Chest decompression during the resuscitation of patients in prehospital traumatic cardiac arrest

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ABSTRACT

Background: Tension and bilateral pneumothorax can cause or contribute to death following trauma. A surgical incision (thoracostomy) or needle decompression through the chest wall rapidly treats these conditions. Resuscitation of patients in traumatic cardiac arrest focuses on treating common and reversible life-threatening conditions. A study was undertaken to observe the practice, findings and outcome of chest decompression when performed as part of the resuscitation strategy of these patients by air ambulance crews.

Methods: Patients in prehospital traumatic cardiac arrest were identified over a 39-month period from an air ambulance database. The use of thoracostomy or needle decompression was identified together with indications, findings and outcome. Primary outcome was return of cardiac output by arrival at hospital.

Results: 18 of 37 cases underwent chest decompression (17 thoracostomy, 1 needle decompression). Four patients had a return of cardiac output (3 tension pneumothorax, 1 bilateral pneumothorax). Six further cases were positive for intrathoracic injury. In 2 cases the injuries identified were incompatible with life and resuscitation efforts were consequently ceased.

Conclusions: Chest decompression in traumatic cardiac arrest identifies and treats a high proportion of potentially life-ending injuries and should be considered as part of the resuscitation effort of patients in traumatic cardiac arrest. In a proportion of patients, non-survivable injuries are identified which guide resuscitation efforts.

Traumatic thoracic injuries are the primary cause of death in up to 25% of cases and contribute to a further 25%.[1] Chest injuries cause respiratory compromise by affecting ventilation in cases of bilateral pneumothorax, large pneumothorax and impede cardiac return in tension pneumothorax. These conditions can rapidly lead to loss of cardiac output and are recognised as reversible causes of traumatic cardiac arrest.

Successful management of these patients depends on rapidly diagnosing and treating the underlying condition as part of an advanced ABC approach to resuscitation. Standard in-hospital management includes the insertion of a chest drain together with endotracheal intubation and ventilation. However, time is of the essence, particularly in prehospital care where numbers of resuscitation personnel are limited. During initial resuscitation this procedure can be shortened to perform a dissection and finger sweep into the thoracic cavity (thoracostomy) allowing diagnosis (audible release of air or appreciation that the lung is not adjacent to the thoracic wall) and treatment.[2] Furthermore, haemothorax can be identified, the volume of blood quantified and conditions incompatible with survival such as large airway disruption or massive haemothorax can be diagnosed, aiding decision-making when ceasing resuscitation efforts. Under current national guidelines, paramedics are not permitted to perform thoracostomy but may perform needle chest decompression (NCD) of the thoracic cavity when treating a suspected tension pneumothorax.[3] This permits treatment of a tension pneumothorax but can be complicated by not traversing the chest wall,[4] becoming blocked with tissue and does not allow appreciation of pneumothorax, haemothorax or continuing air leak.[5 6]

The main aim of this study was to identify the use of chest decompression (thoracostomy or NCD) in cases of prehospital cardiac arrest and to observe the effect on outcome and decision-making. Thoracostomy is widely used in contemporary prehospital care in patients with a cardiac output,[7 8] but is not well described as part of the resuscitation of patients in cardiac arrest. The primary outcome measure of the study was return of cardiac activity following thoracostomy. Secondary outcome measures included analysis of findings and their effect on decision-making.

METHODS

All patients on initial clinical assessment by air ambulance crews without signs of life following traumatic injury were identified by searching a Microsoft Access database at the Warwickshire and Northamptonshire Air Ambulance. Patients with isolated head injuries, penetrating thoracic trauma mandating thoracotomy or hangings were excluded. Data were recorded prospectively. The study period was January 2004 to March 2008 inclusive (39 months). Subsequent management including attempts at resuscitation, chest decompression (either thoracostomy or NCD), clinical examination of the thorax before and after any procedure and return of spontaneous cardiac activity (ROSC) were recorded. The primary outcome was taken as ROSC and cardiac activity on arrival at hospital. Secondary outcome measures were positive identification of pneumothorax following chest decompression, presence of haemothorax, survival at 30 days, decision to confirm death at the scene or transfer of the patient to hospital.

