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CSOP 035 – Resuscitative Thoracotomy

Version No: 1.1 Effective date: 29/05/2024

APPROVALS

Original Document Author:	Name Dr Jake Turner, Dr Caroline Leech	Date	Signature
Revised Document Prepared by:	Dr Jake Turner		
Reviewed by:	Dr Caroline Leech, Deputy Clinical Lead Phil Bridle, Head of Operations Richard Milton, Consultant Cardiothoracic Surgeon		
Director Approval:	Dr Justin Squires, Deputy Clinical Lead		
Next Review Date:	May 2026		

HISTORY

Effective Date	Version No.	Summary of Amendment
March 2023	1.0	Original drafting
May 2024	1.1	Stop moment to ensure compliance with SOP, solo operator concept, minor amendments to surgical reflection/review terminology. Addition of intra-arrest and post-intervention aide-memoires (Appendix 2).

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Lott C, Truhlář A, Alfonzo A, Barelli A, González-Salvado V, Hinkelbein J, et al. European Resuscitation Council Guidelines 2021: Cardiac arrest in special circumstances. Resuscitation. 2021 Apr;152–219.

DEFINITIONS/ACRONYMS:

Abbreviations/Acronym	Definitions
TCA	Traumatic Cardiac Arrest
PEA	Pulseless Electrical Activity
ROSC	Return of Spontaneous Circulation
CSSD	Central Sterile Services Department
CCP	Critical Care Paramedic

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1. Purpose

To ensure that all TAAS practitioners are familiar with the indications, process, and procedure for performing resuscitative thoracotomy in the pre-hospital setting.

2. Scope

It is a requirement of registration that a practitioner will only act within his or her scope of practice. Clinicians will be provided with training to maintain their currency in this procedure and the associated surgical skills.

3. Background

- The primary aim is to restore cardiac output. This can be achieved by decompressing cardiac tamponade, controlling cardiac wounds and other sources of intrathoracic haemorrhage, and prioritising aortic arch resuscitation.
- Secondary aims are to control proximal aortic control in subdiaphragmatic exsanguination.
- Chest compressions in traumatic cardiac arrest (see CSOP 019) should be continued until the history and mechanism can be established but should not interfere with the treatment of reversible causes.
- Continue chest compressions in patients with hypovolaemia who have been volume resuscitated and have poor myocardial contractility or disorganised electrical activity.
- Chest compressions in hypovolaemic patients with organised electrical activity may impede right ventricular filling and should be de-emphasised to allow treatment of reversible causes.

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4. Indications

Both blunt and penetrating cardiac tamponade can have good outcomes if RT is undertaken immediately, whereas exsanguination with absent mechanical cardiac activity is almost universally fatal for both blunt AND penetrating trauma (Perkins Z et al.) Decision making around resuscitative thoracotomy should be based on likely diagnosis rather than mechanism of injury.

Immediate prehospital resuscitative thoracotomy should be undertaken for patients in **traumatic cardiac arrest**, with **suspected tamponade or exsanguination**, in a **survivable window**. Each of these criteria is defined in more detail below:

Cardiac Tamponade

Suspected Tamponade*

AND

Loss of signs of life within 15 minutes**

OR

Organised electrical cardiac activity***

Exsanguination

Non-compressible intrathoracic or subdiaphragmatic haemorrhage

AND

Organised electrical cardiac activity***

* Suspected Tamponade
  - Penetrating trauma to thorax, supraclavicular region, or epigastrium
  - Blunt trauma to the chest with signs & symptoms of tamponade (ultrasound confirmed, pulsus paradoxus, or Beck's triad (raised JVP, muffled heart sounds, HD instability)

** Signs of life include a palpable pulse, spontaneous respiration, and response to pain

***Organised electrical activity includes narrow complex PEA (slow or fast), but **not** wide complex agonal or asystolic rhythms

Poor Prognostic Factors

There is a 10-fold difference in survival between tamponade and exsanguination (Perkins et. al.). When committing to a prehospital resuscitative thoracotomy the following poor prognostic factors should be carefully considered, and weighed against the likely outcome:

- Asystole
- Protracted resuscitation or multiple cardiac arrests
- Severe multisystem trauma or other life-threatening injuries
- Unachievable chain of survival: Environment, Equipment, Expertise

A chain of survival includes the following factors:

- The team needs to be trained and current in the practice of thoracotomy, and have appropriate equipment to correct reversible causes
- Available blood products, logistical constraints of the case, and conveyance time to definitive surgery must also be considered

