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FINGER THORACOSTOMY IN PATIENTS WITH CHEST TRAUMA PERFORMED BY PARAMEDICS ON A HELICOPTER EMERGENCY MEDICAL SERVICE

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FINGER THORACOSTOMY IN PATIENTS WITH CHEST TRAUMA PERFORMED BY PARAMEDICS ON A HELICOPTER EMERGENCY MEDICAL SERVICE

ABSTRACT

Objective

To determine the frequency of finger thoracostomy performed by intensive care flight paramedics after the introduction of a training program in this procedure and complications of the procedure that were diagnosed after hospital arrival.

Methods:

This was a retrospective cohort study of adult and paediatric trauma patients undergoing finger thoracostomy performed by paramedics on a helicopter emergency medical service between June 2015 and May 2018. Hospital data were obtained through a manual search of the medical records at each of the three receiving Major Trauma Services. Additional data were sourced from the Victorian State Trauma Registry.

Results

The final analysis included 103 cases, of which 73.8% underwent bilateral procedures with a total of 179 finger thoracostomies performed. The mean age of patients was 42.8(SD=21.4) years and 73.8% were male. Motor vehicle collision was the most common mechanism of injury accounting for 54.4% of cases. The median Injury Severity Score was 41 (IQR 29-54). There were 30 patients who died pre-hospital, with most (n=25) having finger thoracostomy

performed in the setting of a traumatic cardiac arrest. A supine chest x-ray was performed prior to intercostal catheter insertion in 38 of 73 patients arriving at hospital, of these, none demonstrated a tension pneumothorax. There were 3 cases of potential complications related to the finger thoracostomy.

Conclusion

Finger thoracostomy was frequently performed by intensive care flight paramedics. It was associated with a low rate of major complications and given the deficiencies of needle thoracostomy, should be the preferred approach for chest decompression.

Key Words: paramedics, thoracostomy, air ambulance, helicopter emergency medical service

Introduction

The optimal management of suspected tension pneumothorax in the pre-hospital setting is uncertain. In many emergency medical services (EMS), pre-hospital clinicians use needle thoracostomy (NT) in the mid-clavicular line between the second and third ribs to decompress suspected pneumothoraces. However, previous studies have noted that the success rate for paramedic decompression of suspected tension pneumothorax using this approach is low varying from 18% to 62% due to failure of the needle to enter the plural cavity, misplacement or kinking or blockage of the catheter[1-5].

The diagnosis and treatment of tension pneumothorax (TPT) is particularly problematic during air transport due to limitations of performing physical examination during flight. Therefore, a more reliable approach to prevention or treatment of TPT in patients with chest injuries prior to flight might prevent its development during flight. One alternative to NT is the use of finger thoracostomy (FT) in patients with chest injuries who are at risk of tension pneumothorax.

Although FT is used in the Emergency Department (ED) for placement of intercostal catheters (ICC) or doctors in a HEMS service[6-10], there have been few reports of paramedic FT in a HEMS service[11,12]. Barriers to paramedic performed FT include the training required, the risk of complications of a surgical procedure performed in the field and possible risk to paramedics of exposure to iatrogenic injuries by sharps. Also, there is limited data on the

longer-term complications of this procedure. In particular, given that the procedure is performed in the field with limited aseptic technique, the incidence of infective complications such as cellulitis or empyema after hospital arrival is unknown.

In June 2015, intensive care flight paramedics (ICFPs) in Air Ambulance Victoria (AAV) undertook a training program and upon successful completion, were authorised to perform FT in patients with suspected tension pneumothorax or haemothorax. The aims of this study were to determine the number of FT performed by ICFPs after the introduction of the training program, the incidence of radiological tension pneumothorax on arrival to hospital and the incidence of complications, specifically infection associated with ICFP FT diagnosed after hospital arrival.

Methods

Study design: This was a retrospective cohort study including adult and paediatric trauma patients undergoing HEMS FT performed by paramedics between June 2015 and May 2018.

