Paediatric Trauma Anaesthesia Manual

Dr Joseph Hobson

CONTENTS

INTRODUCTION

Version: **5.5**

Major trauma in children is not common.

Anaesthetic management of paediatric trauma patients undergoing surgery can have significant impact on both immediate and long-term outcomes. The purpose of this document is to provide guidance for anaesthetic practice in paediatric major trauma, with the aim of improving care during high-acuity, low-occurrence (HALO) events.

Each topic is presented on a single page and is structured with subheadings including general considerations, induction, maintenance, and post-operative management.

Legal waiver: The information in this document is up to date as of 20.07.25 and is intended as a guide only. Procedures outlined in this document are not intended to instruct an anaesthetist without prior experience. The anaesthetist should always work within their area of expertise and complement existing local and national protocols. The final responsibility for patient management lies with the individual.

Glossary

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

Author
Dr Joseph Hobson MBBCh FRCA PGCertMEd
Consultant in Paediatric Anaesthesia. Alder Hey Children's NHS Foundation Trust, Liverpool.

LinkedIn joe-hobson-bb6030289

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^{o} head up tilt and consider 10ml/kg Plasmalyte preload

Opioid: Fentanyl (2mcg/kg) | Alfentanil (20mcg/kg) | Remifentanil 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 **2**mcg/kg Ketamine **2**mg/kg Rocuronium **2**mg/kg (max. 150mg)
Haemodynamically unstable: **(1-1-2)** Fentanyl **1**mcg/kg Ketamine **1**mg/kg Rocuronium **2**mg/kg
Haemodynamically critical: **(1-2)** Ketamine **1**mg/kg Rocuronium **2**mg/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)
Remifentanil 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 $PaCO^2$ 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 1st choice inotrope for <5kg

Targets for optimal cerebral perfusion

PaO^2 >12kPa $PaCO^2$ 4-5kPa $etCO^2$ 4.2-5.2kPa SATs >95% Temp <37^{o}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 sedative premedication
Avoid pressure from mask on injured eye
Consider RSI
Muscle paralysis. Avoid Suxamethonium
Deep intubation

Additional considerations for IOP on induction
Decrease stimulation from Propofol and laryngoscopy

Fentanyl 2mcg/kg or Alfentanil 20mcg/kg
Remifentanil 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 etCO^2 4 – 4.5kPa
Avoid N_2O
Good analgesia. IV opioid usually required
Hyperventilate to decrease CO^2
Antiemetics
Atropine 10-20mcg/kg (if oculocardiac reflex)

Infusions: Remifentanil infusion 0.1-0.3mcg/kg/min

Extubation

Techniques to reduce coughing risk

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

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 fibreoptic intubation

Option 2

Asleep & spontaneously breathing nasal fibreoptic 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 1st 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
Remifentanil 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	CVP <8 mmHg	pH 7.35-7.45
SATs >95%	PaO^2 8-12kPa	$PaCO^2$ 4-5kPa	$etCO^2$ 4.2-5.2kPa
MAP (mmHg) <1yr >50 1-5yrs >60 5-10yrs >65 10-17yrs >70			BIS <60

Extubation

Injury >T6. Coughing risks bradycardia. Consider:
LMA exchange
Extubation with Remifentanil 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 1st 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 & fibreoptic 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)

Fibreoptic scope assisted direct/video laryngoscopy

1. Place ETT at the opening of the larynx under direct vision
2. Fibrescope 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: Fibreoptic intubation or fibreoptic 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: Fibreoptic intubation or fibreoptic 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_2O

One Lung Ventilation p10

Consider: Fluid resuscitation → Careful drug titration → Dilute Adrenaline

Haemodynamically stable: **(2-2-2)** Fentanyl **2**mcg/kg Ketamine **2**mg/kg Rocuronium **2**mg/kg (max. 150mg)
Haemodynamically unstable: **(1-1-2)** Fentanyl **1**mcg/kg Ketamine **1**mg/kg Rocuronium **2**mg/kg
Haemodynamically critical: **(1-2)** Ketamine **1**mg/kg Rocuronium **2**mg/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^2 8-12kPa	$PaCO^2$ 4-5kPa	MAP normal	pH(art) >7.35	pH(cap) >7.25	Temp >35°C
Hb >80g/l	Hct >0.25	Plt >75 10^9/l	PT ratio <1.5	APTT ratio <1.5	Ca^{2+} >1mmol/l
Fibrinogen >1g/l	Lactate stable	K^+ 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

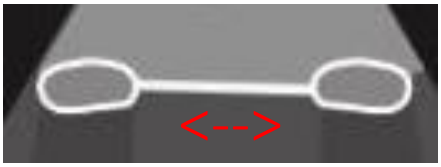
THORACIC ULTRASOUND.