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Other Considerations

- Resuscitative thoracotomy in the context of exsanguination is to facilitate either:
  - Intrathoracic haemorrhage control, or
  - Descending thoracic aortic control for subdiaphragmatic bleeding (either via a left lateral thoracotomy or clamshell thoracotomy, as skill/experience allow)
- Proximal aortic control should be gradually removed ASAP as volume resuscitation and physiology allow, aiming for complete removal or partial occlusion as a minimum.
- Minutes Matter: There is a 5% reduction in survival for every 1-minute delay to prehospital resuscitative thoracotomy in cardiac tamponade (Perkins et. al.):
  - We should de-emphasise proximity to hospital and immediately undertake a resuscitative thoracotomy if signs of life are lost, before cardiac rhythm deterioration
  - If the patient arrests on an ambulance, safely stop, move the trolley into the middle of the cab, and commence PHRT whilst concurrently instigating ALS
  - If thoracotomy efficiency or safety is impeded by limited space on the DCA, consider offloading to attain 360 access

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5. Advanced Surgical Module

- The advanced surgical module consists of both single use items, and an autoclaved tray of re-useable surgical equipment (Figure 1).

Figure 1: Advanced surgical module and re-useable surgical equipment

- The logistics chain for autoclaving the reusable surgical items is provided by QMC Nottingham Central Sterile Services Department (CSSD).
- Please see Clinical Notice 48 (Surgical Tray Sterilisation 20/01/2023) for details of how to clean the tray/package, who to notify, and how to return to CSSD for sterilisation after use.

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6. Chest Opening & Pericardiotomy

- Following a brief stop moment between the doctor and CCP to ensure the patient is within a survivable window, the decision to undertake a thoracotomy should be made within 30 seconds of arriving at the patient's side. This decision must be clearly communicated to the wider prehospital team.
- Move the patient to an area with 360° access. Ideally position the patient off the ground, supine, with arms abducted and sufficient light.
- Leadership of the overall resuscitation should be transferred to the CCP who will coordinate concurrent activity: secure the airway, establish/secure wide bore IV access, maintain sharps awareness, and prepare blood products for administration (see CSOP 034).
- Sterile gloves and appropriate PPE should be worn for aseptic practice and personal protection. **Consider wearing a head torch**.

1. Deploy the kit dump from the advanced surgical module on the same side of the patient as the main operator, at the level of the patient's hips. Review aide-memoire (appendix 2.)
2. Perform bilateral thoracostomies (4-5th intercostal space, mid-axillary line) using a 22-blade scalpel and Spencer Wells forceps. Announce whether the lungs are initially up or down. If training and resources allow then a single operator approach to opening the thorax may allow optimal concurrent activity with the CCP leading on resuscitation/CRM/comms and the doctor commencing the thoracotomy. This technique will be discussed and practised during the TAAS surgical training days.
3. Connect the thoracostomies (or extend the chest incision from a single left thoracostomy in a single operator approach) with a broad swallow shaped skin incision using a 22-blade scalpel, following the same rib space, across the sternum, down to intercostal muscle layer.

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4. Cut through the intercostal muscles with heavy duty shears, avoiding traversing rib spaces, and protecting the underlying heart and lung with your index finger. If the patient is intubated and ventilated ask the airway assistant to pause ventilation.
5. The sternum can be cut using heavy duty shears. If this fails, pass the Gigli saw wire under the sternum with the Spencer Wells forceps, holding forceps over the sternum until divided.
6. Open the clamshell incision with the Finochietto rib spreaders to minimise the risk of bone fragment injury and optimise exposure.
7. If exposure is inadequate extend the skin and intercostal muscle incisions to the posterior axillary line.
8. Push down on the mediastinum gently to separate the sternopericardial ligament from the sternum to optimise exposure of the heart.
9. Regardless of appearance, open the pericardium to deliver the heart. Pick up the pericardium with forceps, cut a small vertical hole and extend to a large longitudinal T-shaped incision with the mayo scissors, avoiding the phrenic nerves which run more laterally.

If on opening the pericardium it is immediately evident that that patient has sustained an injury incompatible with survival, or which cannot immediately be surgically repaired, it is acceptable to cease resuscitative efforts and declare the patient to be dead on scene. If a single operator approach to opening the thorax has been utilised, the expectation should be that the CCP or second doctor on scene should be immediately available to support further intra-thoracic interventions once other core aspects of ALS have been established.

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7. Thoracic Interventions

Wound identification

- Examine the heart carefully and systematically for wounds front and back. Remember an anterior wound may be associated with a posterior wound that is only evident after filling.
- The heart may fibrillate during resuscitation. Prioritise good quality internal cardiac massage, and if this doesn't resolve then gently flick the ventricle once, followed by defibrillation with the rib spreaders removed and chest closed. If anterolateral chest wall pad position is not possible due to incision, consider AP positioning of pads. Clearly communicate the findings to the team, including the proposed management strategy and further interventions required.