Setting: Ambulance Victoria is the sole EMS provider for the state of Victoria, Australia, servicing a population of more than 6.3 million people over 227,000 square kilometres (87,645 square miles). AAV is the air transport subsidiary of Ambulance Victoria and is the single provider of helicopter emergency medical services (HEMS) in the state. The service has been described in detail previously[13-16]. Briefly, AAV operates five Augusta Westland 139 emergency helicopters with two based in Melbourne and the remaining three based in the western, northern and south-eastern areas of Victoria. The HEMS undertake more than 2,000 medical and trauma missions each year.

The helicopters are staffed by single ICFPs who are trained and authorised to perform additional procedures compared to Ambulance Victoria road-based intensive care paramedics, including rapid sequence intubation of adult and paediatric patients, blood transfusion, arterial cannula insertion, point-of-care ultrasonography (POCUS) and in-field blood gas and haemoglobin analysis.

Prior to credentialing ICFPs for FT, a one-day training program was developed. The format included didactic lectures, interactive case studies and practical training using a porcine chest

wall. Specific areas covered included working in a sterile field and associated PPE and the introduction of POCUS for the detection of pneumothorax. No in-field/in-hospital practical supervision was undertaken.

The Procedure: FT was indicated in traumatic cardiac arrest or in unconscious patients undergoing positive pressure ventilation when there was suspicion of tension pneumothorax or haemothorax prior to flight based on mechanism of injury, physiological observations, physical examination and/or ultrasound examination. In addition, bilateral FT was performed in cases where the ICFP attended a patient with traumatic cardiac arrest.

The FT procedure is undertaken as follows: the patient is placed supine with the arm on the affected side abducted and externally rotated. The fifth intercostal space is located using the mid-arm point (MAP) technique[17]. The ICFP dons sterile gloves, the lateral chest wall is cleaned with alcoholic preparation solution and a drape with a small open window is placed over the lateral chest. A 20mm incision using a scalpel is made immediately below the MAP at the mid-axillary line immediately over the rib. This is followed by blunt dissection using small curved artery forceps. The forceps are then inserted through the intercostal muscles, over the rib above and into the pleural space. The forceps are opened widely to allow the expulsion of air and/or blood. A gloved finger is then inserted through the incision to perform a finger-sweep and to ensure pleural decompression. A stoma bag dressing is utilised to cover the wound and collect any blood. This reduces the potential for exposure of the pre-hospital

clinician to bodily fluids. No intercostal catheter (ICC) is inserted into the chest cavity during prehospital care.

After arrival at the ED an ICC could be inserted at physician discretion through the incision made by the ICFP at or through a new sterile insertion site.

Data Sources: After each case, an electronic patient care record is completed by the attending ICFP. This is uploaded and stored within the Ambulance Victoria data warehouse. The warehouse was searched for all cases in which FT was performed by ICFPs during the study period.

Hospital data were obtained through a manual search of the medical records at each of the three receiving major trauma service (Alfred Hospital, Royal Melbourne Hospital and the Royal Children's Hospital). For patients presenting to the Royal Melbourne Hospital, data was obtained from the Royal Melbourne Hospital Trauma Registry. For the other two sites, the authors manually retrieved data from the patient's medical record. The Injury Severity Score (ISS) was sourced from the Victorian State Trauma Registry, part of a state-wide system of trauma care, that collects information about all major trauma patients in Victoria[18]. Hospital data for those who died at scene or who were transported to a non-trauma centre was excluded.

Statistical Analysis: The primary outcome measure was the number of FT performed by ICFP during the study period. Secondary outcome measures were presence of a tension pneumothorax among patients transported alive to the ED and undergoing a CXR prior to ICC placement, and the incidence of adverse outcomes. Continuous variables were described using means and standard deviation or median and interquartile range, as appropriate. Categorical data are presented as frequencies and proportions. All statistical analyses were performed using Stata version 14 (Statacorp, College Station, TX, USA).

Ethics: Ethics approval for this study was granted by the Human Research Ethics Committees of the Alfred Hospital, Royal Melbourne Hospital and Royal Children's Hospitals. The Research Committee of Ambulance Victoria also approved the study.

Results

During the study period, a total of 110 patients undergoing FT were identified. Of these, 2 were excluded as they were taken to non-trauma centres. A further 5 were excluded due to missing data leaving a total of 103 cases in the final analysis. Of these 103 patients, 76 had bilateral FT performed, with a total of 179 thoracostomies performed. A summary of the patients undergoing FT is shown in Figure 1.

