North West Children's Major Trauma Network
Always Children First

Thoracic Injury

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Thoracic Injury

Chest Trauma

In the event that a **penetrating chest trauma** is brought to the department, particularly where a cardiac injury is suspected, the paediatric surgical registrar/ consultant and team leader will decide on the urgency and the need for assistance from cardio-thoracic on call consultant. The cardiac surgeon should be made aware of exactly which theatre the patient is being transferred to and should go directly there to assess the patient. They should be met at the ambulance entrance and taken to theatre by portering staff.

Penetrating Trauma Chest – Cardiac Origin

If cardiac injury is suspected call the relevant **Consultant** Surgeon.

1. If the patient *arrests in ED, is peri-arrest, or has arrested within 5 minutes of hospital arrival and there is penetrating chest injury* then a thoracotomy performed in ED may be indicated

- The Paediatric Surgical SpR (if they have been trained in this procedure) or Consultant should undertake this procedure. Occasionally the ED Consultant may have started the thoracotomy before you arrive – assist them and take the lead as required
- The Consultant Surgeon must be called
- Ensure that you are trained to perform a thoracotomy and know what to do if you find injury
- There is appropriate equipment in ED - make sure you know where it is. It is your responsibility to familiarise yourself with the kit.
- The cardiothoracic surgeon on call should be contacted
- Many of the T&O SpR's will have some experience in thoracotomy, which is performed on a regular basis in spinal surgery. They may be able to help.

2. In patients who have not arrested but in whom there is suspicion of a cardiac injury:

The trauma team leader in association with the Surgical SpR/ Consultant and the Cardiothoracic Consultant on call will determine the best course of action. This will depend on other injuries (if present).

Penetrating Trauma Chest – Non-Cardiac Origin

The Surgical/Cardiac SpR, Orthopaedic SpR or ED Registrar will be expected to perform thoracostomies/place chest drains in patients with diagnosed or suspected haemothorax in the trauma resuscitation

Unstable patients with significant haemothorax will require a thoracotomy. Call the appropriate Surgical Consultant.

In the peri-arrest / arrested patient then a thoracotomy will be required. Whenever possible thoracotomy should be performed in theatres.

- Definitive Surgery in Trauma Skills course recommends a left antero-lateral thoracotomy converted into a clamshell
- A decision on surgery should be undertaken between the Paediatric Surgical Consultant and Thoracic Surgical Consultant.
- In the more stable patient, on-going blood loss should be discussed with the Paediatric Surgical Consultant with a view to surgery.