The air ambulance is crewed with either a doctor and paramedic or a double paramedic crew depending on doctor availability. Air ambulance doctors meet training criteria[9] and treat suspected tension pneumothorax with NCD or thoracost-

omy (2–3 cm incision extended into the pleural space with blunt or sharp dissection followed by a finger sweep in the fourth or fifth intercostal space in the anterior axillary line). Paramedics work within Joint Royal Colleges Ambulance Service Liaison Committee guidelines where NCD is advocated to treat suspected tension pneumothorax.

Categorical data were compared using the χ^2 test and the Fisher exact test where a value was below 5.

RESULTS

Prehospital traumatic cardiac arrest was identified in 61 patients, 37 of whom received resuscitation attempts. The presence of a doctor among the air ambulance crew had no significant effect (doctor and paramedic crew 62% (28/45) vs double paramedic crew 56% (9/16); p = 0.89). Chest decompression was performed in 18 cases; this was more likely by doctor-led crews (61% (17/28) vs 11% (1/9); p = 0.01) who used thoracostomy in every case. Paramedic crews used NCD once. No complications of the procedures were recorded.

Four patients undergoing chest decompression had ROSC activity and transfer to hospital; in each case potentially life-ending injuries were diagnosed and treated (3 tension pneumothorax, 1 bilateral pneumothorax). In a further four cases, potentially life-ending injuries were diagnosed and treated but were not associated with a ROSC (3 tension pneumothorax, 1 pneumothorax). In two more cases, chest decompression diagnosed non-survivable thoracic injuries resulting in cessation of resuscitation at the accident scene (1 massive haemothorax (''aortic disruption?''), 1 massive air leak (''major airway disruption'')).

The positive predictive value of chest decompression performed for positive clinical signs was 1 (N = 5/5). Conversely, chest decompression performed due to mechanism of injury in the absence of either external or clinical signs of chest injury had a positive predictive value of 0 (N = 0/4). When decompression was performed on the basis of external signs of chest injury alone, the positive predictive value was 0.56 (N = 5/9). These associations were significant (p = 0.009).

Table 1 details the clinical findings, procedure and outcome for all patients undergoing chest decompression.

Of the four patients who gained ROSC activity, three died on the day of injury and the fourth died the following day. The cause of death was non-survivable head injury in all cases. The patient who survived 1 day underwent organ donation before cessation of artificial ventilation.

DISCUSSION

Thoracostomy is frequently performed as part of resuscitation efforts by doctor-led HEMS crews treating patients in traumatic cardiac arrest. The high incidence of pneumothorax observed in this cohort of patients—particularly when associated with either external or clinical signs of chest injury—supports this

Table 1 Case descriptions when chest decompression was used during resuscitation of patients following traumatic cardiac arrest: mechanism of injury, clinical findings, transfer to hospital and ROSC activity

Crew*	MOI	Mechanism of chest decompression	ROSC	Clinical signs of pneumo thorax†	Pneumo thorax confirmed	Indication	Findings	Findings 2	Transfer to hospital	Findings influenced decision to cease resuscitation?
Doctor	RTC car	Thoracostomy	Yes	Yes	Yes	Decreased AE L side	Tension (L)		Yes	
Para	Suicide (jumped off bridge)	NCD	Yes	Yes	Yes	Decreased AE L side	Tension (L)		Yes	
Doctor	RTC car	Thoracostomy	Yes	No	Yes	MOI: chest injury	Tension (Bil)		Yes	
Doctor	RTC car	Thoracostomy	Yes	No	Yes	MOI: chest injury	Pneumothorax (Bil)	Haemothorax	Yes	
Doctor	RTC motorcyclist	Thoracostomy	No	Yes	Yes	Hyperexpanded chest	Tension (Bil)	Haemothorax	No	
Doctor	RTC motorcyclist	Thoracostomy	No	Yes	Yes	Hyperexpanded chest and decreased AE	Tension (R)		No	
Doctor	RTC motorcyclist	Thoracostomy	No	Yes	Yes	Decreased AE L side	Pneuothorax (L)		No	
Doctor	RTC car	Thoracostomy	No	No	Yes	MOI: chest injury	Pneumothorax (Bil)	Huge haemothorax ? Aortic disruption	No	Yes
Doctor	RTC car	Thoracostomy	No	No	Yes	MOI: chest injury	Tension (L)		No	
Doctor	RTC motorcyclist	Thoracostomy	No	No	Yes	MOI: chest injury	Pneumothorax (Bil)	Massive air leak ? Bronchial disruption	No	Yes
Doctor	RTC car	Thoracostomy	No	No	No	MOI: chest injury	Nil		No	
Doctor	RTC car	Thoracostomy	No	No	No	MOI: chest injury	Nil		Yes	
Doctor	RTC pedestrian	Thoracostomy	No	No	No	MOI: chest injury	Nil		No	
Doctor	RTC motorcyclist	Thoracostomy	No	No	No	MOI: chest injury	Nil		No	
Doctor	Airplane crash	Thoracostomy	No	No	No	MOI	Nil		No	
Doctor	RTC car	Thoracostomy	No	No	No	MOI	Nil		No	
Doctor	RTC pedestrian	Thoracostomy	No	No	No	MOI	Nil		Yes	
Doctor	Sky dive accident	Thoracostomy	No	No	No	MOI	Nil		No	