Patient and Baseline Characteristics

Patient and baseline characteristics are provided in Table 1. Mean age of patients undergoing FT was 42.8(SD 21.4) years. The ages ranged from 12 months to 88 years. Male patients made up 73.8% of the group. Motor vehicle collisions were the most common mechanism of injury accounting for 54.4% of cases. Most patients had multiple injuries, with a median Injury Severity Score of 41 (IQR 29-54). Suspected traumatic brain injury was present in 69.9% of patients. POCUS was used in 17 (16.5%) patients prior to FT.

Prehospital Care

Table 2 summarises the prehospital management of FT patients. Anterior NT was performed by road paramedics prior to HEMS arrival in 75.7% of cases. Unilateral FT was performed in 27 (26.2%) and bilateral FT in 76 (73.8%) cases. All patients underwent endotracheal intubation and pre-hospital packed red blood cells were transfused in 76 (73.8%) of patients.

Of the 32 (31.1%) patients who had FT performed in the setting of traumatic cardiac arrest, 25 (78.1%) died pre-hospital, 4 (12.5%) died in hospital and 3 (9.4%) survived. Of the 25 patients who were in cardiac arrest and died pre-hospital, 4 (16%) of these had transient return of spontaneous circulation, defined by any blood pressure at all recorded. Based on paramedic assessment of injuries sustained in addition to chest trauma, 16 (64%) had head injury, 8 (32%) abdominal injury, 7 (28%) pelvic injury and 4 (16%) no other injuries documented.

Of the 71 included patients that were not in cardiac arrest, 5 (7.0%) died pre-hospital and 21 (29.6%) died in hospital.

Chest x-ray (CXR) was performed prior to ICC insertion in 38 of 73 (52.1%) of cases, of these 14 (42.0%) showed the absence of haemothorax and pneumothorax. There were no patients with radiological tension pneumothorax.

In-hospital Care

Table 3 summarises the in-hospital management of patients who underwent FT.

Only 39 of the 73 patients arriving in hospital had documentation of the incision site used for ICC insertion. Of these, a new incision was performed in 13 (33.3%), the prehospital FT incision site was used in 22 (56.4%) and 4 (10.3%) did not have an ICC inserted. Three ED

thoracotomies were performed and a further two emergency thoracotomies were performed in the operating theatre. Antibiotics were administered in the ED in 52 (71.2%) cases.

Among the 63 patients who did not die pre-hospital or in the ED, the incidence of long-term complications of FT was 4.8% (95% CI: 1.6-13.1), this totalled 3 patients. One patient developed an infective complication of FT (chest wall cellulitis) during their inpatient stay. This patient had an ICC inserted through the pre-hospital FT site and had received antibiotics in ED. Two further patients had complications considered to be related to the FT. One had arterial bleeding from the prehospital thoracostomy site requiring surgical ligation in theatre (ICC inserted through the same incision). The other had a laceration of diaphragm and liver which was documented in the operative records by the surgeon to be likely due to the FT.

Discussion

This study demonstrates that paramedics can be trained to perform FT as an alternative to NT and the procedure was frequently performed in critically injured patients. The rate of important complications was low, with only one significant infective complication and two complications related to incorrect position of the incision or dissection. This compares favourably with the overall incidence of chest wall infection or empyema of 0.5% in patients with ICCs inserted in the ED by physicians under sterile conditions[19].

These complications should also be considered in the setting of high rates of failure and/or complications of prehospital NT for decompression of suspected tension pneumothorax[4]. The NT procedure can be ineffective for several reasons. Firstly, the needle/ catheter may fail to enter the pleural cavity. Many EMS use a 5cm catheter inserted via the 2nd intercostal space in the mid-clavicular line. The failure rate for insertion at this site has been reported as 38% compared to 13% if the 4/5th intercostal space at the anterior axillary line[1]. On the other hand, the lateral approach on the left side may cause injury to the heart. Secondly, if a longer catheter (8cm) is inserted at the mid-clavicular line, there is an increased risk of injury to the heart and/or lungs[3]. Finally, even if a catheter is correctly placed, there is a high incidence of failure of a catheter to allow the escape of air and decompression of a tension pneumothorax due to kinking or blockage of the catheter[5].