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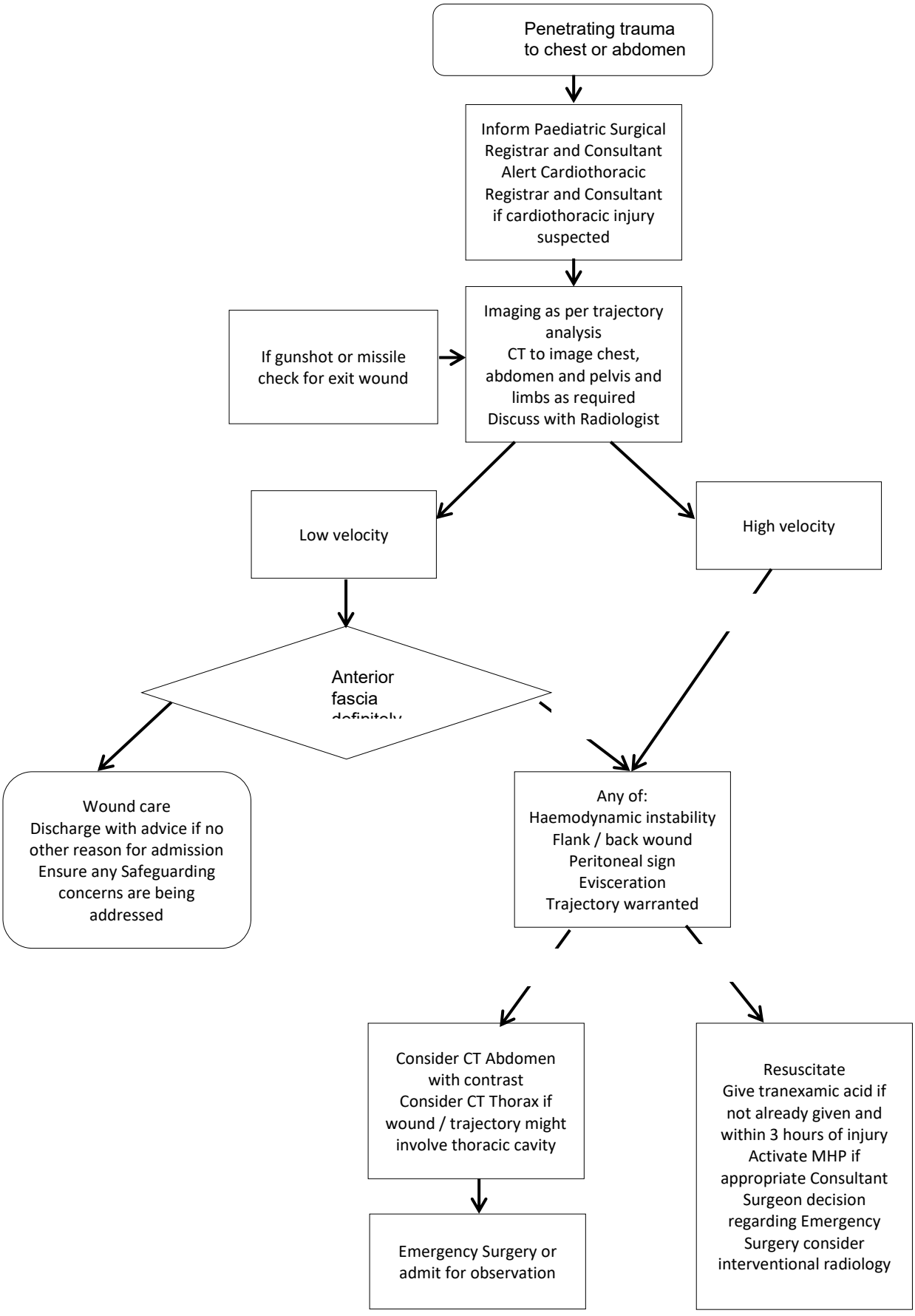
Suspected Penetrating Trauma Algorithm



Blunt Chest Trauma

Thoracotomy in Blunt Thoracic Trauma

- The basic tenet is that there is no role for emergency thoracotomy in ED for *blunt* thoracic trauma
- The final decision will always rest with the ED Consultant and Surgical/ Thoracic / Cardiac Consultant if present
- Unstable patients with blunt chest trauma but with vital signs can be considered for thoracotomy but this should aim to be done in theatre
- **You must discuss with your Consultant -** be prepared to move the patient rapidly (see thoracotomy guideline in Circulation).

