CareFlight Pre-hospital Thoracotomy Guideline

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Introduction

Pre-hospital thoracotomy is considered an essential, although rarely performed, skill of the prehospital physician. It may, in the presence of favorable pathology when performed very close to the time of cardiac arrest, produce neurologically intact survivors, who would otherwise have died.

Neurologically intact survivor rates vary widely between pre-hospital services but rates of up to 15% have been achieved.¹ All of these patients had pericardial tamponade caused by stab wounds. Other mechanisms such as gunshots are unlikely to produce neurologically intact survivors.²

The decision to perform a thoracotomy in traumatic arrest must be balanced against:

- 1. The risk of physical and psychological injury to the performing team and bystanders; and:
- 2. The likelihood of a successful neurological outcome following the procedure.

Mechanisms of injury

Available evidence suggests pre-hospital thoracotomy is unlikely to produce a favorable neurological outcome unless the underlying cause of arrest is pericardial tamponade¹⁻⁶.

- Therefore, thoracotomy should only be performed if there is clinical or ultrasonic suspicion of cardiac tamponade.
- The usual mechanism of tamponade in these cases is a single stab wound to the right ventricle.^{1,2,3}
- Knife injuries, or similar, carry the best chance of survival and are the main target group for this intervention.
- Unless the injury is from a knife (or similar), survival is unlikely.²
 - High energy gunshot injuries are not usually consistent with a salvable cardiac injury.
 - Multiple gunshot or stab wounds are also associated with minimal survival.
 - Low energy ballistic wounds such air rifle, small caliber pistol and longer-range shotgun injuries may confer some survival if tamponade is the primary cause of arrest.
 - Despite being practiced by some organisations, there is currently no convincing evidence to support performing a pre-hospital thoracotomy in blunt trauma.^{3,4,5,6} To date, only two neurologically intact survivors have been reported.^{7,8} A Japanese case series of 81 blunt thoracotomies (34 pre-hospital) produced no survivors to hospital discharge.⁶
 - The presence of concurrent un-survivable injuries should be considered a absolute contraindication to performing a pre-hospital thoracotomy.

Timing

Thoracotomy should be performed within a reasonable time of cardiac arrest.

• The closer to this time, the more likely a neurologically intact survivor.

- The most widely quoted cut-offs of 10 minutes and 15 minutes following arrest are not supported by any robust evidence.⁵ The largest case series of pre-hospital thoracotomy survivors found a good neurological outcome is most likely if performed within '5-10 minutes' of arrest.¹
- Survival is best in the agonal patient (e.g. those presenting with no central pulses but with signs of life such as Cheyne–Stokes breathing).^{1,5} If tamponade has been demonstrated on ultrasound and the patient is not responding to volume resuscitation, thoracotomy should be performed before waiting for the patient to fully arrest.
- Documented time of arrest is unreliable, particularly by non-medical providers.
- Dynamics surrounding pre-hospital arrest are hugely variable and time to completion of thoracotomy (arguably a more sensible measure than time of start) will vary between patients and providers.
- The timing of thoracotomy is probably best judged by the team at the patient's side and tailored to the individual risk/benefit profile of the patient, team and situation.
- We suggest if thoracotomy cannot be **completed** within 10 minutes from time of arrest, you should not proceed.
- Once it is agreed amongst the team that the criteria for pre-hospital thoracotomy has been reached, the procedure should be performed immediately.

Thoracotomy should not be delayed until in the ED.

- Resuscitative thoracotomy is rarely performed in Australian emergency departments. In general, emergency department staff do not routinely train for this procedure. It is likely to expose more staff members to psychological and physical injury.
- Delaying thoracotomy worsens outcome.
- Therefore, thoracotomy should not be delayed for arrival in the emergency department unless arrest occurs in the ambulance or resuscitation bay.

Role of ultrasound

Where possible ultrasound should be used as a clinical decision tool in traumatic penetrating arrest.

- ECG rhythm does not appear to be useful in prognosticating survival in pre-hospital thoracotomy.¹
- In the absence of both pericardial fluid and coordinated cardiac activity on ultrasound, survival is very unlikely.⁹ Experienced ED thoracotomy providers suggest performing thoracotomy only in the presence of these two ultrasonic findings.¹⁰
- Ultrasound is substantially more accurate than clinical exam in the diagnosis of pericardial effusion.^{11,12} Conversely, ultrasound findings of tamponade are subtle so, as per standard eFAST teaching, the retrieval doctor should assume that if any significant pericardial fluid is found and the patient is shocked, tamponade is present.
- Ultrasound of the pericardium is a core skill of the retrieval physician but can take minutes to perform accurately, particularly in the presence of other pathology e.g. large pneumothorax.