The procedure of FT had been previously reported to be performed by paramedics in patients with traumatic cardiac arrest where simple thoracostomy was used during the resuscitation

effort[11] and reported to have similar low rates of complications. A FT was performed on 57 patients of whom 70% were blunt trauma. There were no reported patient or paramedic injuries due to the use of the FT. A "short cut review" had previously identified 5 reports on pre-hospital finger thoracostomy in the setting of trauma, primarily performed by physicians[9]. Deakin et al. described FT in 45 patients as an alternative to TT (tube thoracostomy), and there were no infective complications[20]. Massarutti et al. reported on 55 consecutive severely injured patients with suspected pneumothorax who underwent FT. No cases of major bleeding, lung laceration or pleural infection were recorded [21]. Aylwin et al. reviewed both in-hospital chest drain insertion and pre-hospital FT. Over a seven-month period, 65 FTs were performed on 35 patients in the pre-hospital setting, a further 26 TTs were performed in hospital. In total there were 9 deaths and 8 major complications (9%), all of these occurring in patients receiving a prehospital FT[8]. Chesters et al. reviewed 236 thoracostomies performed in 110 patients over a four-year period. FT was performed due to cardiac arrest or peri-arrest in 40%. No immediate complications were recorded[10]. Finally, in the study by High et al. 421 FTs were performed by HEMS staff consisting of either a nurse/nurse, nurse/emergency medical technician or nurse/paramedic team. In total 250 patients (18 years of age or older) underwent FT/TT, with a total of 421 procedures performed[12]. The complication of empyema occurred in one patient (0.4% of the cohort).

Limitations

This was a retrospective study with associated limitations, particularly selection bias. It is possible that cases where FT was attempted but not completed may not have been

documented in the patient care records. Outcome data were not compared to a control group and therefore the superiority of FT compared with NT for patients transported by HEMS cannot be estimated from this study. On the other hand, previous reports of NT cite high rates of complications. Being a retrospective review of a time-critical procedure in the pre-hospital setting, information bias through limited documentation may have resulted in a lower reported complication rate. Potential additional complications of the procedure including risk to the operator, such as through sharp injuries or damage to adjacent structures such as the diaphragm, liver or spleen, could not be adequately assessed.

There was no reliable gold standard for confirming relief of tension pneumothorax in this study. Sample size for the secondary outcome measure of radiological tension pneumothorax on arrival to hospital was substantially smaller due to a high proportion of pre-hospital deaths and emergency procedures performed prior to chest x-ray. We refrained from attempting a retrospective clinical assessment of clinical tension pneumothorax due to multiple confounders present in major trauma patients. For future studies, a review of the post-mortem CT, consistent with our methodology of reviewing pre-hospital deaths will add to the assessment of this procedure among patients that died in the pre-hospital phase[22].
Consistent with the critical nature of the injuries requiring multiple life-saving interventions, a high proportion of patients died pre-hospital or in the ED or had emergent procedures on arrival to hospital, limiting our ability to assess effectiveness and safety of pre-hospital FT in isolation. It is possible that some of these patients suffered procedural complications as a

result of the FT. However, among assessable patients, the absence of tension pneumothorax after FT and the low rate of longer-term complications was re-assuring.

Conclusions

Our study demonstrates that after training, finger thoracostomy can be performed by intensive care flight paramedics within a set of formal standard operating procedures and the governance of a major trauma system. It was associated with a low rate of major complications. This demonstrates success of introduction of FT to HEMS. Ongoing surveillance with prospective measurement of short- and long-term outcomes of the procedure is indicated.