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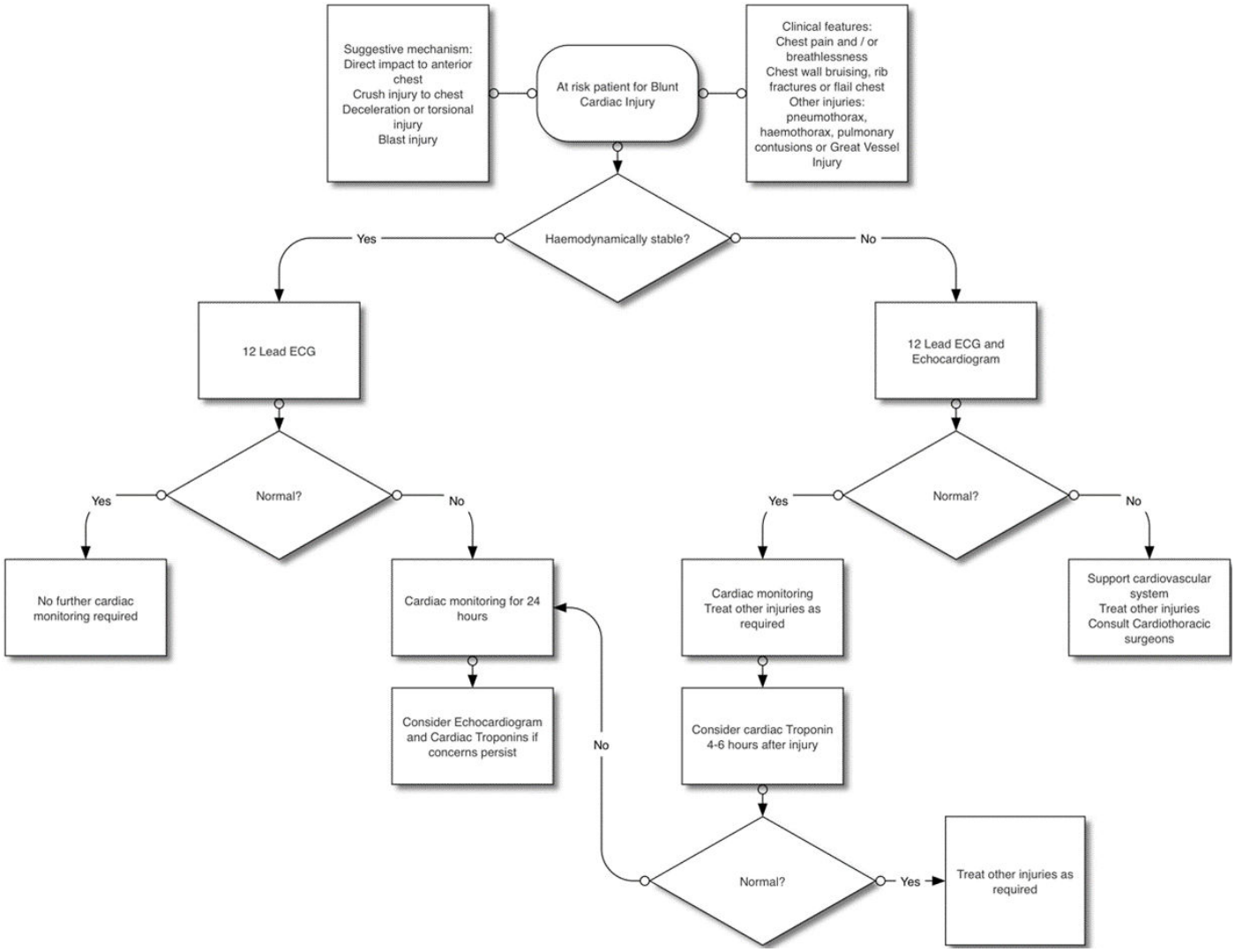
Blunt Cardiac Injury Algorithm



Paediatric Traumatic Cardiac Arrest

Emergency Thoracotomy Algorithm

Major Trauma Standard Operating Procedure
Paediatric Traumatic Cardiac Arrest (TCA)

Algorithm – see page 60
Thoracotomy guide – see page 62

Background

TCA is a low-frequency, high-acuity event associated with high mortality and morbidity. A significant proportion of cases are managed in trauma units.

- An analysis of TARN data revealed 275 children and young people < 18 years presented to hospital with TCA over 10 years (2006 – 2015). This accounted for 0.6% of paediatric patients included in TARN database and included non-energy transfer mechanisms such as drowning or electrocution, so the true number is lower. The median age was 11 years and the majority occurred from RTC. ISS was 25-34. Survival rate was 5%.
- In paediatric TCA, the focus is on delivering immediate, simultaneous life-saving interventions and treatments of reversible causes, which are prioritised over cardiac compressions and defibrillation.
- The response to TCA is time critical and success depends on a well-established chain of survival, including focused pre-hospital and specialised trauma centre care.
- TCA (hypovolemic shock, obstructive shock, neurogenic shock) is different from cardiac arrest due to medical causes; this is reflected in the treatment algorithm (Fig. 1).
- Use ultrasound to identify the underlying cause of cardiac arrest and target resuscitative interventions.
- Treating reversible causes **simultaneously** takes priority over chest compressions. Chest compression must not delay treatment of reversible causes in TCA.
- Control haemorrhage with external pressure, haemostatic gauze, tourniquets and pelvic binder.
- 'Don't pump an empty heart'.
- Resuscitative thoracotomy (RT) has a role in TCA and traumatic peri-arrest.

