Injury, Int. J. Care Injured 46 (2015) 1738–1742

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Clamshell thoracotomy and open heart massage—A potential life-saving procedure can be taught to emergency physicians An educational cadaveric pilot study

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ARTICLE INFO

Article history:
Accepted 19 May 2015

Keywords:
Clamshell thoracotomy
Resuscitative thoracotomy
Emergency thoracotomy

ABSTRACT

Aims: Selected patients in traumatic cardiac arrest may benefit from pre-hospital thoracotomy. Pre-hospital care physicians rarely have surgical training and the procedure is rarely performed in most European systems. Limited data exists to inform teaching and training for this procedure. We set out to run a pilot study to determine the time required to perform a thoracotomy and the a priori defined complication rate.

Methods: We adapted an existing system operating procedure requiring four instruments (Plaster-of-Paris shears, dressing scissors, non-toothed forceps, scalpel) for this study. We identified a convenience sample of surgically trained and non-surgically trained participants. All received a training package including a lecture, practical demonstration and cadaver experience. Time to perform the procedure, anatomical accuracy and a priori complication rates were assessed.

Results: The mean total time for the clamshell thoracotomy from thoracic incision to delivery of the heart was 167 s (02:47 min:sec). There was no statistical difference in the time to complete the procedure or complication rate among surgeons, non-surgeons and students. The complication rate dropped from 36% in the first attempt to 7% in the second attempt but this was not statistically significant. This is a pilot study and small numbers of participants arguably saw it underpowered to define differences between study groups.

Conclusion: Clamshell thoracotomy can be taught using cadaver models. In this simulated environment, the procedure may be performed rapidly with minimum equipment.

Introduction

Resuscitation from traumatic cardiac arrest requires a different approach to that used for medical cardiac arrest, with immediate care aimed at identifying and treating reversible causes such as blood loss, tension physiology and, airway obstruction [1–7]. Priorities are not closed chest compression and cardioversion but oxygenation, ventilation, volume replacement, relief of tension pneumothoraces and in selected cases, thoracotomy. This approach may be associated with increasing survival [8–10].

Thoracotomy offers relief of pericardial tamponade, potential to temporize bleeding and internal cardiac massage [8–10]. In pre-hospital care systems that involve a doctor-paramedic team thoracotomy has successfully treated victims of traumatic cardiac arrest, with evidence of unexpected survivors [3,5,11,12]. Emergency department thoracotomy has a neurologically intact survival rate of 0–35% [3,5,13–19]. Favourable outcome is associated with cardiac arrest consequent upon pericardial tamponade, penetrating as opposed to blunt trauma, knife as opposed to gun as wounding mechanism, thoracic as opposed to extra thoracic injuries and shorter delays to treatment [3,5,13–20]. Neurologically intact survival is unusual if the duration of cardiac arrest is greater than 15 min in penetrating and 10 min in blunt trauma [2,14,15]. This narrow time window sees

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http://dx.doi.org/10.1016/j.injury.2015.05.045
0020–1383/

Emergency and Pre-hospital Physicians (EP's) performing thoracotomy when timely transfer to hospital and operating theatre is not feasible. However since EP's may not have a surgical training background and the number of procedures performed per team is low, so training and skill retention are challenging.

There are several techniques described to perform a thoracotomy but the clamshell technique provides excellent exposure and is both rapid and simple to perform [21,22]. This allows the procedure to be performed with the use of only four instruments (Plaster-of-Paris shears, dressing scissors, non-toothed forceps and a scalpel).

In this pilot study we set out to introduce a standard operating procedure and teaching package for clamshell thoracotomy, as described in methods section. We aimed to assess the time taken to for non-surgical trainees and students to perform the procedure and assess the a priori defined complication rate. We benchmarked their performance against experienced surgeons.

Materials and methods

Participants

We recruited a convenience sample of students and doctors based in our institution who work in the pre-hospital arena. Four groups were identified; groups one to three had no surgical experience.

Group 1: Three specialist anaesthetist doctors, all experienced in pre-hospital Emergency Medicine, performing a minimum of two shifts each month for at least 5 years.

Group 2: Three Internal Medicine doctors with experience in pre-hospital Emergency Medicine as above.

