Traumatic cardiac arrest (TCA) in children and young people

Version:	1
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Traumatic cardiac arrest (TCA) in children and young people 0 -16 years

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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 such as BSUH.

- A recent 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 early, aggressive, life-saving interventions which are prioritised over cardiac compressions and defibrillation.

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

Management

Pre-arrival:

1. **Put out a code red trauma call** based on credible pre-hospital information (see paediatric code red protocol on BSUH microguide > Paediatrics and Neonatology > Paediatrics > Paediatric Major Trauma guidelines)

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

→ No cardiac activity on ultrasound scan (do not delay interventions to perform USS)

TCA Algorithm

SIMULTANEOUS life-saving interventions to treat reversible causes using 4Hs & 4Ts approach

(Prioritise over chest compressions and defibrillation)

Hypoxia	• Ensure adequate oxygenation and ventilation
Hypovolaemia	• External haemorrhage control • Splint pelvis / fractures (pelvic binder, Thomas splint) in blunt trauma • Rapid volume replacement (IV / IO) with warmed blood and blood products (see code red protocol)
Tension pneumothorax	• Bilateral thoracostomies

Continue CPR

Monitor $ETCO_2$

No routine adrenaline

Consider 4Hs & 4Ts

See notes below for further details

Cardiac tamponade

Consider THORACOTOMY
Especially in penetrating injury

Return of spontaneous circulation?

YES

- Give tranexamic acid
- Consider transfer to theatre for damage control surgery (DCS)
- Consider formal imaging (CT)
- Consider vasopressors in isolated head injury
- Arrange retrieval to Paediatric MTC

NO

Decision to STOP resuscitation can be *guided* by:

- Duration of cardiac arrest
- Lack of response to life-saving interventions detailed above
- Persistently low $ETCO_2$
- Cardiac standstill on USS

Notes

- Algorithm is based on available paediatric evidence (see references below).
- Paediatric TCA should be treated the same across the paediatric age range (0-16 years).
- The bundle of life saving interventions in the algorithm is a guide. Not all interventions will be appropriate all of the time e.g. if a reversible cause can be excluded or is considered futile e.g. non-survivable brain injuries.

Specific management points

- Effective oxygenation and ventilation should be given via an ETT or supraglottic device e.g. i-gel or LMA.
- Measurement of $ETCO_2$ is a recommended adjunct to confirm ETT tube placement, and to assess effectiveness of chest compressions (if given). Although paediatric evidence is lacking, $ETCO_2$ may also aid decisions around stopping resuscitation (persistently low $ETCO_2$) or recognition of ROSC (sudden rise in $ETCO_2$).

- 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 a 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

- **Tranexamic acid dosing regime:** 15 mg/kg (max 1g) over 10 minutes then infusion of 2 mg/kg/hr for eight hours. For children over 12 years, use adult dose regimen of 1g and then an infusion of 1g over 8 hours.

- 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.

- 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 or consultant paediatrician) 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 $ETCO_2$ (< 2 kPa): adult studies have shown persistently low $ETCO_2$ levels have been associated with poor outcomes and can be used to assess futility of ongoing resuscitation. In the absence of paediatric evidence, $ETCO_2$ 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.

References

1. Vassallo J, Nutbeam T, Rickard AC, et al. Paediatric traumatic cardiac arrest: the development of an algorithm to guide recognition, management and decision to terminate resuscitation. *Emerg Med J* 2018;**35**:669-674
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5. Wessex Children's Major Trauma Guidelines (Trauma Unit version) July 2017. Retrieved from https://www.piernetwork.org/trauma.html 24/02/2020

Clam shell thoracotomy for children with major trauma in the emergency department

(Adapted from the Wessex children's major trauma guidelines – TU version 2017)