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

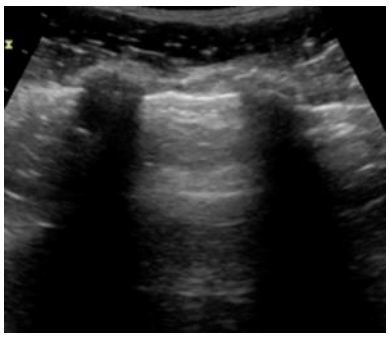
Probe placement: Longitudinally | Pointing up | Mid clavicular line | 2-4th intercostal space.
Probe: High frequency | Large | Linear **Start medially:** Move laterally to posteriorly

Ultrasound findings on anterior chest wall

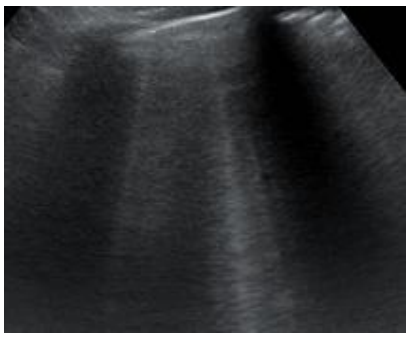
'Lung sliding'



Viseral pleura sides to-and-fro under the parietal pleura
Lost: Pnuemothorax



A lines are equidistant horizontal artifact lines below the pleura
Increased: Pneumothorax



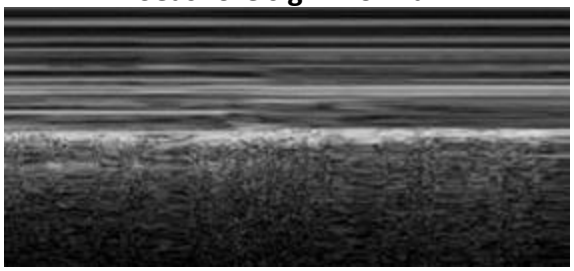
B lines/comet tails are vertical artifact lines
Lost: Pneumonthorax

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

Place the ultrasound in 'M' mode

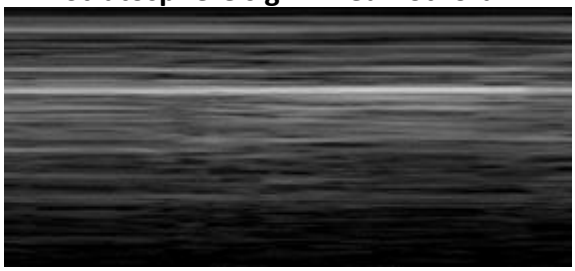
'M' mode = 'Motion' mode. It detects motion over time

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 VENTIALTION (OLV).

Does this need to be done? **For surgical access or to prevent lung contamination** **Requires 2-3 people**

Selective endobronchial intubation

1st choice in an emergency

(suitable for all ages)

Equipment

COETT Bronchoscope port connector Fibreoptic scope

The inner diameter of the ETT should be ≥2mm 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 → Extra luminal 5Fr BB

>5.0 COETT / > 2yrs / >15kg → Intraluminal 5Fr BB

>6.0 COETT / > 8yrs / >25kg → Intraluminal 7Fr BB

Double Lumen Tube

8-10 years old → 28Fr

10-12 years old → 28-32Fr

12-14 years old → 32Fr

14-16 years old → 35Fr

>40kg as an advised minimum for 32-35Fr (>50kg 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
1º Address reversible causes (see below)
2º 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	The reversible cause
(call emergency paediatric surgical team)	
1. 100% O2 / Check ETT / Check ventilation	**Hypoxia**
2. Bilateral finger thoracostomies (5th intercostal space, anterior/mid-axillary line)	**Tension pneumothorax**
3. Massive transfusion protocol (warm products) Consider a pelvic binder	**Hypotension**
Clamshell thoracotomy	**Blood loss or Cardiac tamponade**

Fatal injury?