NB. Management of non-energy transfer traumatic cardiac arrest e.g. drowning, hanging, electrocution should be guided by standard APLS algorithms.

Management

Pre-Arrival:

1. **Put out a trauma call and activate the MHP** based on credible pre-hospital information (see paediatric code red protocol)

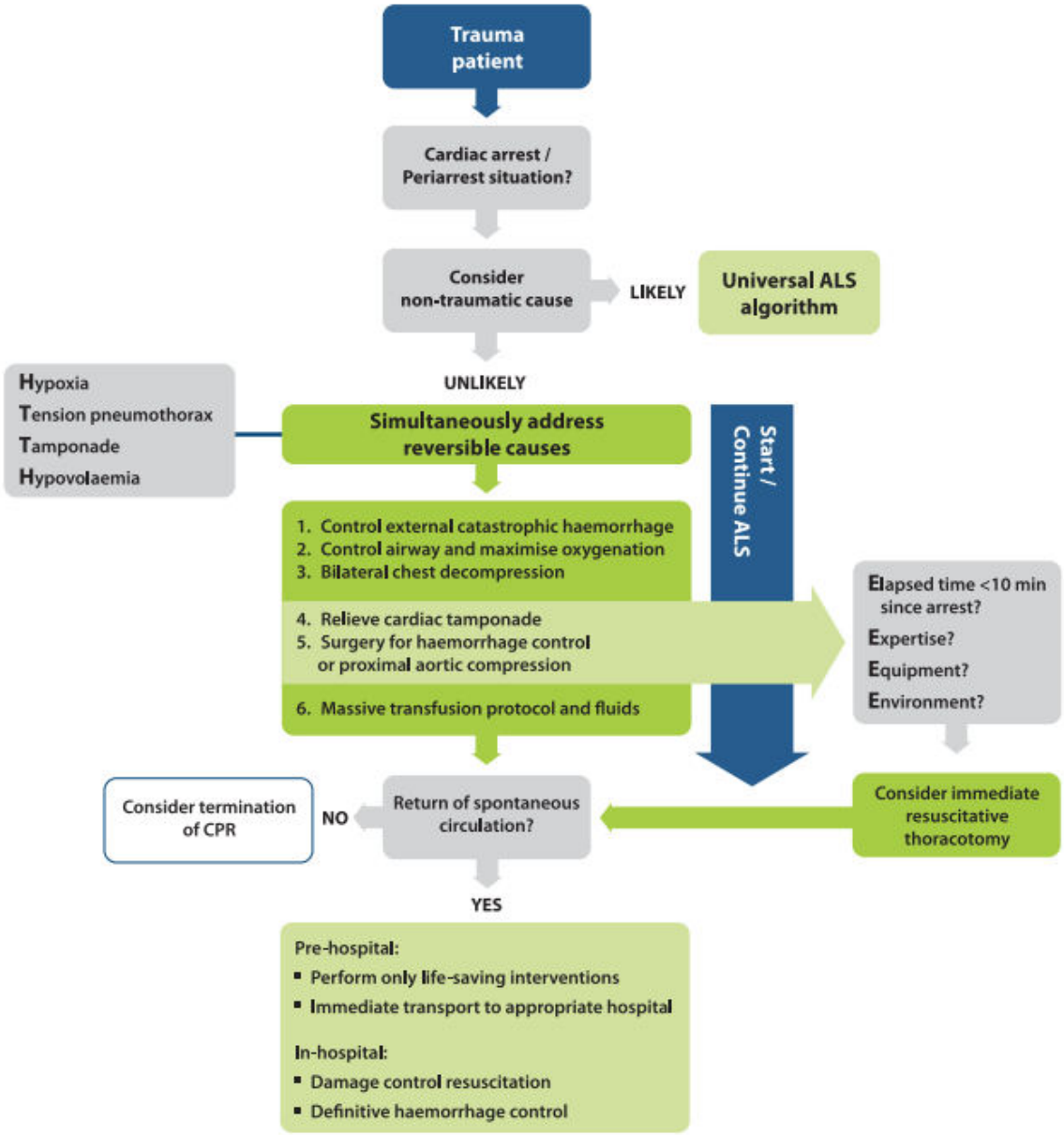
2. **Assemble team to include**
    - Trauma team leader (TTL)
    - Interventions clinician e.g. thoracostomies, thoracotomy
    - Interventions assistant e.g. pelvic binder application
    - Paediatric code red team: communication lead, blood coordinator, and porter
    - Cardiac arrest team members (airway, breathing, circulation)