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 cardiac output

Equipment

Thoracotomy

Scalpel with size 10 blade

Forceps

Heavy scissors

PPE

Gloves

Gown

Goggles

Haemostasis

Suture on needle – silk or prolene, size 1/0

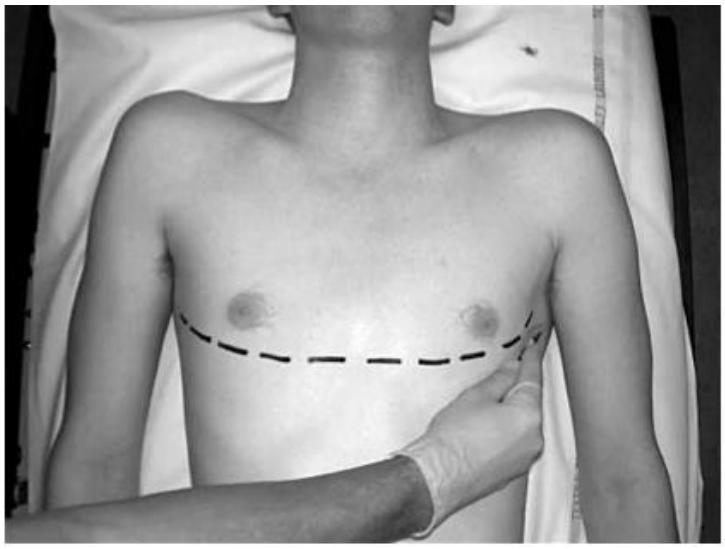
Foley catheter

Forceps x 4

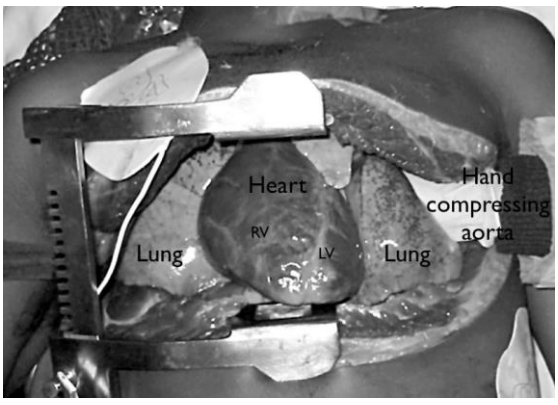
Procedure

1. Procedure must be done in the emergency department as soon as need identified. Do not delay to take 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 make bilateral thoracostomies (through intercostal muscles and parietal pleura) in 5th intercostal space in mid-axillary line.
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.

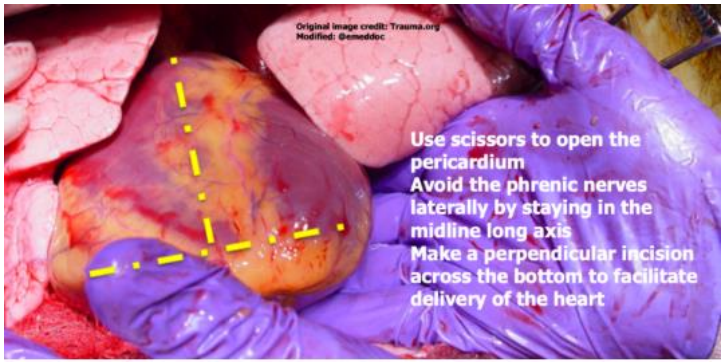


6. Insert two fingers into one side of the thoracostomies to hold the lung out of the way whilst cutting through all layers of the intercostal muscles and pleura towards the sternum using the heavy scissions via the skin incision already made.
7. Do above on the left and right sides to sternum.
8. Cut through sternum using the heavy scissors.
9. Open the “clam shell” using one or two gloved assistant. 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.



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:

    a. With a finger or piece of gauze if < 1cm

    b. If bleeding cannot be controlled with finger the defects will need sutures or staples. 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 in close proximity to (proximal) coronary arteries.

13. 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 operators thumb perforating the right ventricle.

Ensure that the heart remains horizontal (in the anatomical intra-percardial 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 stabilized by the trauma and surgical teams and discussed with the regional paediatric transport co-ordination consultant on 02380 775502.

    The regional paediatric transport co-ordinator will conference in the paediatric cardiothoracic surgeons and a plan for further care and transport of the child to Southampton will be made.