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Table 1: Patient characteristics

Demographics	Age, mean (SD) in years	42.8 (21.4)
	Age Range	1 - 88
	Male Gender, n (%)	76 (73.8)
Mechanism of Injury	Motor Car Collision, n (%)	56 (54.4)
	Motorbike Collision, n (%)	15 (14.6)
	Pedestrian Collision, n (%)	8 (7.8)
	Fall, n (%)	8 (7.8)
	Other Trauma, n (%)	11 (10.7)
	Medical, n (%)	5 (4.9)
Paramedic assessment of other injuries, n (%)	Head, n (%)	72 (69.9)
	Abdomen, n (%)	28 (27.2)
	Pelvis, n (%)	37 (35.9)
	Limbs, n (%)	58 (56.3)
Transported to hospital		73 (70.9%)
ISS of those transported (n=73)	Median (IQR)	41 (29-54)
	<12 (%)	1 (1.4)
	12 to 30 (%)	17 (23.3)
	31 to 50 (%)	31 (42.5)
	>51 (%)	18 (24.7)
	NA- medical (%)	2 (2.7)

	Missing (%)	4 (5.5)

Table 2: Pre-hospital Management

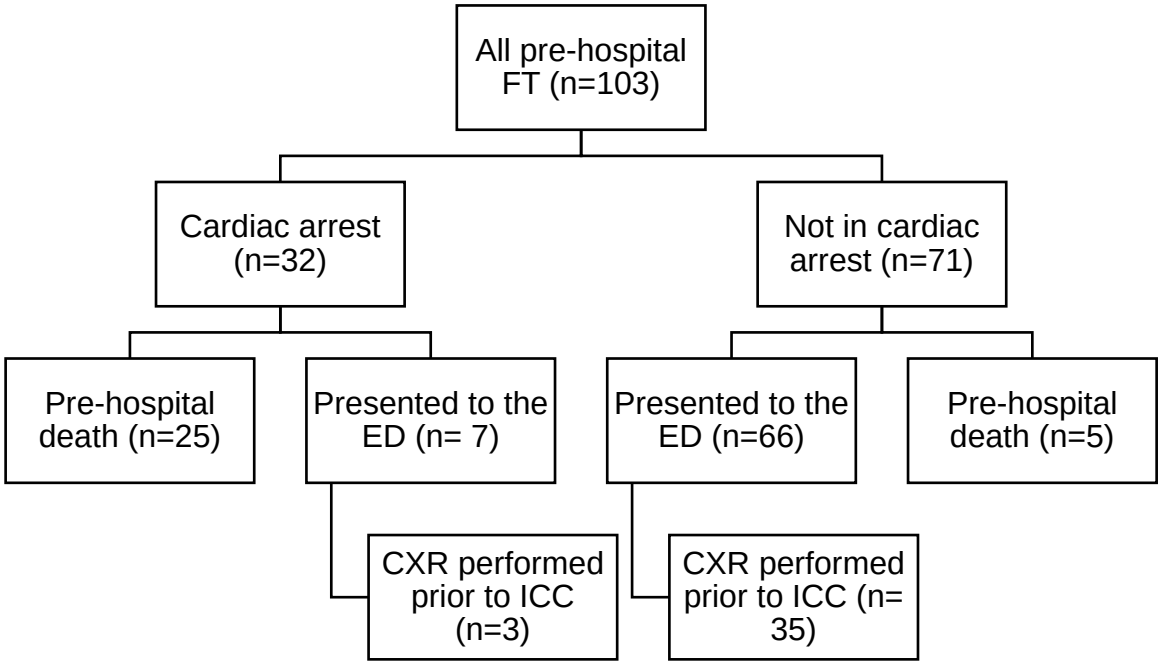
Indication for FT	Cardiac arrest, n (%)	32 (31.1)
	Clinical, n (%)	54 (52.4)
	Confirmed with ultrasound n (%)	17 (16.5)
Received blood transfusion	Nil, n (%)	27 (26.2)
	1 unit, n (%)	10 (9.7)
	2 units, n (%)	16 (15.5)
	3 units, n (%)	14 (13.6)
	4 units, n (%)	34 (33.0)
	>4 units, n (%)	2 (1.9)
Scene outcome	Death, n (%)	30 (29.1)
Times (minutes)	Scene time, mean (SD)	83 (29)
	Transport time, mean (SD)	45 (28)

Table 3: In-hospital Management and outcomes (73 patients)

