Emergency Medicine Australasia

Emergency Medicine Australasia (2021) doi: 10.1111/1742-6723.13846

ORIGINAL RESEARCH

Conservative management of traumatic pneumothoraces: A retrospective cohort study

Benjamin C GERHARDY, Paul LIEBENBERG and Graham SIMPSON

Cairns Hospital, Cairns, Queensland, Australia

Abstract

Objective: Traumatic pneumothoraces (T-PTXs) are traditionally managed with an intercostal catheter (ICC), despite little evidence for this. Success with conservative management of primary spontaneous PTX has been demonstrated, and our ED has adopted a conservative approach where safe for all PTX.

Methods: We reviewed all T-PTXs at our institution over a 7-year period to assess outcomes of those conservatively managed and compare with those who received an ICC. A total of 144 cases were identified, 65 managed conservatively and 79 invasively. Each was individually reviewed and variables including demographics, aetiology, smoking/lung disease history, T-PTX size (apical interpleural distance and hemithorax percentage), length of stay, Revised Trauma Score, Injury Severity Score and delayed intervention/complications were recorded. Chi-squared, *Z*-score, Mann–Whitney *U* and *t*-tests were used for analysis.

Results: The mean apical interpleural distance was 26.8 mm (95% confidence interval [CI] 22.1–29.7 mm) in the conservative group and 49.1 mm (95% CI 41.2–57.0 mm) in the ICC group ($P < 0.05$ for difference between groups). Mean T-PTX percentage 25.9% (95% CI 22.1–29.7%) in the conservative group *versus* 45.9% (95% CI 39.7–50.5%) in the ICC group ($P < 0.05$ for difference between two groups) and mean Revised Trauma Score 7.4 (conservative) *versus* 6.8 (invasive) ($P < 0.05$). No conservatively managed patient required a delayed intervention for their T-PTX, and 2 of 79 (3%) patients in the ICC group had a complication (one infection, one haemothorax).

Conclusion: Our data support conservative management of selected T-PTXs and shows a need for a prospective randomised trial to further examine this intervention.

Key words: *conservative, pneumothorax, trauma.*

Key findings

- Retrospective data demonstrates that T-PTXs can be managed conservatively in clinically appropriate patients, reducing length of hospital stay and sparing them an additional procedure.
- Randomised prospective trials are needed to further define the role of intervention in T-PTXs.

Introduction

Traditional treatment for a traumatic pneumothorax has been the insertion of an intercostal catheter (ICC). As recently as 2018 the American College of Surgeons in their advanced trauma life support guidelines recommended ICC insertion for any traumatic pneumothorax, with needle aspiration a potential alternative in the asymptomatic patient where a suitably qualified practitioner is present.[1]

Evidence supporting this approach is not comprehensive. In 1996, Johnson published a small case series of 29 traumatic pneumothoraces managed conservatively over a 3-year period, all described as either 'minimal', 'small' or 'moderate', with 2 of 26 requiring a delayed intervention.[2] A recent observational study by Walker *et al.* demonstrated success (defined as not requiring a delayed intervention) with conservative management alone in 90% of a cohort of 277 traumatic pneumothorax patients.[3] However, the median pneumothorax size in this cohort was only 5.5 mm measured at either the apex or hilum and only 17 of the 277 were >20 mm (of which 5/17 required a delayed intervention). At 5.5 mm, a pneumothorax is difficult at best to appreciate on a chest X-ray, which is often the first and certainly the most readily accessible radiological investigation in trauma.

Guided by previous work demonstrating safety in conservative management of primary spontaneous pneumothorax,[4,5] our hospital has taken a conservative approach to the management of traumatic pneumothoraces where clinically appropriate (i.e. safe). Considering the paucity of literature describing outcomes of conservative management in the trauma setting, we hypothesised that our conservatively managed traumatic pneumothoraces would have an acceptable (<10%,

Correspondence: Dr Benjamin C Gerhardy, Cairns Hospital, 165 The Esplanade, Cairns, QLD 4870, Australia. Email: b.gerhardy@hotmail.com

Benjamin C Gerhardy, MBBS (Hons), FRACP, Respiratory Physician; Paul Liebenberg, MBChB, DCH, MS, FACRRM, General Surgical Fellow; Graham Simpson, MD, FRCP, FRACP, Respiratory Physician.