On arrival to the ED, confirm cardiac arrest

- No signs of life
- No palpable pulses OR
- No cardiac activity on ultrasound scan (do not delay interventions to perform USS)

The bundle of life saving interventions in the algorithm is a guide. Not all interventions will be appropriate all the time e.g. if a reversible cause can be excluded or is considered futile e.g. non-survivable brain injuries..

Emergency Thoracotomy (ETC) Algorithm



Specific Management Points

- Effective oxygenation and ventilation should be given via an ETT or supraglottic device e.g. i-gel or LMA.
- Measurement of ETCO2 is a recommended adjunct to confirm ETT tube placement, and to assess effectiveness of chest compressions (if given). Although paediatric evidence is lacking, ETCO2 may also aid decisions around stopping resuscitation (persistently low ETCO2) or recognition of ROSC (sudden rise in ETCO2). External haemorrhage control will include tourniquets and haemostatic dressings as appropriate e.g. following traumatic amputation.
- Early IV / IO access is crucial. Follow the paediatric code red trauma call (massive haemorrhage) protocol for blood and blood products. This will advise on volumes and types of

blood and blood products and will ensure that the transfusion lab have the required products available.

- If blood is not immediately available, use crystalloids until blood arrives.
- Use the Belmont warmer to avoid hypothermia.
- In PEA or in the presence of obvious thoracic trauma, external cardiac compressions may be omitted until all other interventions have been performed.
- There is no evidence to support use of adrenaline in paediatric TCA
- Bilateral finger thoracostomies are favoured over needle decompression for tension pneumothorax. If needle decompression is more familiar to the intervention clinician however, they may elect to do this over thoracostomies in the first instance. Clamshell thoracotomy should be strongly considered in the context of TCA with penetrating trauma if within 10 minutes of witnessed cardiac arrest.
- Evidence for use of thoracotomy in blunt trauma is limited, but should be considered, particularly if all other interventions have failed in the absence of an obvious non-survivable injury.
- The aim is to relieve tamponade, contain pulmonary bleeding and apply aortic compression for control of downstream haemorrhage, and if necessary, to provide internal cardiac massage.

When to stop resuscitation

- The decision to stop resuscitation is challenging and should be made by the most senior clinician (usually the TTL) in consultation with other team members.
- Factors which can influence the decision will include:
- Duration of cardiac arrest: resuscitation attempts beyond 20 minutes are unlikely to be successful in the absence of e.g. hypothermia or toxins
- Lack of response to the suggested interventions
- Persistently low ETCO2 (< 2 kPa): adult studies have shown persistently low ETCO2 levels have been associated with poor outcomes and can be used to assess futility of ongoing resuscitation. In the absence of paediatric evidence, ETCO2 levels can guide decisions but should not be the only driver to stop resuscitation.
- Cardiac standstill on USS: paediatric evidence is lacking and is based on adult studies.

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Clam Shell Thoracotomy for Children with Major Trauma in the Emergency Department

Background

Primary aim is to treat cardiac tamponade.

Indications

- Cardiac arrest associated with penetrating thoracic trauma – success only likely if within 10 minutes of witnessed arrest
- May be considered in cardiac arrest associated with blunt trauma if all other interventions have failed and in absence of non-survivable injuries in order to:
  - Relieve cardiac tamponade
  - Occlude aorta to control distal bleeding provide internal massage

Contraindications

- Child with an effective cardiac output

Equipment

Thoracotomy
Scalpel
Forceps
Heavy scissors

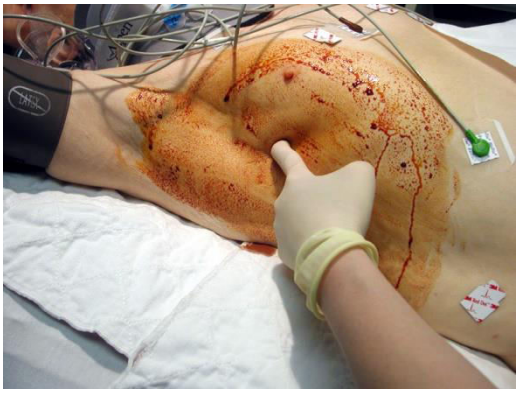
PPE
Gloves
Gown
Eye protection (glasses/goggles/shield)

