BUTTERWORTH HEINEMANN

Injury Vol. 26, No. 9, pp. 581–585, 1995

0020–1383/95 $10.00 + 0.00

0020-1383(95)00107-7

Pre-hospital management of patients with severe thoracic injury

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The physiological variables of oxygen saturation, blood pressure and pulse rate were compared in the pre-hospital phase and on arrival at hospital in a group of 63 patients with severe chest injury. Eighty-nine pre-hospital thoracic drainage procedures were carried out. Pre-hospital Advanced Trauma Life Support (ATLS) was associated with a significant improvement in all three variables. Median oxygen saturation increased by 17 per cent ($P < 0.001$), median blood pressure increased from 90 to 120 mmHg ($P < 0.001$) and median pulse rate decreased from 125 to 105 ($P < 0.001$). Pre-hospital intervention is indicated for tension pneumothorax, and contraindicated for haemothorax without respiratory compromise. In other situations further evidence is required, and standard ATLS protocols should be used until this is available.

Injury, Vol. 26, No. 9, 581–585, 1995

Introduction

There is controversy about the best form of pre-hospital treatment for patients with thoracic injury. Thoracic drainage is the definitive management for most patients with thoracic injury, and is a life saving intervention during initial in-hospital management of the injured, with well-established indications[1,2]. Needle chest decompression is a recognized procedure in many American pre-hospital Emergency Medical Service systems[3], but little evidence of the results of these interventions has been published. At present 'there is little evidence available to define the place of thoracic drainage in pre-hospital care',[4] apart from case reports[5].

Materials and methods

Ambulance Services task the Helicopter Emergency Medical Service (HEMS) to patients with severe injuries[6]. The helicopter medical team consists of an Ambulance Paramedic and an Advanced Trauma Life Support (ATLS) trained post-fellowship Registrar in Trauma and Immediate Care[7]. This team performs on-scene resuscitation, then transfers the patient to the nearest appropriate hospital.

A retrospective study was undertaken of all patients who had a thoracic drainage procedure performed between 1 January 1991 and 31 June 1992. Vital signs, oximetry, type of intervention, Injury Severity Score (ISS), complications of thoracic drainage, and outcome were extracted from the trauma database. The first set of physiological variables were taken at the incident scene, as soon as possible after initial assessment and resuscitation manoeuvres. The second set used in this study were taken on arrival at the Emergency Room. If no Emergency Room data were available the last pre-hospital value was substituted.

Blood pressure measurement and oximetry were performed using a Propaq 106 (Protocol Systems, Fenstanton, UK) monitor throughout. Data before and after pre-hospital treatment were compared using the Wilcoxon signed rank test.

Results

Of 1048 patients attended by the HEMS, thoracic drainage was performed in 63 (6 per cent). Twelve patients sustained penetrating injuries (19 per cent). Twenty-six procedures were bilateral, giving a total of 89 hemithoraces drained. The mean age was 35 years (range 4–80 years). Most patients had haemopneumothoraces, but were classified according to the predominant feature. Tension pneumothorax occurred in 57 hemithoraces (64 per cent), massive haemothorax in 20 hemithoraces (22.5 per cent), simple pneumothorax with no high-pressure escape of air following drainage in nine hemithoraces (10 per cent), and lung contusion alone in three (3.5 per cent) (*Table I*).

Fifty-four (86 per cent) patients in whom thoracic drainage was performed had an abnormal respiratory rate, outside the range 10–29, on the first recorded observation and 26 (41 per cent) had an initial Revised Trauma Score (RTS)[8] of 0 (cardio-respiratory arrest). Including the 26 in cardio-respiratory arrest, 43 (68 per cent) patients were ventilated. Only one of the 43 ventilated patients survived, most having a combination of severe chest and head injuries with a median Injury Severity Score[9] of 45 (interquartile range 34–57).

