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Walker, S., Maskell, N., Barratt, S., & Thompson, J. (2018). Conservative Management in Traumatic Pneumothoraces: An Observational Study. *Chest*, *153*(4), 946-953. https://doi.org/10.1016/j.chest.2017.10.015

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Conservative Management in Traumatic Pneumothoraces: An Observational Study.

Total Word Count: 2757

Conservative Management in Traumatic Pneumothoraces: An Observational Study.

Running head: Conservative Management in Traumatic Pneumothoraces

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Abbreviations

Advanced Trauma Life Support (ATLS)

Computerised tomography (CT)

General Anesthetic (GA)

Glasgow Coma Scale (GCS)

Hazard ratio (HR)

Injury severity score (ISS)

Interquartile range (IQR)

Major Trauma Centre (MTC)

Peripheral Oxygen Saturation (SpO2)

Positive pressure ventilation (PPV)

Standard Deviation (SD)

Systolic blood pressure (SBP)

Trauma Audit and Research Network (TARN)

Abstract

Background:

Traumatic pneumothoraces are a common consequence of major trauma. Despite this, there is a paucity of literature regarding their optimal management, including the role of conservative treatment. The aim of this study was to assess the treatment, complications and outcomes of traumatic pneumothoraces in patients presenting to a Major Trauma Centre.

Methods:

The prospectively collected Trauma Audit and Research Network (TARN) database was used to identify all patients presenting with traumatic pneumothoraces to a UK Major Trauma Centre from April 2012 to December 2016. Demographics, mechanism of injury, injury severity score (ISS), management and outcomes were analysed.

Results:

602 patients were included in study period. Mean age 48 (SD 22) with 73% male. Mean ISS was 26 and inpatient mortality 9%. Of the 602 traumatic pneumothoraces, 277/602 (46%) were initially treated conservatively. 252/277 (90%) of this cohort did not require subsequent chest tube insertion, including the majority, 56/62 (90%), of patients on admission positive pressure ventilation (PPV). Hazard ratio for failure of conservative management showed no difference between the ventilated and non-ventilated patients (HR 1.1 p 0.84). Only the presence of large hemothorax was associated with increased likelihood of failure of conservative management.

Conclusions:

In the largest observational study of traumatic pneumothoraces published to date, over 90% of patients whose pneumothorax was managed conservatively never required subsequent tube drainage. Importantly, this also applies to patients requiring PPV, with no significant increased risk of failure of expectant management. This data supports a role for conservative management in traumatic pneumothoraces.

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Introduction

Traumatic pneumothoraces are present in a fifth of multiple trauma patients(1) and is the most common potentially life-threatening injury in blunt chest trauma(2). Thoracic trauma occurs in nearly two thirds of multiple trauma cases and represents the primary cause of death in 25% of trauma(3). Trauma as a whole, is a major public health problem, with over 150,000 deaths and over 3 million non-fatal injuries per year in the US(4), representing the leading cause of death for individuals under 45 years of age(5).

Whilst an uncomplicated traumatic pneumothoraces may be well tolerated, the risk of tension and resultant cardiorespiratory compromise makes identification important, particularly as a basic procedure, tube thoracostomy insertion, can potentially avert significant morbidity and mortality(6). Current guidance by the American College of Surgeons Advanced Trauma Life Support (ATLS)(7) advises chest tube placement for any traumatic pneumothorax, though it suggests that asymptomatic pneumothoraces can be managed with observation and aspiration at the treating physicians discretion. It does, however, state that a chest drain is required in patients receiving either general anesthesia or positive pressure ventilation (PPV) to avoid a life-threatening pneumothorax(7).

This concept has been challenged, principally with the increased use of computerised tomography (CT) scans in trauma, identifying small, sub-centimetre sized pneumothoraces. This has raised the question whether these small 'occult' pneumothoraces, which can make up to 76% of all traumatic pneumothoraces(8), can be left untreated, particularly when positive pressure is required. Despite an early study indicating a high rate of tension in conservatively management patients on positive pressure ventilation(9), more recent studies (6, 8, 10-12) suggest that occult pneumothoraces can be managed expectantly, including patients receiving PPV.