Group 3: Five medical students in Emergency Medicine temporarily working as paramedics.

Group 4: Comparison group consisting three surgically trained doctors; one specialist in cardiothoracic (consultant, experience of more than 10 years) and two in trauma surgery (resident, 3 years experience; consultant with more than 15 years experience).

Informed consent was sort from all participants. The study was approved by the local ethical committee (26-252ex13/14).

Cadavers

We used 29 cadavers provided by the Anatomical Institute of the Medical University of Graz and preserved according to the embalming method of Thiel [23]. The study involved 28 cadavers for participant practice, and one for the initial demonstration.

Study equipment

Adapted from Wise et al. [21], we used three types of instrument: two types of scissors (dressing scissors and Plaster-of-Paris shears), dissecting forceps and a scalpel with number 10 blade.

Teaching material

All participants completed a 20-min e-learning lecture, provided 1 week before the study day. This e-learning lecture included a step-by step instruction of how to perform the clamshell procedure (see below 'Surgical procedure') and some schematic drawings of the procedure. The study day involved a 5-min cadaveric demonstration of the clamshell thoracotomy (Fig. 1), followed by each participant performing the procedure under supervision twice in 1 h.

All participants were aware of the study endpoints.

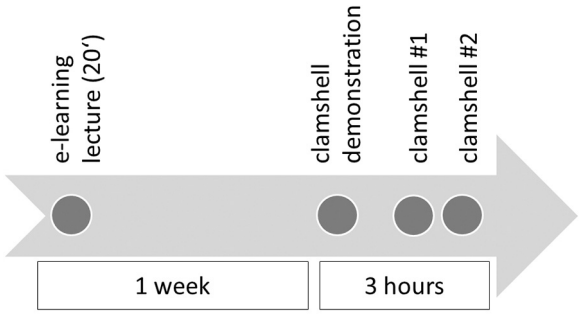

Fig. 1. Timeline for teaching clamshell thoracotomy.

Surgical procedure (clamshell thoracotomy)

We developed a standard operating procedure (SOP) for a clamshell thoracotomy after Wise et al. [21].

Following skin preparation bilateral thoracostomies (without chest tube insertion) are functioned in the fifth intercostal spaces in the mid-axillary line, so decompressing any tension pneumothoraces. If this manoeuvre does not result in return of spontaneous circulation the two incisions are connected by a scalpel incision running along the intercostal space and over the sternum. The scalpel dissects skin and subcutaneous fascia down to intercostal muscle. Intercostal muscle is then separated using the bandage scissors and blunt finger dissection. The Plaster-of-Paris shears are used to cut through the sternum, so joining the left and right thoracic incisions. The chest is then opened. Inadequate chest wall opening may be facilitated by extending the incisions posteriorly. The non-toothed forceps are used to elevate the pericardium centrally and this is then carefully opened with the dressing scissors. Then the incision is extended cranially and caudally, and the heart delivered through the breach in the pericardium and cradled in both hands.

Measurements

The participants were assessed by time, anatomical accuracy of the procedure and a priori defined complications.

Firstly, three different times were recorded:

Time 1: From first skin incision to the transection of the sternum.

Time 2: Duration of the sternotomy.

Time 3: From sternal transection to cardiac massage (pericardiotomy completed and both hands applied on the heart).

Total time was calculated by summation of times 1, 2 and 3.

Secondly, the ability of the participants to identify the correct intercostal spaces (fifth space left and right), and the correct position of the descending aorta were recorded. Latter was marked with a needle.

Finally after every thoracotomy the cadavers were examined by the thoracic surgeon or the main investigator to identify a priori defined injuries, which included: lung laceration during transection of the intercostal spaces; injuries to phrenic nerves, great vessels or the heart including coronary arteries during pericardiotomy. Direct feedback and learning points were discussed with participants.

Injuries to participants were also recorded.

Statistical analysis

All measurements were exported into Microsoft Excel sheets (Microsoft Excel 2010; Microsoft, Redmond, WA, USA) for descriptive statistical analysis. Data was exported into SPSS Statistics (IBM Corp. Released 2012. IBM SPSS Statistics for