Table I. Indication for thoracic drainage in 89 hemithoraces

Tension pneumothorax	57
Massive haemothorax	20
Simple pneumothorax	9
Lung contusions	3

Table II. Outcome, indication for thoracic drainage and Injury Severity Score for 63 patients

	Unilateral Procedure				*Bilateral Procedure*			
	Tension pneumothorax	*Massive haemothorax*	*Pneumothorax*	*Contusions*	*Bilateral tension pneumothorax*	*Other bilateral pathology*	*Total*	*Median ISS*
Survived	9	2	4	2	0	2	19	25
Died in hospital	6	1	0	0	2	0	9	50
Died before admission to ward	3	2	0	1	1	4	11	34
Dead on scene	4	2	0	0	12	6	24	—

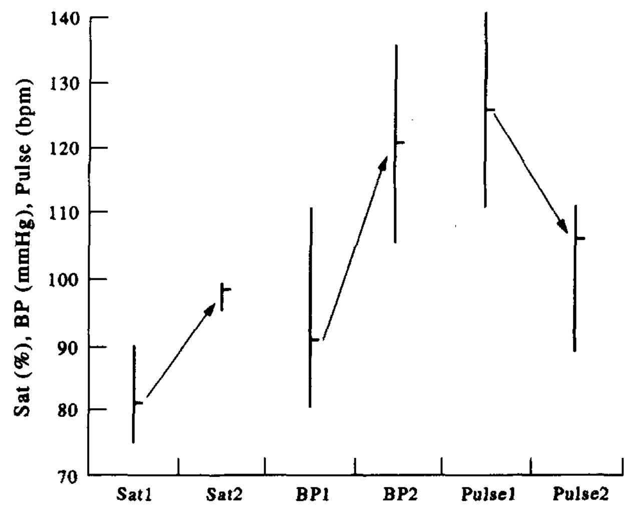

Figure 1. Overall changes in each physiological variable following pre-hospital treatment (median and interquartile range).

Seventeen hemithoraces (19 per cent) were treated by standard needle chest decompression only. Seven of these patients were ventilated. Thirty-three (37 per cent) were treated by formal tube thoracostomy only and 35 (39.5 per cent) were treated by standard needle chest decompression followed by tube thoracostomy. Four (4.5 per cent) pre-hospital thoracotomies were performed, the indication for each being a witnessed cardiac arrest at the incident scene caused by penetrating trauma. None of these patients survived.

Twenty-five (40 per cent) patients were declared dead at the accident scene. Twenty-four of these patients were in cardio-respiratory arrest on arrival of the medical team. Eleven (17.5 per cent) patients died in hospital before reaching a ward, and nine (14 per cent) died in a ward. Eighteen (28.5 per cent) patients survived, nine of whom had a unilateral tension pneumothorax. The median ISS and indication for thoracic drainage for each of these groups is shown in *Table II*.

The changes in physiological variables are shown in *Figure 1*. Of the 39 patients that reached hospital alive 22 had paired initial and findal recordings of oxygen saturation. The median oxygen saturation changed from 81 per cent (interquartile range 75–90) to 98 per cent (interquartile range 95–99) following pre-hospital treatment ($P < 0.001$). The median blood pressure (39 paired recordings) changed from 90 mmHg (interquartile range 80–110) to 120 mmHg (interquartile range 105–135), ($P < 0.001$). The median pulse rate (39 paired recordings) changed from 125 (interquartile range 110–140) to 105 (interquartile range 88–110), ($P < 0.001$).

The median change in oxygen saturation for patients who required both ventilation and a chest drain was +20 per cent (interquartile range +10 per cent to +23 per cent). The corresponding median change for patients who required chest drainage, but not ventilation, was +10 per cent (interquartile range +1 per cent to +15 per cent). These groups of patients are not comparable as they had very different injuries, with a large number of severe head injuries in the ventilated group.

There were no infected drain sites in this series. A single extra-thoracic placement of a drain was noted and corrected during the pre-hospital phase. One patient had an unnecessarily large skin incision (12 cm). Post-mortem examination of patients who died in hospital showed no evidence of iatrogenic injury.

Discussion

Assessment of the effect of a pre-hospital intervention is a complex problem due to the large number of variables that come into play between a treatment and eventual morbidity or mortality. There are many variables involved as multiple injury embraces a wide range of underlying pathology. The best way to solve a complex problem is to break it down into a number of simple components. If pre-hospital treatment is to have an effect on long-term outcome, it is also likely to have a measurable immediate effect on the pathophysiological state of the patient. The first step towards defining the effect of treatment on outcome is to ask if there is any immediate benefit.

The ideal controlled trial to establish the physiological effect of pre-hospital treatment of patients with severe chest injury would require the withholding of treatment from a control group of patients assessed as needing emergency thoracocentesis until arrival in hospital. This was not considered to be ethically acceptable before a review of the effects of current practice, and so no control group was included in this initial study.