Whether these results can translate to all traumatic pneumothoraces is unclear and needs clarification. CT is now almost ubiquitous in multiple trauma patients, and the distinction between occult and overt pneumothoraces may become antiquated. Recent case studies have also suggested it is possible to treat larger pneumothoraces with observation (2, 13).

The aim of our study was to use a large trauma patient cohort to create a profile of consecutive patients presenting with traumatic pneumothoraces to examine the outcomes of conservatively managed patients, and determine whether there are factors that can help predict whether a chest tube is required.

Methods

Patients were identified, from April 2012 to November 2016, as part of the Trauma Audit and Research Network (TARN) on patients presenting to emergency department at Southmead Hospital, a regional UK Adult Major Trauma Centre (MTC). It covers a population of 2.3 million, is supported by 6 other trauma unit hospitals and admits over 1000 major trauma patients/year. The TARN registry is a prospective, observational registry of hospitalised major trauma patients in England and Wales. TARN has ethical approval (Section 251) for research on the anonymised data submitted by member hospitals. The TARN database includes all trauma patients irrespective of age who have a direct admission or transferred in whose length of stay is 3 days or more or admitted to a High Dependency Area regardless of length of stay. It also includes deaths of trauma patients occurring in the hospital including the Emergency Department and those transferred to other hospital for specialist care or for an ICU/HDU bed. Certain specific injuries were excluded), including isolated neck of femur or inter/greater trochanteric fractures over 65 years.

ICD-10 codes included were S270 (Traumatic pneumothorax), S270 (Traumatic pneumothorax closed), S2701 (Traumatic pneumothorax open), S271 (Traumatic hemothorax), S2710 (Traumatic hemothorax closed), S2711 (Traumatic hemothorax open), S272 (Traumatic hemopneumothorax), S2720 (Traumatic hemopneumothorax closed), S2721 (Traumatic hemopneumothorax open).

Information was collected on demographics, injury (mechanism of injury, description of injuries, Injury Severity Score (ISS)), management (type, size of drain, length of drain placement) and pneumothorax characteristics (laterality, size and accompanying hemothorax). Airway support was characterised as either requiring positive pressure ventilation pre-hospital or in the Emergency Department (initial PPV) or requiring PPV subsequently due to GA administration or clinical deterioration (subsequent PPV). Size of pneumothorax was taken for chest radiographs at hilum and apex, and on CT, the largest collection was measured along a line perpendicular from chest wall to lung or mediastinum. Clinical parameters were taken from initial observations on attendance to the Emergency Department. Respiratory distress was determined if either respiratory rate was ≥30 or <8; if supplementary 02 or mechanical or manual ventilation was used; a Sp02 ≤90% or if the patient was in respiratory arrest. Hemodynamic instability was determined if SBP <90mmHg or heart rate ≥ 100bpm. Conscious level impairment was determined if either GCS <15 or the patient was ventilated at arrival.

Statistical analysis

Descriptive statistics were used to summarise patient characteristics and clinical data. Means (±SD) were calculated for parametric data and medians (IQR) were calculated non-parametric data. Several checks for normality, including Kolmogorov-Smirnov, Shapiro-Wilk, kurtosis and skewness calculations were performed. Continuous parametric variables were analysed using independent t-test and continuous non-parametric variables were analysed using Mann-Whitney test. Categorical data was analysed using Chi-squared test. A P-value of <0.05 was considered statistically significant.

Univariate proportional hazard ratios were calculated using Cox regression analysis for factors associated with failure of conservative treatment (size of pneumothorax, mechanism of injury, ISS, presence of ribs fractures, clinical features (respiratory, hemodynamic, GCS), presence of hemothorax, bilateral versus unilateral pneumothorax, use of PPV and surgical procedures). Further multivariable cox regression analysis was performed to determine which factors (age, size of pneumothorax, ISS, presence of ribs fractures, clinical conditions (respiratory, hemodynamic, GCS), presence of hemothorax, bilateral versus unilateral pneumothorax and use of PPV) were independently predictive of failure of conservative management. These factors were decided on in a priori statistical analysis plan. All statistical analysis was performed using IBM SPSS statistics version 23.0 (SPSS Inc. Chicago, IL)

Results

Demographics

3771 trauma patients presenting to this MTC were registered on the TARN database from April 2012 to December 2016. 765 patients were identified using the search criteria. 636 patients with pneumothoraces were identified, with 602 patients (see Figure 1) included for analysis. Table 1 summaries patient demographics, mechanism of injuries, ISS, pneumothorax characteristics, management and outcomes for patients managed non-conservatively and conservatively. Table 2 summaries the characteristics and outcomes for successful and failed observed management.