Guidance on the futility of continued resuscitation efforts
Persistently low CO^2 | 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 1º 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 intercoastal 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 **2**mcg/kg Ketamine **2**mg/kg Rocuronium **2**mg/kg (max. 150mg)
Haemodynamically unstable: **(1-1-2)** Fentanyl **1**mcg/kg Ketamine **1**mg/kg Rocuronium **2**mg/kg
Haemodynamically critical: **(1-2)** Ketamine **1**mg/kg Rocuronium **2**mg/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

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

Once bleeding controlled

Fentanyl boluses 1mcg/kg (max. 10mcg/kg)

Allows vasodilation → further resuscitation

Inotropes/Vasopressors

Avoid pure α agonists if possible

1st line: dilute Adrenaline if needed

Targets during damage control surgery

PaO^2 8-12kPa	$PaCO^2$ 4-5kPa	pH(art) >7.35	pH(cap) >7.25	Lactate stable	Temp >35°C
Hb >80g/l	Hct >0.25	Plt >75 10^9/l	PT ratio <1.5	APTT ratio <1.5	
Fibrinogen >1g/l	Ca^{2+} >1mmol/l	K^+ 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 α&β agonist | Adrenaline 1st line α&β 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 1st line

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

Use a fluid warmer. Ideally a rapid infuser
ROTEM/TEG (p15) for coagulation guidance
10% Ca^{2+} gluconate 0.5ml/kg (guided by the ABG)

Reassess after every bolus
Different lines for plts and cryo. (Same cannula is ok)
Monitor 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

PaO^2 8-12kPa	$PaCO^2$ 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	K^+ 3.5-5mmol/l	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

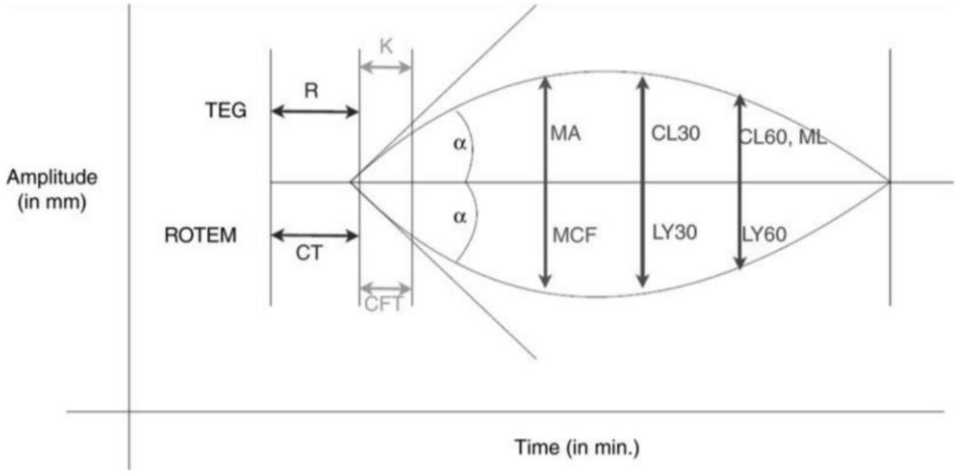
ROTEM: A5/A10 good predictors of MCF ’10 & 10’ Aim for A10 above 10 on FIBTEM

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

Consider TXA15mg/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^{2+} 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: 1st Burns 2nd 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 **2**mcg/kg Ketamine **2**mg/kg Rocuronium **2**mg/kg (max. 150mg)
Haemodynamically unstable: **(1-1-2)** Fentanyl **1**mcg/kg Ketamine **1**mg/kg Rocuronium **2**mg/kg
Haemodynamically critical: **(1-2)** Ketamine **1**mg/kg Rocuronium **2**mg/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

1º Shockwave injuries

Major haemorrhage (without penetrating wounds)	**Major Haemorrhage** p14 | **ROTEM/TEG** p15
Air embolism (CV collapse)	100% O^2 / Fluids / Vasopressors / CPR
Pulmonary haemorrhage	Early intubation / Suction
Pneumothorax	Decompress / Chest drain / Avoid N_20
Great vessel injury	CT thorax in 1 º survey / Specialist surgeon
GI perforation or Traumatic amputation	**DCL p13 | Crushed Limb p18**
Pelvic disruption	Pelvic binder / Proximal control