Resuscitation by the HEMS medical team follows ATLS guidelines which provide the foundation for pre-hospital trauma management[10]. The practical data necessary to define a protocol for pre-hospital thoracic drainage are not available, so the Standard Operating Procedures for the HEMS team follow the standard ATLS guidelines. Indications for thoracic drainage therefore include tension pneumothorax, hypoxia associated with simple pneumothorax, and massive haemothorax. While one member of the medical team secures the airway and cervical spine, administering a high concentration (80–100 per cent) of oxygen, the other assesses breathing and treats the chest.

Some roles can be performed by either member of the HEMS team as the paramedics are trained to perform needle chest decompression under medical supervision. This is useful when a complex airway problem or the need for an anaesthetic requires the doctor's attention. Formal tube thoracostomy is performed by the doctor. The placement of the chest tube or anterior chest thoracocentesis is carried out as a standard ATLS technique[1]

There are difficulties in the assessment of changes in physiological variables. Critical interventions must come before full assessment, so blood pressure and oxygenation was usually not measured until after the Primary Survey and critical interventions. This creates a bias against finding the significant differences shown by this study, as the interventions made, such as intubation and thoracic drainage, are likely to have caused an (unmeasured) improvement in the patient's physiological state. Neither respiratory rate or Glasgow Coma Score could be recorded after treatment because 68 per cent of patients were anaesthetised and ventilated, so an analysis of changes in these variables could not be performed.

Pre-hospital anaesthesia with intubation and ventilation is likely to have a major effect on the physiological status of the injured patient. It is not possible to isolate the physiological effect of thoracic drainage from that of ventilation. A comparison of the physiological changes in ventilated patients with and without chest drains does not compare like with like, as the underlying injuries are different between these groups.

This series demonstrates a significant improvement in oxygen saturation and blood pressure, and a significant fall in pulse rate following pre-hospital treatment of patients with severe chest injury requiring thoracic drainage. Following pre-hospital treatment and median and interquartile ranges for all these variables fall within the normal range.

There was only one survivor in the group that required both pre-hospital thoracic drainage and ventilation, the indication for ventilation in these patients being severe head injury. This poor prognosis for patients with a combination of head and chest injury is well known[11].

The survivors of tension pneumothorax in this series are unlikely to have survived without roadside treatment, however a formal trial of the effect of thoracic drainage on survival cannot be carried out as it is unethical to withhold treatment for a life-threatening condition. A small study in Belgium identified the pre-hospital relief of tension pneumothorax as the main factor leading to improved survival in patients treated by a doctor[12]. The presence of bilateral tension pneumothoraces is shown to be strongly associated with death at the incident scene in the present series.

Two patients with a simple pneumothorax had respiratory compromise, one with an oxygen saturation of 80 per cent and the other a respiratory rate of 33. Both these abnormalities resolved with pre-hospital thoracic drainage. Three simple pneumothoraces were drained due to clinical suspicion that they might be under tension, but no high-pressure escape of air was heard. A further three simple pneumothoraces were drained pre-emptively, to prevent tension occurring during transport. In an Intensive Care Unit, close observation without drainage may be used in this situation[13]. Monitoring and intervention during transport can be difficult and prophylactic chest drainage is prudent. In this series there are too few patients in the unilateral massive haemothorax and unilateral simple pneumothorax groups to make a comparison of physiological changes for each underlying pathology.

Diagnostic errors occurred in six (7 per cent) patients, three lung contusions were thought to be haemothoraces and three simple pneumothoraces were thought to involve tension. Misdiagnosis of lung contusion as massive haemothorax is due to the presence of chest injury with hypoxia, hypotension and a dull, silent hemithorax in both conditions. No patient arrived in the Emergency Room with an untreated tension pneumothorax, or massive haemothorax with respiratory compromise. Previously a 4 per cent error rate has been shown for chest tube insertion in the Emergency Room following penetrating trauma[14]; decisions being least accurate when emergency drainage was required before chest radiography.

The pre-hospital assessment of the chest requires the evaluation of subtle signs which may be masked by noise or precluded by difficult access to the patient. The anxiety engendered by the accident scene and an urge to transport the patient before full stabilization may also create mistakes. Errors are minimised by training, initial performance under direct supervision, then indirect supervision by video and continuing audit.