Haemostasis
Suture on needle – silk or prolene, size 1/0
Foley catheter
Forceps x 4

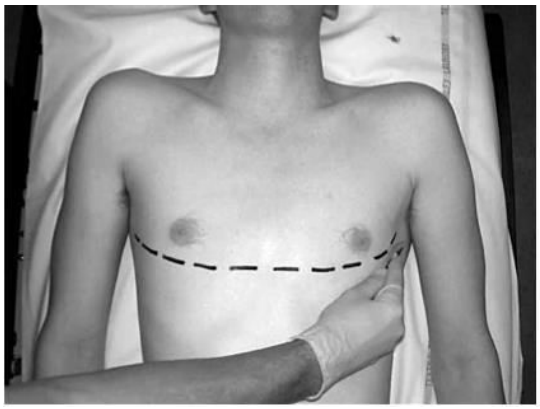
Procedure

1. Procedure must be done in the emergency department as soon as need identified by the TTL. Do not delay taking an arrested child to theatre. Procedure can be carried out by anyone trained to do it.
2. Intubation and ventilation plus other interventions should be done and must not delay thoracotomy.
3. Rapid access of skin preparation if available immediately e.g. 2% chlorhexidine / 70%alcohol preparation, otherwise can forego.
4. Using scalpel and blunt forceps (clip/clamp) make bilateral thoracostomies (through intercostal muscles and parietal pleura) in 5th intercostal space in mid-axillary line.

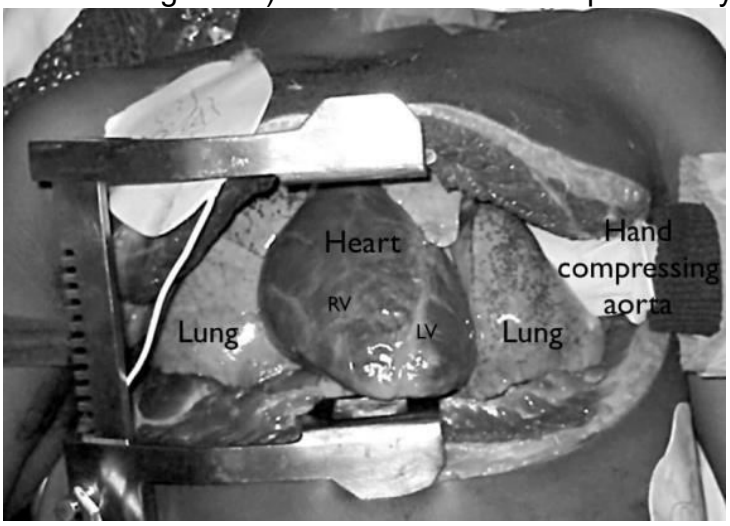
   NOTE – stop at this point if tension pneumothorax is relieved and cardiac output returns.



5. Connect the thoracostomies with a deep skin incision following the 5th intercostal space. Ensure the incision extends posteriorly bilaterally to the posterior axillary line – this allows adequate access when opening the clamshell.