Traumatic pneumothoraces were present in 636/3771 (17%) of trauma patients during the study period. The mean age was 48 (SD 22), 438/602 (73%) were male, and 330/602 (55%) suffered their injury as a result of a road traffic accident. The mean ISS score (26) represented very severe injuries; and 189/602 (31%) required immediate invasive ventilation and 56/602 (9%) died during admission. 325/602 (54%) of patients had an intervention performed pre-hospital or on admission, either with needle decompression, chest tube insertion or chest surgery, with the remaining 277/602 (46%) of the pneumothoraces were initially treated conservatively. The patients managed conservatively, had significantly smaller pneumothoraces compared to patient managed with an immediate intervention (median 5.5mm vs 22mm), with the majority less than 10mm in size (see Figure 2).

Patients who were managed with an immediate intervention also had a higher incidence of respiratory, hemodynamic and neurological compromise, and a higher proportion of significant hemothorax than those managed conservatively. Both groups, have comparable ages, ISS score, mortality rate and total LOS.

Of the 277/602 (46%) of patients managed conservatively, 252/277 (90%) did not require subsequent thoracic intervention. This included the majority, 56/62 (90%), of patients requiring immediate PPV who were treated conservatively. There was no significant difference in the failure rate between the patients on PPV (6/62, 9.7%) and those not requiring PPV (19/215, 8.8%) in the conservative arm.

Using univariate analysis, size of pneumothorax, mechanism of injury, presence of rib fractures, clinical condition, surgery and ISS were not significantly associated with failure of conservative management (Table 3). The median size of pneumothorax (5.3 vs 8.2 mm p 0.13) was comparable between groups and did not increase the likelihood of progression requiring chest tube insertion, with HR of 1.61 (p 0.08) and 2.84 (p 0.07) on univariate and multivariable analysis

Univariate and multivariable analysis also confirmed that acute PPV does not appear to confer an additional risk of failure of conservative management (HR 1.1 p 0.8 and HR 1.5 p 0.96 respectively). Additionally, requiring subsequent PPV during inpatient stay, either due to clinical deterioration, or for general anesthesia did not represent an increase risk of failure of conservative management. In contrast, the presence of a hemothorax was associated with increased likelihood of failure of expectant management (hazard ratios of 4.08 (p < 0.01)) and confirmed by multivariable cox regression analysis (Table 4).

Of the 25/252 patients who failed observed management, 23 had a large chest drain inserted and 2 went to have thoracic surgery (rib fixation with hemothorax evacuation). The main indication for chest tube insertion was increasing pneumothorax (19/23) and enlarging hemopneumothorax (4/23). The mean duration prior to chest tube insertion was 2.96 days (SD 4.03). Requiring subsequent chest insertion in the conservative arm led to a non-significant increase length of stay (11 vs 10 days p 0.597). The 2 mortalities in this group had severe ISS of 40 (>25 represents severe/critical injuries) with intracranial hemorrhages and it is

unlikely that the pneumothorax contributed to the overall outcome. The rate of cardiothoracic surgery was higher in the intervention cohort, with 18/325 requiring surgery.

Table 5 demonstrates the characteristics of patients with a pneumothorax visible on chest radiograph (overt pneumothorax) and those not visible on chest radiograph (occult pneumothorax). 177 patients had a chest radiograph as their initial chest imaging. 137 of these patients proceeded to a CT chest. Of these 137 patients, 11 had a chest drain in-situ at time of chest radiograph. Of the remaining 126, 61/126 (48%) had no visible pneumothorax. Occult pneumothoraces were generally smaller than the overt pneumothoraces, with respective median size of 7.26mm vs 25.07mm (p<0.001).