CXR findings: ICC placed before initial CXR, n (%)	Total Pneumothorax Haemothorax Neither	38 (52.1) 13 (34.2) 9 (23.7) 16 (42.0)
CXR findings: ICC placed after initial CXR, n (%)	Total Pneumothorax Haemothorax Neither	33 (45.2) 13 (39.4) 9 (27.3) 14 (42.4)
No CXR performed, n (%)		2 (2.7)
Antibiotics given in ED, n (%)		52 (71.2)
ED disposition, n (%)	ICU Theatre Interventional radiology Cath lab Death	34 (46.6) 26 (35.6) 2 (2.7) 1 (1.4) 10 (13.7)
Complications in those surviving to hospital admission (63 patients), n (%)	Empyema Cellulitis Injuries to other structures	0 1 (1.6%) 2 (3.2%)

Length of hospital stay (Days)	mean (SD)	16.5 (13.6)
Disposition	Home, n (%)	8 (11.0)
	Rehabilitation, n (%)	29 (39.7)
	Transfer to another hospital, n (%)	10 (13.6)
	Death, n (%)	26 (35.6)

Figure 1:



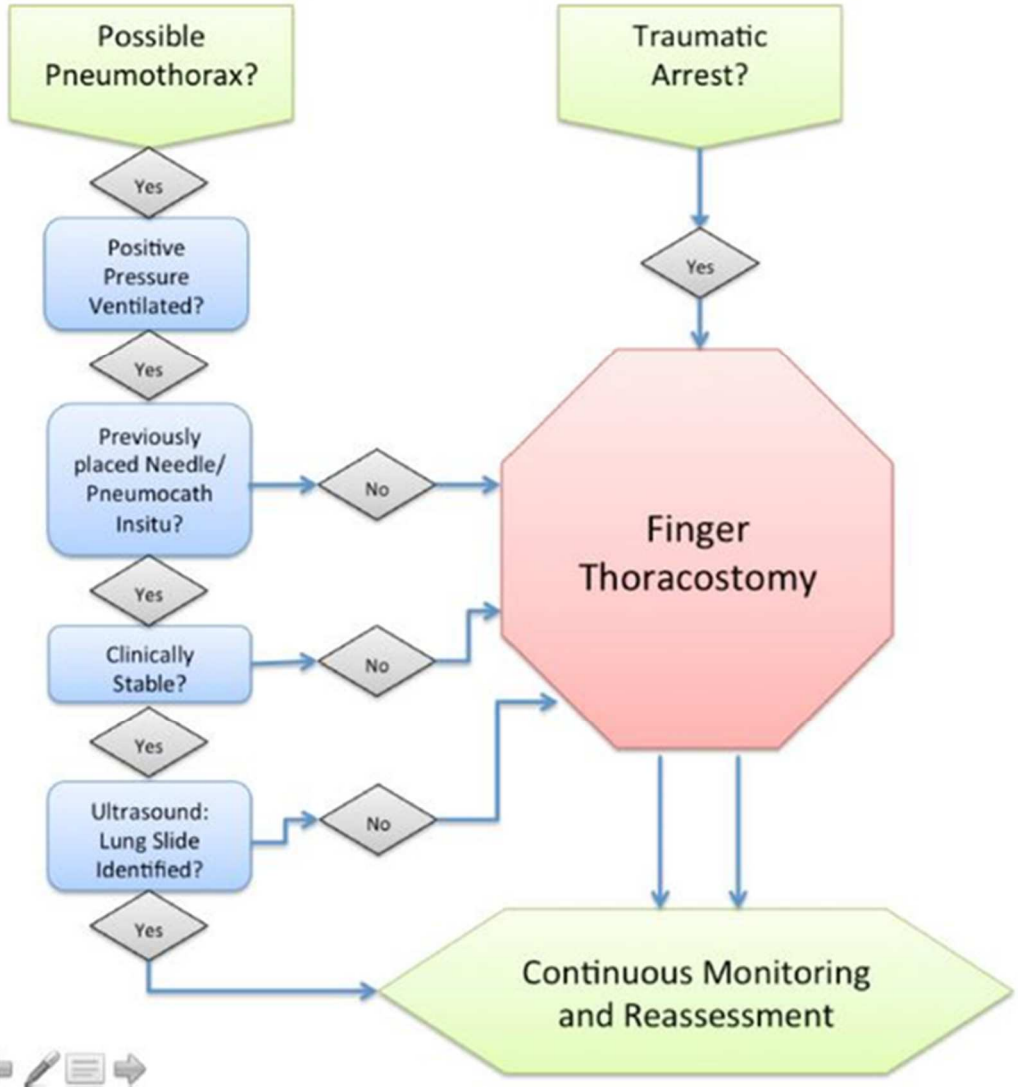
Pleural Decompression with Finger Thoracostomy