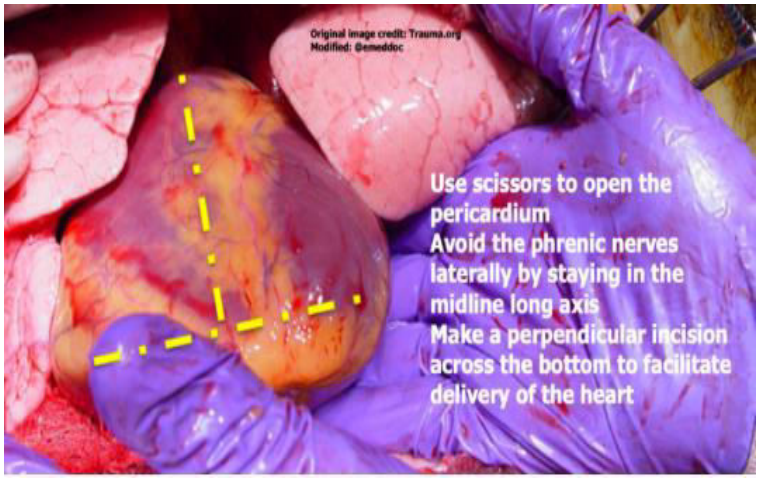


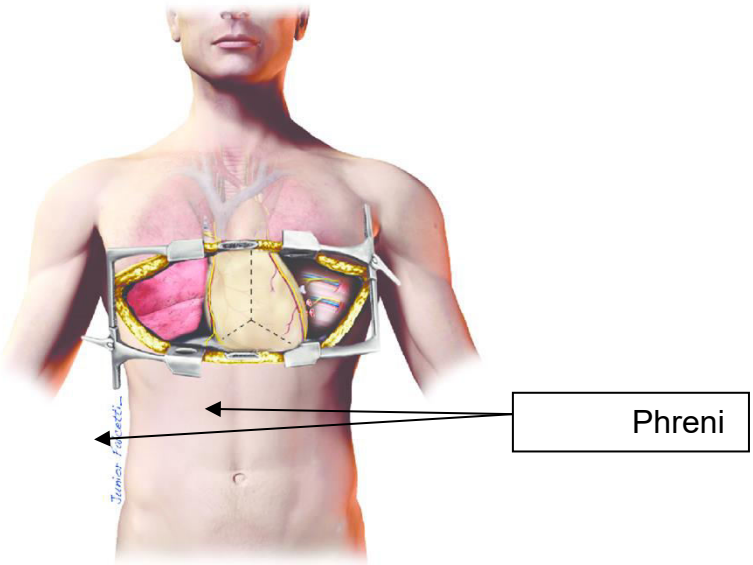
6. Insert two fingers into one side of the thoracostomies to hold the lung out of the way whilst cutting through all layers of the intercostal muscles and pleura towards the sternum using the heavy scissions via the skin incision already made.
7. Do above on the left and right sides to sternum.
8. Cut through sternum using the heavy scissors/gigli saw
9. Open the “clam shell” using one or two gloved assistants (using gauze to prevent injury from bone fragments). Extend the incisions posteriorly if exposure is inadequate.



10. Lift or tent the pericardium with forceps and make a large midline longitudinal incision using scissors.

> This approach minimises risk of damage to phrenic nerves – run in the lateral walls of the pericardial sac. **The pericardium may appear normal despite the presence of tamponade. It must ALWAYS be opened.**





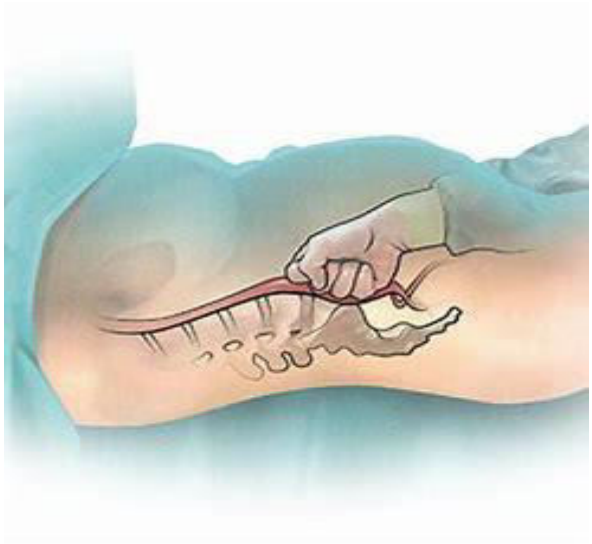
11. Take the heart out of the pericardium and evacuate all blood and clot present, then inspect the heart for site of bleeding.

12. Cardiac wounds will need occluding:

- With a finger or piece of gauze if < 1cm If bleeding cannot be controlled with finger the defects will need sutures or staples (rarely foley catheter).
- This is a last resort due to risk of coronary artery occlusion.

Minimise the number of sutures as far as possible. Take 1cm ‘‘bites’’ – do not do this with wounds close to the right AV grove or near the (proximal) coronary arteries.