Therefore, if the time course and mechanism are correct, ultrasound should not delay thoracotomy in the event of an arrested patient.

• Ultrasound may also be used to rule out tension pneumothorax in penetrating traumatic cardiac arrest.

Indications and contraindications

These are also summarised in the thoracotomy flowchart (Figure 1) below.

- Thoracotomy should only be performed if there is a penetrating injury in an area consistent with cardiac injury and it is thought that the thoracotomy can be completed within 10 minutes of witnessed signs of life.
 - If the injury is from a stab wound, ultrasound should not delay thoracotomy.
 - If the injury is a mechanism other than from a stab wound, thoracotomy should not be performed unless cardiac activity and pericardial effusion have been reliably demonstrated on ultrasound.
- Thoracotomy should be performed in the agonal patient prior to complete arrest providing the mechanism is correct, they have had an ultrasound demonstrating a pericardial effusion and usual methods resuscitation have failed.
- In the patient who arrests, and a recent ultrasound has clearly demonstrated no pericardial effusion, a thoracotomy should not be performed.

Figure 1. Thoracotomy Flowsheet





The procedure

Preparation

- Removing the patient from the vehicle or aircraft and achieving 360-degree access is essential before performing a thoracotomy.
- Gloves and eye protection must be worn by all members of the team. The Doctor should be double gloved with sterile gloves.
- In the event of a two-doctor team, the initial parts of the thoracotomy should be completed by one doctor only (preferably the consultant) to reduce the incidence of needlestick and misalignment of cuts at the sternum. The registrar should support the consultant with the procedure and only assist where there is no cutting involved (such as retraction of the sternum/lungs and aortic compression).
- The doctor(s) will be task focused. The Paramedic or Flight Nurse should assume the role of the scene leader. This role includes the coordination of the required steps in the procedure:
 - Ensuring that, where possible, the number of emergency providers and general public exposed to the procedure are kept to an absolute minimum.
 - Consideration of shielding (eg with tarpaulins/other barriers) for patient privacy from potential media and limiting exposure as per above.
 - Insertion of an LMA (this is a quicker alternative to ETT that can be achieved by a paramedic) and ventilation.
 - Appropriate vascular access. Jugular veins are distended in tamponade and easily accessible. Humeral IOs are also an option.
 - Readying of blood products primed through a warmer.
 - Performing an equipment dump around the patient's left side.
 - Ensuring overall scene safety.
- Where possible, the above tasks should be delegated to other team members so the Paramedic or Flight Nurse can support the proceduralist(s) with equipment and assist with some parts of the procedure such as retraction of the sternum.

Performing the thoracotomy

The primary reasons for thoracotomy are to relieve tamponade, repair a myocardial laceration, provide manual compression of the aorta and internal cardiac massage. Other maneuvers within the chest cavity such as the 'hilar twist' may be beyond the skill set of the retrieval physician but may be attempted if the physician has received appropriate training.

A bilateral clamshell thoracotomy is performed for simplicity and superior access to the chest. ^{12,13}

- Identify the 5th intercostal space on the right side of the patient. This is at the level of the nipple in males, and the inframammary crease in females.
- Perform a right-sided open thoracostomy using scalpel and forceps then repeat on the left.
- The trajectory of the fourth intercostal space should be followed in a 'W' shape using a broad skin incision from the right thoracostomy crossing the sternum to left. This should extend to the chest wall most or all the way through the fat to ribs/intercostals.