1. Purpose

This CWI provides guidance on the correct technique of pleural decompression using finger thoracostomy. Where required, this technique can be applied after tension pneumothorax decompression either by the Air Release System (ARS)/IV cannula and/or Arrow Pneumocath.

SCOPE OF PRACTICE					
ARV MO ☒	MFP ☒	MICA ☐	ALS ☐	BLS ☐	CERT/ACO ☐

Indications



Contraindications

Not to be performed on a conscious patient.

Clinical Precautions

- For positive pressure ventilated patients where management of pneumothorax is indicated, pleural depression via finger thoracostomy is the preferred approach.
- Where there is anticipated delay to pleural decompression via finger thoracostomy (e.g. inability to access lateral chest), needle decompression may be considered as a bridging procedure until pleural decompression via finger thoracostomy can be performed.
- This procedure is limited to those patients in which the arm on the affected side can be adequately abducted.
- Consideration must be made to performing the procedure prior to loading the patient into an aircraft due to patient access limitations.
- Components of this procedure require a sterile field and sterile gloves.

Equipment Required

- Chlorhexidine applicator.
- Finger thoracostomy pre-packed kit.
- Tracheostomy tape.
- Sterile surgical gloves.
- Surgical marker pen.

Health, Safety and Welfare

- Apply standard precautions.
- Modify as informed by the dynamic risk assessment.
- It is recommended that paramedics are “double gloved” with sterile gloves, wear safety glasses and a P2 mask.
- There is a risk of body fluid being expelled under pressure when the procedure is initially done or if CPR is subsequently performed.
- There is a risk of finger/hand injury due to fractured ribs or rib fragments whilst performing this procedure.

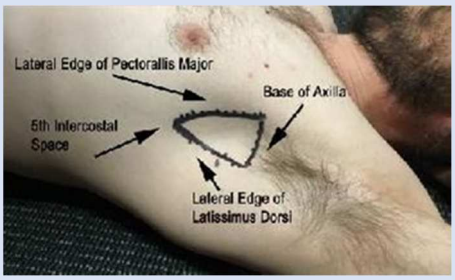
2. Instructions

KEY POINTS	EXPLANATORY NOTE	Y/N
Patient and Paramedic position 1. The Paramedic should be positioned on affected side. This may necessitate removing stretcher from ambulance or aircraft. 2. With the patient supine, abduct the arm so the elbow is at 90 degrees and hand is mid-pronated or in the 'handshake' position.	 Move the elbow to the correct position	
Identify landmarks 3. Take the length of tracheostomy tape and align the acromion and point of elbow. 4. Fold the tape back in half to find midpoint of humerus. Mark the arm. 5. Find the corresponding point on the lateral chest wall at mid axillary line.	   Align the tape before marking the arm	

6. Ensure the mark is within the “triangle of safety”, formed by:

    - lateral border of pectoralis major
    - anterior border of latissimus dorsi
    - base of axilla

    Note: This is generally at the level of the nipple in males or mammary fold in females