The majority, 470/603 (78%), of study patients had evidence of rib fractures, with 361/470 and 143/470 suffering more than 3 and 5 rib fractures respectively. 427/470 of the fractures were unilateral and 167/470 were reported as flail chest, with 12/470 reported as bilateral flail chest. There was no statistically significant association between presence of rib fractures and significant haemothorax (χ^2 = 0.946, p = 0.331).

There was a 10% complication rate associated with chest tube insertion. 15 (4.4%) patients required their drain to be re-sited, 4 (1.2%) patients had their drains dislodged, 5 (1.5%) had intraparenchymal drains on CT, 2 (0.6%) patients developed an empyema, and 1 (0.3%) patient had a guidewire left in the pleural cavity. 8 (2.4%) patients required a subsequent drain after initial removal due to re-accumulation of air or fluid.

Discussion

Chest drain insertion is not without risk of complication, with documented complications rates ranging from 15-30% (12, 14-16). Current guidelines recommends chest tube placement for traumatic pneumothorax, particularly in patients on PPV(7), with a caveat that asymptomatic non-ventilated patients can be managed with observation or aspiration at the treating clinician's discretion. Existing literature has examined whether occult pneumothoraces can be managed conservatively (6, 12). Scoring systems, to determine whether chest tube intervention is required for occult pneumothoraces, are in their infancy and have not been prospectively validated (17). We sought to determine whether traumatic pneumothoraces can be treated conservatively and examine factors that safely identify patients who could avoid chest tube insertion. Here we show the majority of patient managed conservatively did not required further invasive ventilation, including patients requiring PPV.

Recent studies(6, 12) have focused on whether there is a role for conservative management for 'occult' pneumothoraces not initially visible on chest radiograph. The resultant positive findings, including patients on PPV, have been incorporated into clinical guidelines(18). Whilst these studies have been useful in establishing management pathways for traumatic pneumothoraces, they do have limitations. It is difficult to translate their findings into a clinical practice where CT is becoming the first line investigation, with the majority of patients (70%) in our study having a CT scan as their initial imaging and over 90% during their inpatient stay. Furthermore, the distinction between overt and occult can be misleading; whether a pneumothorax is seen on chest film, is not solely related to its size, and can be influenced by other factors, e.g. use of supine chest radiograph has decreased sensitivity (8), with 'occult' pneumothoraces in our study reaching over 80mm in size.

With this is mind we proposed to look at the outcomes for traumatic pneumothoraces as a whole. Nearly half (46%) of the patients included were managed conservatively, with the majority of these, 252/277 (90%), not requiring subsequent invasive treatment for their pneumothorax. This included 56/62 (90%) of patients who received immediate PPV. Multivariable analysis supported that immediate or subsequent PPV did not confer an additional risk of failure of conservative management. This is consistent with the most recent study on occult pneumothoraces, with Moore et al demonstrating a failure rate of 14% of patients on PPV managed with observation. Whilst this was higher than their 4.5% failure rate for those not on PPV, PPV was not identified as an independent predictor of failed management on multivariate analysis (12) and no patient developed tension pneumothorax related to delayed tube insertion. Smaller, earlier studies found conflicting results. Brasel et al(11) and Enderson et al (9) demonstrated a 22% and 53% failure rate respectively for patients with occult pneumothoraces on PPV managed with observation. Brasel's(11) paper concluded that observation was safe in these patient, whilst Enderson(9) et al recommending tube thoracostomy for all patients requiring PPV. This has led to ongoing debate regarding the management of occult pneumothorax on PPV. The East Practice Management Guidelines (2011) on occult pneumothoraces (18) recommend that occult pneumothoraces may be observed in stable patients regardless of PPV. The currently recruiting OPTICC trial (NCT00530725) which is randomising occult pneumothoraces on PPV between chest tube insertion and observation should contribute to this evidence base.

The size of pneumothorax was not a predictor of failed observation in our study on univariate and multivariate analysis, with non-significant differences in size of pneumothorax between the successful and failed observed groups. Pneumothorax size had previously been thought to be a predictor of progression(19), with De Moya et al(17) proposing a scoring system using size of occult pneumothorax and its relationship to the hilum to guide management. However this has not been successfully validated(12), with Moore et al demonstrating that pneumothorax size was not an independent predicator of failed observation (12).