- Using a pair of trauma shears, follow the path of the incision from right to left, joining the thoracostomies. For speed and simplicity, sterile trauma sheers are advised for crossing the sternum and are usually adequate.
- If trauma shears are ineffective, a Gigli saw can be used. Pass the forceps behind the sternum and pull the wire beneath the sternum before attaching it to the handles. Care should be taken to avoid touching the blade with gloves as they risk being torn.
- Extend the incisions past the thoracostomies to the posterior clavicular line before opening the chest. This allows full opening of the clamshell for more complete access.
- CareFlight does not carry Finocietto rib spreaders so a member of the team wearing appropriate PPE should maintain retraction of the chest from the right side of the patient. Ideally this should be the registrar or a senior paramedic on scene.
- Use a pair of forceps to pick up the pericardium in the midline (avoiding the phrenic nerves) forming a tent on the anterior surface of the heart. Cut a vertical hole with a pair of scissors extending to the great vessels. Do not tear the pericardium.
- 'Deliver' the heart and evacuate any haematoma. It is not uncommon for the heart to begin beating or fibrillate at this stage.
- If a cardiac laceration is identified it can be occluded with a finger.
 - If closure is deemed necessary, staples are the preferred method, this reduces the likelihood of needlestick injury, and are not as skill-dependent as sutures. However, if the clinician is comfortable with advanced closure techniques using pericardial pledgets then there are silk sutures are available.
 - Wounds adjacent to the coronary arteries should be carefully managed, and not over sewn.
 - It is recommended that wound repair is performed prior to defibrillation.
 - During inspection of the heart or any instrumentation, artificial respirations should be withheld.
- If the heart is not spontaneously beating at this point, simply flicking the heart over the LV may produce a return of contractions. If this is unsuccessful or contractions ineffective, two-handed internal cardiac massage should be performed.
- To perform internal cardiac massage, 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. Aim for a rate of around 80 BPM.
- Any patient having internal cardiac massage should also have simultaneous aggressive volume replacement and manual compression of the descending aorta to increase aortic root and cardiac perfusion pressure. This is performed by reaching around the left hemithorax until the anterior surface of the spine is felt and compressing any soft structures against it with your hand.
- Continue internal massage until cardiac activity appears vigorous. Aliquots of adrenaline can be used cautiously.
- In the event of VF, good cardiac massage, aortic compression and volume replacement should be continued for several minutes before attempting defibrillation to fully perfuse the heart and maximise success of restoring sinus rhythm.



- Pads are placed on the right anterior chest and left posterior lateral chest defibrillation can be tried with the chest open initially (so the time between CPR and defibrillation is minimised). If this is unsuccessful, defibrillation can be attempted with the chest closed.
- In the event of ROSC there are several points to consider:
 - At this time the team leader should be initiating volume replacement and resuscitation of the patient as described in the Penetrating Trauma Guideline.
 - Occasionally patients can rapidly gain consciousness. Be ready to anaesthetise your patient!
 - If the mammary or intercostal arteries start to bleed, clamp them with mosquito forceps.
 - It may be necessary to perform an RSI if an ETT has not already been placed during the resuscitation but this should not delay transport unnecessarily.
 - Aortic compression and/or pressure over a laceration may be required during transport. If so, it will be necessary to load the patient feet-first in an ambulance for access to the left side of the chest.

Transport

Rapid transport to the closest major trauma centre should occur. A Code Crimson or equivalent should be activated.

Psychological impacts

The psychological impact of performing a thoracotomy to the CareFlight team, emergency service providers and potentially bystanders should not be underestimated.

A hot debrief at the hospital should be undertaken and should include the CareFlight team and ideally involve all emergency workers who were present at the scene. The personnel involved will often look to the medical team for guidance on the overall mission, as well as the procedure itself.

On completion of the mission a 'mission debrief' back at the base is standard practice, however the CareFlight team should also involve their line managers to and follow the CARE process, this is described in detail in the relevant guideline. In addition to this, it is advised that the Paramedic should also contact their relevant line managers and follow their local debrief procedure.

Training

Training for all members of the clinical team is recommended.

- Pre-hospital thoracotomy is a complex surgical procedure rarely performed by retrieval physicians in or out of hospital. Although significant injury is reasonably infrequent and usually minor,^{3,11} in order to minimise injury and maximise success both the physician(s) and paramedic/flight nurse should be trained and drilled as a team for the procedure.
- Physicians should undertake a five-yearly, external professional course such as STRESS or the Alfred Procedures Course. These courses give the physician the opportunity to practice other life and limb saving procedures such as traumatic amputation.



• Physicians and paramedics at CRRH should undertake regular team-based training in both the two- and three-person medical team. This forms a large part of the yearly animal lab trauma skills/thoracotomy recap evening at CRRH.

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Document History

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