Haemorrhage Control Techniques

- Small wounds (< 1cm) can be left if there is little blood loss. If bleeding is significant, they can be occluded with a finger, clamped (thin-walled structures), sutured, or stapled.
- Avoid plugging cardiac injuries with a finger as this can accidentally extend the wound. Use the simplest and easiest method of wound closure as skill/experience allow.
- Peri-coronary lesions require a horizontal mattress suture closure (Figure 2) or simple finger occlusion, to preserve distal myocardial perfusion.
- Thin-walled cardiac structures and major vascular defects can be closed rapidly with an atraumatic vascular clamp (Figure 3). Following application of an atraumatic vascular clamp, this can be left in place or followed by definitive closure with suture(s) or staples.
- Internal mammary arteries may start bleeding following ROSC and will require bilateral arterial forceps clamping or suturing. Mammary arteries can bleed both antegrade and retrograde from the cut ends and may need clamping in 4 locations.

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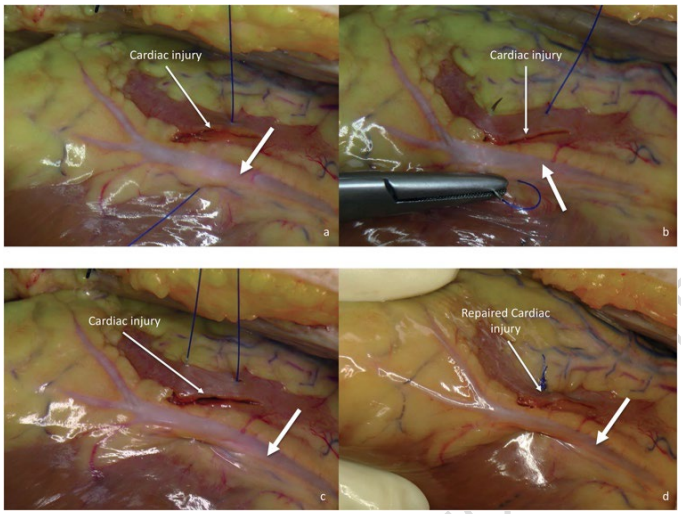

Figure 2: Horizontal mattress suture closure of a cardiac incisional wound in close apposition to coronary vasculature, to maintain perfusion and distal cardiac function.

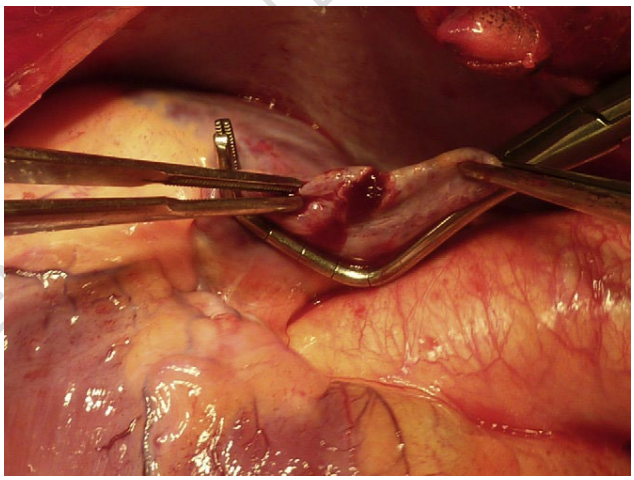

Figure 3: Right atrial appendage wound with atraumatic vascular clamp application.

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Aortic Arch Resuscitation

- Following decompression or exclusion of a tamponade, to achieve and sustain a ROSC the priority should be aortic arch resuscitation, consisting of four main aspects:
    - Rapid haemorrhage control from cardiac, vascular, or pulmonary lesions
    - Concurrent volume resuscitation with blood products
    - Aortic compression to facilitate rapid re-pressurisation of the aortic arch
    - High quality internal cardiac massage to reinstitute forward coronary flow
- Aortic compression should be applied for all cases where a ROSC is not achieved immediately following pericardiotomy to rapidly optimise coronary perfusion:
    - Lift the left lung upwards, gently dividing the inferior pulmonary ligament if necessary
    - Directly visualise the thoracic aorta running adjacent to the thoracic spine
    - Run a hand across the posterior thoracic wall, and compress the aorta against the thoracic spine as low as possible/adjacent to the diaphragm
- If sub-diaphragmatic exsanguination is the primary cause for the cardiac arrest, then proximal aortic control via digital compression is the priority and should be undertaken by the critical care team.
- Internal cardiac massage must be dynamic and proportionate to the rate of ventricular filling and volume resuscitation (start slow and increase rate with filling).
- Use a two-handed technique to ensure the heart remains horizontal with no kinking of the vascular pedicles.
- If myocardial activity is sluggish despite adequate filling, and internal cardiac massage/aortic compression have been optimised, then intravenous 100mcg adrenaline aliquots can be considered.
- Internal massage should be continued until myocardial activity is coordinated and effective and may need to be intermittently restarted following ROSC to support contractility.