AE, air entry; Bil, bilateral; MOI, mechanism of injury; L, left; R, right; ROSC, return of spontaneous cardiac activity; RTC, road traffic collision.
*HEMS crew composition: doctor, doctor and paramedic; para, double paramedic.
†Clinical signs of pneumothorax were those elicited from clinical examination of the chest (these include: decreased air entry, hyper-resonant thorax, tracheal deviation, high airway pressures during ventilation, subcutaneous emphysema) and did not include external signs of chest injury such as contusions or rib fractures.

practice. Thoracostomy is part of the wider resuscitation effort which includes intubation, ventilation, intravenous or intraosseous access with fluid replacement. We cannot therefore provide clear evidence that chest decompression was responsible for the ROSC activity in these cases. However, the incidence of tension pneumothorax and bilateral pneumothorax among these patients logically supports the association and practice. Relying on clinical signs of the thorax alone will not identify all patients with these injuries, and our data support extending the practice into all patients with a suitable mechanism of injury together with external evidence of chest injury.

Chest decompression was performed less frequently by paramedic crews. This is likely to reflect the personal experience of the HEMS doctors who are observing a high incidence of intrathoracic injuries when performing thoracostomy, which is likely to influence practice positively. Appreciation of most of these injuries is only possible with thoracostomy. Given the observed incidence of tension pneumothorax in our cohort of patients, we support the routine practice of bilateral chest decompression by suitably trained paramedic crews as part of the resuscitation attempts of these patients. This must be the wider paramedic community, including land as well as air ambulance paramedics.

Our aim is to provide advanced prehospital clinical practice that translates into improved morbidity and mortality. It is therefore disappointing that, despite achieving ROSC activity in a proportion of patients, none survived to leave hospital. There is some comfort in knowing that one of the patients survived long enough to contribute to an organ donation programme. Presumably this may not have been the case if advanced prehospital care including chest decompression had not been performed.

Head injuries were responsible for all deaths following ROSC activity and this reflects trauma mechanisms in the UK.[10] We have observed a high incidence of potentially life-ending thoracic injuries which can be quickly treated by thoracostomy and, despite the incidence of non-survivable head injury among these patients, we will continue to advocate this practice. We assume that a small proportion of patients will survive this process. A review of 909 patients with all-cause prehospital traumatic cardiac arrest found that 9% of survivors (6/68) underwent decompression of tension pneumothorax.[11] If patients are not clearly dead, our default position is to begin resuscitation efforts. As time is of the essence, thorough identification of injuries cannot be performed in many patients without delaying resuscitation. Frequently, as the resuscitation evolves, injuries are appreciated that eventually lead the crew to cease the resuscitation. Furthermore, we have observed that thoracostomy adds to this process in a proportion of patients. Declaring death at the scene impacts on the efficiency of this limited resource and allows other emergency services to conduct their business.

We have identified a high proportion of patients in prehospital traumatic cardiac arrest with potentially life-ending injuries who can be treated and diagnosed by chest decompression. In all patients undergoing resuscitation attempts, the practice of routine chest decompression must therefore be considered and, we suggest, is mandatory if external or clinical signs of injury are present.

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