The presence of a hemothorax appears to be predictive of failure of conservative management in both overt and occult pneumothoraces(12). This is consistent with clinical practice. A significant hemothorax is an indication for chest tube insertion, to evacuate blood from the pleural space and avoid complication such as infection and a fibrothorax and when combined with the presence of pneumothorax, this provides a strong incentive for intervention.

In this study, patients who do not require prehospital or admission chest procedures generally did not require a chest procedure later in hospitalization. When this information is combined with previous trials on traumatic pneumothoraces it appears that there is a subpopulation that can be managed conservatively. Certainly, when there is no significant hemopneumothorax (<2cm in size) there can be consideration for expectant management. Mechanism of injury, ISS or size of pneumothorax do not appear to provide a strong indication for intervention. Additionally in our study, clinical condition did not confer an adverse prognosis, although in other studies respiratory distress has (12). Although the use of ventilation has been controversial, it appears from our findings and previous studies that pneumothoraces can be managed conservatively with careful observation on PPV with no increased risk of harm(6, 12).

This is a retrospective observational trial, and as such will be subject to the inherent limitations of such a study. The data was collected from a single centre, with a low rate of penetrating chest wall injury (5%), which should be considered when generalising the findings to other centres. Selection bias may have been introduced by physician selection and variation in initial imaging modality, and the decision to intervene may have affected the conservatively treated cohort characteristics and it is likely that the high risk unwell patients were underrepresented in the conservatively treated arm. Those treated with an immediate intervention, despite similar ISS, likely represented a more unwell population, with higher rates of cardiorespiratory compromise, PPV use, surgical referral rates and higher mortality rates. The length of stay criteria (length of stay is 3 days or more or admitted to a High Dependency Area regardless of length of stay) is likely to have biased against patients successfully conservatively managed and not requiring a prolonged hospital admission, suggesting that the overall rate of effective conservative management is probably greater. Efforts were made to minimise bias, by including large number of consecutive unselected patients into the analysis and careful documentation and comparison of cohort characteristics.

Conclusion

Our study represents the largest observational study on traumatic pneumothoraces to date. It demonstrates that the majority of conservatively managed patients were successfully managed without requiring a chest drain. This includes the majority of patients on positive pressure ventilation (PPV), the use of which did not present an increased risk of failure of expectant management. This study provide support for an observed, expectant approach if the treating physician does not feel an immediate chest drain is warranted in the patient with a traumatic pneumothorax. Future prospective randomised trials examining the outcomes of a conservative approach in traumatic pneumothorax, regardless of pneumothorax size or use of PPV would help clarify which patients are best managed expectantly.

Word count 2902

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Table 1: Characteristics and Outcomes of Non-Conservative vs Conservative Patients

	Initial Non-Conservative Management (325)	Conservative Management (277)	p value
Age, yr (SD)	48.8 (21.5)	47.1 (21.9)	0.36
Male Gender (%)	252 (77.5)	186 (67.1)	0.04
Mechanism of injury (%)			0.04
• Vehicle collision	175 (53.8)	155 (56)	
• Fall <2 meters	58 (17.8)	55 (19.9)	
• Fall >2 meters	52 (16)	48 (17.3)	
• Stabbings	25 (7.7)	5 (1.8)	
• Crush injuries	7 (2.2)	8 (2.9)	
• Blows	8 (2.5)	6 (2.2)	
Mean ISS (SD)	26.9 (14.7)	25.0 (12.3)	0.08
Median Pneumothorax size, mm (IQR)	22 (35.9)	5.5 (8.8)	<0.001
Significant (>2cm) hemothorax (%)	58 (17.8)	17 (6.1)	<0.001
Initial Positive Pressure Ventilation (%)	127 (39.1)	62 (22.4)	<0.001
Subsequent Positive Pressure Ventilation (%)	159 (48.9)	139 (50.2)	0.12
Presence of Respiratory distress (%)	199 (61.2)	138 (49.8)	0.06
Presence of hemodynamic compromise (%)	132 (40.6)	71 (25.6)	<0.001
Presence of decreased GCS (%)	135 (41.5)	90 (32.5)	0.03
Median Hospital length of stay, days (IQR)	10 (17)	10 (13.5)	0.35
Median ICU length of stay, days (IQR)	2 (9.5)	0 (5)	<0.001
Mortality (%)	11.1%	7.2%	0.1
GCS: Glasgow coma scale, ICU: intensive care unit			