Carefully mark out the triangle

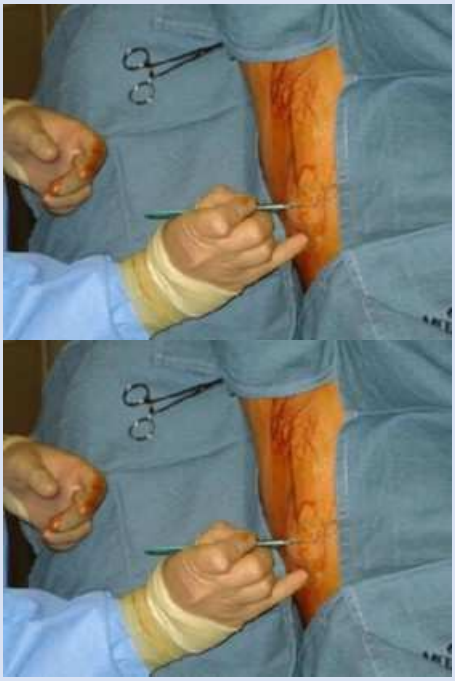
Prepare the site

7. Move the arm so it is in the ‘raise your hand’ position or if possible, place the palm behind the head. The identified site on the skin will move superiorly.
8. Cleanse the site with the chlorohexidine applicator.
9. Don personal protective equipment including two pairs of sterile gloves.
10. Drape the site.

Position the arm correctly before draping the site

Procedure

11. Using a disposable safety scalpel, make a 30-40mm incision into the subcutaneous tissue – overlying the rib below – in the same direction as the rib.
12. Render the scalpel safe.

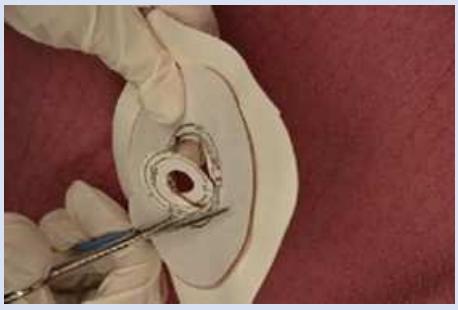


Make an incision in the precise area

13. Insert a finger and locate the intercostal muscles.
14. With curved forceps, dissect through the intercostal muscles whilst supporting the forceps with the non-dominant hand. Maintain proximity to the superior surface of the inferior rib.
15. Penetrate the pleura and anticipate a rush of air and/or blood.
16. Spread the site horizontally and vertically by expanding the forceps.
17. Insert a finger through the pleura and perform finger sweep assessing for air, blood and lung inflation, ensuring the ostomy is large enough to prevent ‘re-tensioning’.

With a finger locate the muscles

Penetrate and anticipate a rush of air and/or blood.

	 Expand the forceps to widen the site  Use a finger to check air, blood and lung inflation	
Post procedure 18. Cleanse the site using sterile gauze only. 19. Apply modified stoma bag to site and monitor for air and blood. 20. If re-tension occurs, using sterile gloves, 're-finger sweep' the site. 21. Dispose of all contaminated waste and sharps.	 Use stoma bag and before disposing	

3. Assessment

Candidate's name and date	Comments

Instructor's name	Satisfactory	
	☐ Yes	☐ No

Document name	**PLEURAL DECOMPRESSION WITH FINGER THORACOSTOMY CLINICAL WORK INSTRUCTION**
Applies to	ARV MO ☒ MICA ☐ ALS ☐ MFP ☒ BLS ☐ CERT/ACO ☐
Document no.	CWI/OPS/170 **Stored:** CM: CWI/OPS/170
Version:	2.0 **Review:** ☐ Annual ☒ 3-Yearly
Division	Medical Directorate
Responsible Executive	Medical Director
Responsible Manager	Manager, Clinical Practice Guidelines — 9840 3980
Review date	By **28 August 2022**, or as required for accuracy.
Relevant National Safety and Quality Health Service Standards	**To be completed by the National Standards Accreditation Lead:** ☐ 1. Clinical governance ☒ 2. Partnering with consumers ☒ 3. Healthcare-associated infection ☐ 4. Medication safety ☐ 5. Comprehensive care ☐ 6. Communicating for safety ☐ 7. Blood management ☒ 8. Recognising and responding to acute deterioration ☐ NSQHS standards are NOT applicable
Material related documents	The following documents are material to this clinical work instruction: • Tension pneumothorax decompression with the Air Release System (ARS) or IV cannula (CWI/OPS/169)

Version control and change history

Version	Date approved	Date superseded	Amendment
1.0	22 August 2016	28 August 2019	• Application of revised CWI template
2.0	28 August 2019	Current	