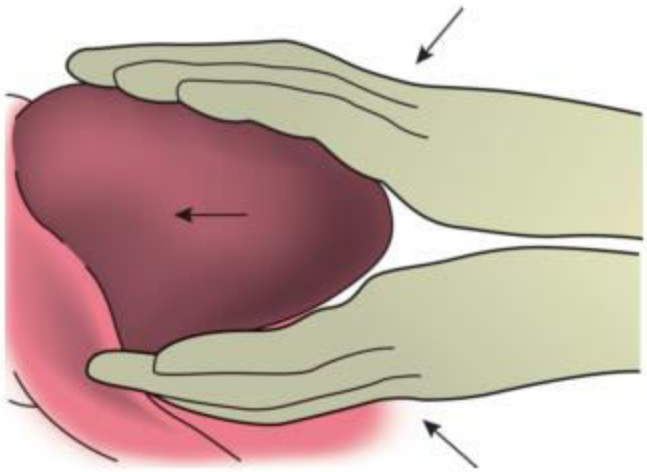
If evidence of significant blood loss or low cardiac output state after tamponade relieved and myocardium closed, manual occlusion of the aorta should be carried out whilst undertaking volume expansion. The descending thoracic aorta should occluded / compressed / clamped as low as possible – this can be most easily achieved compressing the aorta with a closed fist against the vertebral bodies.



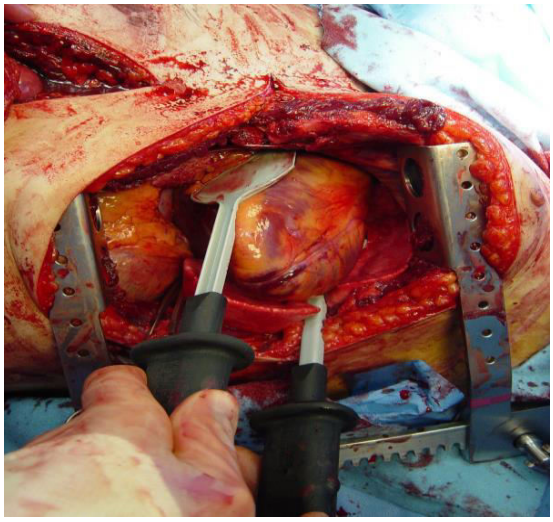
14. If internal cardiac massage is required, one flat hand is applied to the posterior surface of the heart and one on the anterior surface. Blood is ‘‘milked’’ from the apex upwards, aiming for complete ventricular emptying

    Avoid single handed cardiac massage as there is a significant risk of the operator’s thumb perforating the right ventricle.

    Ensure that the heart remains horizontal (in the anatomical intra-pericardial position) during massage – lifting the apex impairs venous filling.



15. If defibrillation is required, use the internal defibrillation paddles and 1J/kg shock.



16. Restoration of circulation may be associated with:

    a. **waking**, and the patient may require **immediate anaesthesia**.

    b. **bleeding**, particularly from the internal mammary and intercostal vessels, and may require **sutures or artery forceps**.

17. Once perfusion has been restored the patient should be moved to theatre immediately for definitive repair.

References

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4. Royal College of Emergency Medicine 2019. Traumatic Cardiac Arrest in Adults. Retrieved from https://www.rcem.ac.uk/docs/RCEM%20Guidance/RCEM_Traumatic%20cardiac%20arrest_Sept%202019%20FINAL.pdf 21/2/2020

5. Wessex Children's Major Trauma Guidelines (Trauma Unit version) July 2017. Retrieved from https://www.piernetwork.org/trauma.html 24/02/2020

Analgesia following Chest Trauma/Rib Fractures

There are many options for pain control following chest trauma/rib fractures. Effective pain management is imperative to treatment as it improves pulmonary function and decreases the risk of pulmonary complications such as atelectasis, poor oxygenation, and respiratory compromise. Every child/young person with chest trauma should be assessed for individualised treatment based on age, level of pain, and extent of the injury. Local pain management guidelines should be referred to, to ensure effective pain management is achieved. Non-accidental injury should be considered in infants who present with rib fractures. A consultation to child protective services should be considered in all children with suspected physical abuse