Table 2: Characteristics and Outcomes of Conservatively Managed Patients			
	Conservative management (Successful) (252)	Conservative management (Failed) (25)	p value
Age, yr (SD)	46.7 (22.4)	51.2 (16.2)	0.33
Male Gender (%)	169 (67.1)	17 (68)	0.92
Mechanism of injury (%) • Vehicle collision • Fall <2 meters • Fall >2 meters • Stabbings • Crush injuries • Blows	 142 (56.3) 49 (19.4) 42 (16.7) 5 (2) 8 (3.2) 6 (2.4)	 13 (53) 6 (24) 6 (24) 0 0 0	0.72
Mean ISS (SD)	24.9 (12.5)	25.0 (11.0)	0.97
Median Pneumothorax size, mm (IQR)	5.3 (8.6)	8.2 (16.5)	0.13
Significant (>2cm) hemothorax (%)	12 (4.9)	5 (20)	<0.01
Initial Positive Pressure Ventilation (%)	56 (22.2)	6 (24)	0.84
Subsequent Positive Pressure Ventilation (%)	123 (49)	16 (64)	0.15
Presence of Respiratory distress (%)	124 (50.2)	14 (60.9)	0.33
Presence of hemodynamic compromise (%)	67 (27.2)	4 (18.2)	0.36
Presence of decreased GCS (%)	80 (32.3)	10 (40)	0.43
Median Hospital length of stay, days (IQR)	10 (13.8)	11 (14.5)	0.66
Median ICU length of stay, days (IQR)	0 (4)	3 (12.0)	0.15
Mortality (%)	7.1%	8%	0.88
GCS: Glasgow coma scale, ICU: intensive care unit			

Table 3: Hazard ratios for failed conservative management

	Hazard ratio	P value	95% Confidence interval
Male Gender	1.05	0.92	(0.45, 2.2)
Size of pneumothorax (≥2cm vs <2cm)	1.61	0.08	(0.94, 2.76)
Bilateral vs unilateral pneumothorax.	1.34	0.25	(0.83, 2.12)
ISS score (very severe vs severe and moderate severe)	1.17	0.69	(0.54, 2.58)
Presence of rib fractures	1.15	0.57	(0.71, 1.88)
Hemothorax (>2 cm)	4.08	<0.01	(1.53, 10.88)
Received initial Positive Pressure Ventilation	1.1	0.84	(0.44, 2.76)
Received subsequent Positive Pressure Ventilation	2.10	0.08	(0.91, 4.87)
Presence of Respiratory distress	1.23	0.33	(0.810, 1.87)
Presence of hemodynamic compromise	0.78	0.37	(0.45, 1.34)
Presence of decreased GCS	1.17	0.45	(0.78, 1.74)

ISS: Injury severity score, GCS: Glasgow coma score

Table 4: Multivariable Cox Regression Analysis For Failure Of Conservative Management

	Hazard Ratio	P Value	95% Confidence interval
Haemothorax >2cm	5.29	<0.01	(1.78, 15.79)

Table 5: Overt and Occult pneumothoraces characteristics

	Occult pneumothoraces (61)	Overt pneumothoraces (65)
Age, yr (SD)	52.04 (23.80)	56.30 (20.45)
Male Gender (%)	48 (78.7)	47 (72.3)
Median size of pneumothorax on CT, mm (IQR)	7.26 (12.39)	25.07 (37.46)
Median ISS (IQR)	20.00 (9.50)	16.00 (11)

CT: computerised tomography

Fig 1. Cohort Diagram: demonstration of the numbers of patients included in the study, providing reasons for non-inclusion where necessary.

Fig 2. Pneumothorax size in Conservatively managed patients