A comparison between different forms of thoracic drainage cannot be made from this series as the numbers receiving only tube thoracostomy or only needle decompression are small. There were major differences in injury severity between the patients in each group. Many of the patients receiving needle decompression alone suffered a cardio-respiratory arrest before the arrival of the medical team, and if there was no response to resuscitation they were declared dead at the incident scene without placement of a tube thoracostomy. In three cases transport following a needle chest decompression was considered a higher priority than formal chest drainage, and so this procedure was delayed until arrival in the Emergency Room. Needle decompression alone may allow patients to reach hospital for formal thoracostomy under sterile conditions, but a pure tension pneumothorax is uncommon after injury, and any blood in the effluent will block the cannula. This occurred five times in this series. Symptoms of tension returned, with escape of air under pressure on insertion of the definitive drain. This risk of cannula blockage makes patient movement without formal tube thoracostomy inadvisable except in exceptional circumstances. Immediate placement of a large bore drain following needle thoracostomy prevents this complication, and conforms to ATLS protocols.

The speed with which a standard chest drain can be inserted in the anaesthetised or unconscious patient has led to its use as a primary procedure, without prior needle decompression. Although this does not conform to ATLS protocols, release of tension is achieved with a speed comparable to needle decompression, and the optimum endpoint of large bore drainage is achieved more rapidly.

Of 52 needle chest decompressions, 17 were performed by ambulance personnel under strict medical supervision, without complication. Although this demonstrates that British ambulance personnel can perform the technique of needle chest decompression safely, this is not evidence that they have the diagnostic ability to determine when the procedure should be performed, or that they could perform it safely without direct medical control.

Patients that suffer a cardio-respiratory arrest at the incident scene following penetrating trauma have a grim prognosis if treatment is delayed until arrival in hospital. Some feel that no attempt at resuscitation is worthwhile[15].

Pre-hospital intervention may give different results, but there are too few pre-hospital thoracotomies in this series to draw any conclusion about the utility of this procedure. This is the subject of further investigation.

The complication rate following thoracic drainage has been reported as being as high as 44 per cent with an empyema rate of 1–5 per cent[16,17,18]. The absence of iatrogenic injury or infective complication in this series illustrates that this is a safe procedure when performed by doctors well practised in pre-hospital care. A realistic empyema rate after pre-hospital thoracic drainage cannot be determined from these data as only 18 survivors could be assessed. Each HEMS registrar performs two field chest drains each month. An occasional operator is likely to have a higher complication rate.

The place of thoracic drainage in the resuscitation room is well defined. The presence of an appropriately trained doctor at the roadside allows earlier definitive intervention[19], but protocols for in-hospital intervention may not be appropriate for pre-hospital care.

Further investigation is needed to determine which sub-groups of injured patients benefit from pre-hospital intervention. It would be wrong to withold immediate decompression from patients with tension pneumothorax, although such patients could be randomized to receive either tube thoracostomy or simple thorocostomy. Patients with either a simple pneumothorax, or haemothorax need to be randomized, half receiving pre-hospital drainage and all (especially those with positive pressure ventilation) having close observation during transport with immediate intervention for signs of tension.

The outcome measures used for the evaluation of the effect of pre-hospital interventions need to be carefully chosen. This study demonstrates that changes in pathophysiology can be used to assess the early effects of treatment. However an early improvement may not lead to a better outcome. Other measures, such as the volume of blood transfused in the first 24 h, may also need to be included.

Thoracic drainage was used as part of intensive pre-hospital resuscitation of patients with severe chest injury, being combined with airway management, supplemental oxygen and volume replacement. This treatment leads to significant improvement in physiology.

Suspected tension pneumothorax should always be decompressed in the pre-hospital phase. Further evidence is needed about the best management of other complications of thoracic trauma. Haemothorax without respiratory compromise should not be drained, nor should a simple pneumothorax without respiratory compromise in the spontaneously breathing patients. The management of simple pneumothorax in the ventilated patient has not been established, but a prophylactic chest drain seems prudent, especially in a patient who requires helicopter transport. For patients with pre-hospital respiratory compromise associated with simple pneumothorax or haemothorax it seems sensible to apply standard in-hospital ATLS algorithms until further evidence is available.

Conclusion

The findings of this series show that pre-hospital treatment of patients with severe chest injury using standard ATLS protocols leads to significant improvements in pulse, blood pressure and oxygen saturation.

Needle chest decompression alone is an inadequate pre-hospital treatment for traumatic tension pneumothorax, as blockage of the needle occurs and reaccumulation is difficult to monitor during transport. Immediate conversion to tube thoracostomy is required. Needle chest decompression is technically successful in the hands of British Paramedics, although their diagnostic capability has not been assessed.

Doctors involved in pre-hospital care should be experienced in thoracic tube placement with frequent practice of the technique, although further study is required to define the place of this intervention in pre-hospital care.

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Paper accepted 31 May 1995

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