Blast lung

Lung protective strategies as per ARDS:
Permissive hypercapnia | Low TV 4-6ml/kg | Adequate PEEP | Peak pressure <30cmH_2O
Not suitable for extubation

2º Fragmentation injuries

Consider injuries along missile's path
Face and eye injury incidence high (27-48%)
Tetanus immunoglobin & Hep B vaccination
Vascular injury incidence high (3-12%)
Consider antifungal cover in abdominal/thorax injury → Fluconazole 6mg/kg (max. 400mg)

3º 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 **2**mcg/kg Ketamine **2**mg/kg Rocuronium **2**mg/kg (max. 150mg)
Haemodynamically unstable: **(1-1-2)** Fentanyl **1**mcg/kg Ketamine **1**mg/kg Rocuronium **2**mg/kg
Haemodynamically critical: **(1-2)** Ketamine **1**mg/kg Rocuronium **2**mg/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 Remifentanil 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 ↓ 3rd 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 1st 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	**Rescue cardioplegia (cardiac arrest)**
Hypovolemia / Hypotension / Rescue cardioplegia / Electrolyte and acid-base abnormalities / Rhabdomyolysis / Acute renal failure / Thrombotic event / DIC (rare)	*Uncontrolled limb re-perfusion in shocked patient* Rapid return of blood to the right atrium that is: cold, acidotic, ↑Ca^{2+}, ↑K^{+}, ↑CO^{2} in an already shocked system
Avoidance of acute renal failure is crucial	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 **2**mcg/kg Ketamine **2**mg/kg Rocuronium **2**mg/kg (max. 150mg)
Haemodynamically unstable: **(1-1-2)** Fentanyl **1**mcg/kg Ketamine **1**mg/kg Rocuronium **2**mg/kg
Haemodynamically critical: **(1-2)** Ketamine **1**mg/kg Rocuronium **2**mg/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	**Analgesia**
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	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)**

K^{+} >6.5

Salbutamol IV 4mcg/kg (max. 250mcg). Dilute to 50mcg/ml. **Give slowly (↓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 K^{+} after 15min

Staged tourniquet release (>1hour)	**Acidosis pH < 7.34 or HCO_3^- <18mmol/L**
Release 30sec → re-apply 3min→ release 30sec → re-apply 3min → release Do not gradually release tourniquet ''Fully on or fully off''	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
Alkalisation 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

Remifentanil 0.1-0.3mcg/kg/min

Monitor Hct

Avoid excess crystalloids

Avoid aemodilution (↓O^2 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^2 4.2-5.2kPa	$PaCO^2$ 4-5kPa	PaO^2 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)

Remifentanil 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 = 3rd 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 **1**mcg/kg Ketamine **1**mg/kg Rocuronium **2**mg/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_2O	Give antiemetic
Target $etCO^2$ 4-4.4kPa	PEEP >5
Slight respiratory alkalosis (↑foetal O^2 delivery)	BNF for concern over drug administration

Hypotension poorly tolerated

Restrict vasopressors unless fluid unresponsive
Placental abruption common even in minor trauma

Amniotic fluid embolism

Sudden CV collapse & DIC
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 >$100x10^9$ | 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
Caution with multi-sedative technique
↑co-morbidities = ↑risk

Majority of complications are 2° to airway or respiratory events

Preparation

Fasting for sedation

Trauma delays gastric emptying
Fasting state vs urgency of the procedure
Fasting not required for N_2O alone

Pre-sedation checklist

Suction	Oxygen / Nasal specs
Airway equipment	Emergency drugs
Monitoring	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	Moderate	GA
IV Midazolam (+/- N_20)	Ketamine only or IV Midazolam + Fentanyl/Ketamine	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 & 1st dose

N_2O 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
Remifentanil → 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	Parental	Social
Chronic disability	Stepparents	Single parent
Learning difficulties	Young parents	Poverty
Premature	Mental health issues	Isolation
Unwanted	Substance abuse	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), ↑ 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 → reduces arrhythmia risk

D: Treat seizures with benzodiazepines | Neuroprotective strategies: OP could ↑ BBB permeability

E: Risk of hypothermia (dysfunctional autoregulation) | Risk of hyperglycaemia (↑ 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 → 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 → 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.