic room is stocked up

Ensure staff have adequate rest breaks

You may be called by your secretary, the anaesthetic registrar on-call or TIR to attend ED

## Anaesthetists/ODPs at home

Stay at home unless called into the hospital

You may be called by your secretary, the anaesthetic registrar on-call or the TIR to attend the hospital

# ORGANOPHOSPHATE (OP) POISONING.

## Considerations

**Guide for a trauma patient coming to theatre**

**Not exhaustive management of OP poisoning**

Causes: Pesticides | Agricultural accidents | Terror attacks

MOA: Inhibiting of acetylcholinesterase (AChE),  $\uparrow$  ACh causes an acute cholinergic crisis

### Symptoms

Dose dependant | Death: Usually through respiratory failure

Common in children: CNS depression | Respiratory compromise | Muscle weakness | Pin-point pupils

Other symptoms: Headache | Dizziness | Seizures | Excessive salivation | Sweating | Cold skin

**Treatment: Atropine | Neuroprotection | IPPV**

## Induction & Maintenance

Ensure decontamination | All clothes and jewellery removed | PPE if continued risk of exposure

### Drug considerations

Use lower dose of non-depolarising neuro-muscular blocking drugs

Caution/Avoid: Suxamethonium | Neostigmine | Ester LA (e.g. Ametop) | Mivacurium

### System considerations

**A/B:** Bronchospasm | Secretions | Pulmonary oedema | Decreased respiratory effort

**C: Vigilance needed:** Arrhythmias | Hyper/Hypotension | Tachy/Bradycardia | Cardiac arrest

Tachycardia cause:

Atropine: Consider combination of Atropine/Glycopyrrolate

Autonomic nicotinic effects (& hypertension): Consider Magnesium (limited evidence)

Treat hypoxia, acidosis & electrolytes imbalances  $\rightarrow$  reduces arrhythmia risk

**D:** Treat seizures with benzodiazepines | Neuroprotective strategies: OP could  $\uparrow$  BBB permeability

**E:** Risk of hypothermia (dysfunctional autoregulation) | Risk of hyperglycaemia ( $\uparrow$  catecholamines)

### Atropine

First line as crosses BBB to reverse CNS signs

Caution as can make arrhythmias worse

20 micrograms/kg every 5–10 minutes (max. 2mg per dose)

Until atropinisation: Skin flushed and dry | Dilated pupils | No bronchospasm | No bradycardia

Atropine therapy should be maintained until there is complete recovery  $\rightarrow$  repeat boluses or infusion

### Oximes

Re-activates AChE

Affects nicotinic receptors

Give after Atropine

Pralidoxime (2-PAM): 30mg/kg over 20mins then 8mg/kg/hr (max. 12g/day)

Bolus: Dilute to 50mg/ml with sterile water

Infusion: Reconstitute vials with 20ml water then dilute with 0.9% normal saline to 10-20mg/ml

## PICU

Patients who exhale traces of agent may contaminate the circuits and ventilator

OP can penetrate rubber and plastics  $\rightarrow$  equipment needs to be appropriately cleaned before next use

# ACKNOWLEDGEMENTS

Dr Carrick Allison. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Richard Craig. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Marie Deane. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Rishi Diwan. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Hilary Eason. Paediatric Anaesthetic Consultant. Royal Manchester Children's Hospital. Manchester.  
Dr William Gauntlett. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Helen Hall. Anaesthetic Consultant. Mid Cheshire Hospitals NHS Foundation Trust. Crewe.  
Dr Alistair Howie. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Helen Neary. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Ijeoma Okonkwo. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Natasha Parrott. ST6 Anaesthetics. King's College Hospital. London.  
Dr Kate Prior. Surgeon Captain, Royal Navy. Consultant in Anaesthetics and Major Trauma. King's College Hospital. London.  
Dr Radha Ravi. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Paul Reavley. Consultant Paediatric Emergency Physician. Bristol Royal Hospital for Children. Bristol.  
Dr Sanaulla Syed. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Jacinth Tan. Paediatric Anaesthetic Consultant. Alder Hey Children's Foundation Trust. Liverpool.  
Dr Caroline Wilson. Anaesthetic Consultant. University Hospitals Bristol and Weston NHS Foundation Trust. Bristol.