- Proximal aortic control should be gradually removed ASAP (as volume resuscitation and physiology allow), aiming for complete removal or partial occlusion as a minimum.

Lung Isolation Techniques

- Pulmonary incisional wounds with ongoing bleeding can communicate with the pulmonary vasculature and cause arterial gas embolisation.
- Small lung wounds are best left untreated. More significant wounds can be controlled by direct pressure with a large dressing, collapsing that lung segment (lobar control technique).
- Any catastrophic bleeding from the lung can be controlled with lobar control techniques, or if ineffective, with hilar control techniques.
- Hilar control techniques (Figure 4) should be reserved for life-threatening pulmonary haemorrhage, and may require blunt dissection of the inferior pulmonary ligament:
    - Hilar Compression: Digital compression of the hilar structures
    - Hilar Sloop: Foley catheter passed around the lung hilum twice, with gentle traction
    - Hilar Clamp: Atraumatic vascular clamp across the hilum
    - Hilar Twist: Rotation of the lung on its hilum (inferior lung anterior)

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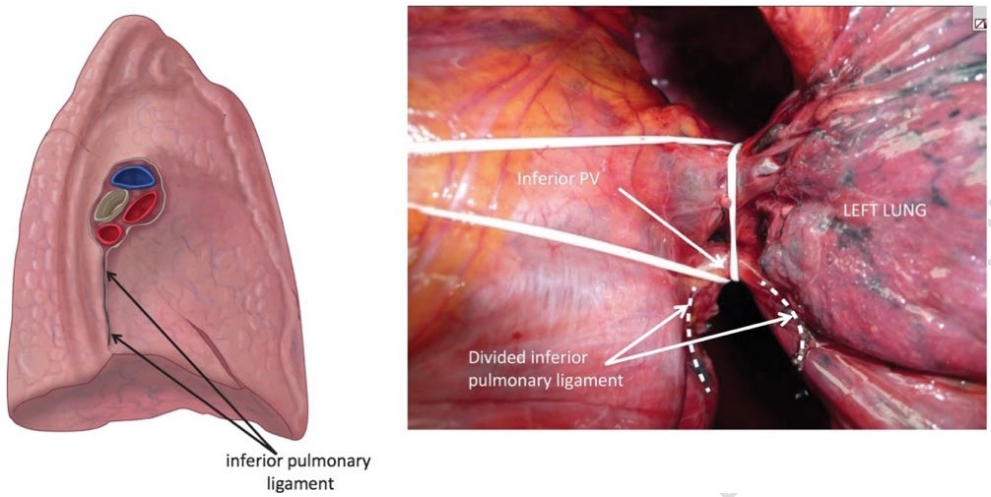

Figure 4: Location of the inferior pulmonary ligament (left image) and tie/catheter ligation (slooping) of the lung hilum (right image).

8. Further considerations

- Wide bore IV access should be attained by peripheral cannulation or subclavian central access. Intraosseous humeral access can be utilised if IV has failed.
- Fine VF indicates inadequate coronary flow: concentrate on aortic arch resuscitation and if VF persists or becomes coarse then defibrillate (AP or AL pad positioning).
- Any improvement in spontaneous cardiac activity during resuscitation should prompt planning for egress: scoop/carry sheet preparation, reverse loading, extrication planning.
- The patient may require ongoing sedation and anaesthesia, depending on low-flow duration and physiological recovery.
- Re-examine the posterior cardiac structures following ROSC for unrecognised cardiac wounds during the initial examination.
- Any retained packs or surgical equipment need documenting and handing over to the receiving hospital team (unrecognised retained equipment is a **NHSE never event**).

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- If despite resuscitation the patient remains in cardiac arrest, it is acceptable to cease resuscitative efforts and declare the patient to be dead on scene. Ensure all surgical equipment and sharps are accounted for (see Appendix 1 for checklist).

9. Training & Governance

Training

- TAAS will provide the necessary theoretical, practical and crew resource management training for clinicians undertaking advanced surgical skills such as resuscitative thoracotomy. All advanced surgical interventions require a surgical procedure reflection form completion at the earliest opportunity, for review by the TAAS surgical procedure lead (see CSOP 028)
- All advanced surgical interventions will be peer-reviewed by an experienced clinician external to TAAS and fed-back into the organisational governance for wider learning.

End of Document