Present address: Benjamin C Gerhardy, Nepean Hospital, Sydney, New South Wales, Australia; Paul Liebenberg, Royal Darwin Hospital, Darwin, Northern Territory, Australia.

Accepted 4 August 2021

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chosen based on clinical experience) complication rate, including the need for delayed intervention.

Methods

We conducted a retrospective cohort study looking at the characteristics, management and outcome of our traumatic pneumothoraces, divided dichotomously into conservatively and invasively managed. All presentations with the International Classification of Diseases code of traumatic pneumothorax (S27.0) to the ED of a tertiary public hospital in far North Queensland, Australia, from July 2012 to June 2019 were reviewed for inclusion.

The sole inclusion criterion was presenting to the ED with a traumatic pneumothorax (aetiologies of both blunt and penetrating trauma, thus including crash, assault, vehicular misadventure, etc) of size sufficient to be visualised on an erect or supine chest X-ray prior to any attempted intervention. Pneumothoraces of questionable (i.e. possibly secondary spontaneous) origin were excluded, as were iatrogenic pneumothoraces (such as those from lung biopsies).

The medical records and imaging of all presentations (i.e. both the screening process and data collection process) were reviewed by two authors to assess if the initial coding was correct and to ensure the pneumothorax was visible on chest X-ray. A representative selection of cases (20 from each group) was subsequently reviewed by a third author (a general surgical Fellow with experience in trauma and rural medical practice) to ensure consistency across the interpretation of size measures.

Variables collected included baseline demographics, smoking status, presence of underlying lung disease, estimated pneumothorax size (Collins method),[6] treatment approach (conservative or ICC), indication for ICC where documented, length of stay and cause of pneumothorax. Presence of underlying lung disease was defined as either a documented history of obstructive or restrictive lung disease diagnosed by a general or respiratory physician in the inpatient or outpatient setting, or the presence of significant radiological change as to infer the presence of clinically significant respiratory disease (including but not limited to radiological bronchiectasis, emphysema, cystic or interstitial lung disease). Complications of ICC insertion and any need to progress from conservative to invasive management were also documented where applicable. Chi-squared (for comparison of categorical variables), *t*-tests (for comparison of normally distributed means), Mann–Whitney *U* tests (for comparison between groups where the distribution was not normal) and the *Z*-score test for population proportions were used to assess for statistical significance. Data are presented as mean (95% confidence interval [CI]), where normally distributed, and median (interquartile range [IQR]), where not normally distributed.

The Revised Trauma Score (RTSc) and Injury Severity Score (ISS) were also calculated. The RTSc is derived from respiratory rate, systolic blood pressure and Glasgow Coma Scale, with potential scores ranging from 0 to 7.8 (lower score indicating higher mortality risk).[7] The ISS is derived from the Abbreviated Injury Scale, an anatomically based trauma severity score with a six point ordinal scale where a higher score is associated with higher morbidity and mortality, and an ISS >15 is a commonly accepted definition for major trauma.[8]

We defined large pneumothorax as those with an interpleural distance at the apex of >20 mm on either an erect posteroanterior or supine anteroposterior chest X-ray. This distance was chosen as it is similar to yet more conservative than the measure of >20 mm at either the apex or the hilum on an erect posteroanterior chest X-ray used in pre-existing literature[3] and it is a distance typically clearly visible on a chest X-ray. The projection of pneumothorax will differ between erect and supine films, however as has been previously demonstrated an apical interpleural distance on a supine film becomes larger if the patient is positioned erect, that is a 2-cm apical interpleural distance on a supine film is closer to 3-cm apical interpleural distance on an erect film.[9] The interpleural distance was measured as a vertical line from the parietal pleural on the inferior border of the apical to the visceral pleura on the superior border of the collapsed lung.

This research was prospectively approved by the local hospital ethics review committee (reference LNR/2020/QCH/63269-1440QA) as part of a broader pneumothorax analysis.

Results

A total of 244 patients were screened with 144 included in the final analysis. Reasons for exclusion are outlined in Figure 1. The most common reason for exclusion at the time of initial screening was inability to see pneumothorax on chest X-ray (38 of 100 excluded cases, 38%). Sixty-five out of 144 patients were managed conservatively and 79 with a pleural intervention (all interventions were ICC insertions).

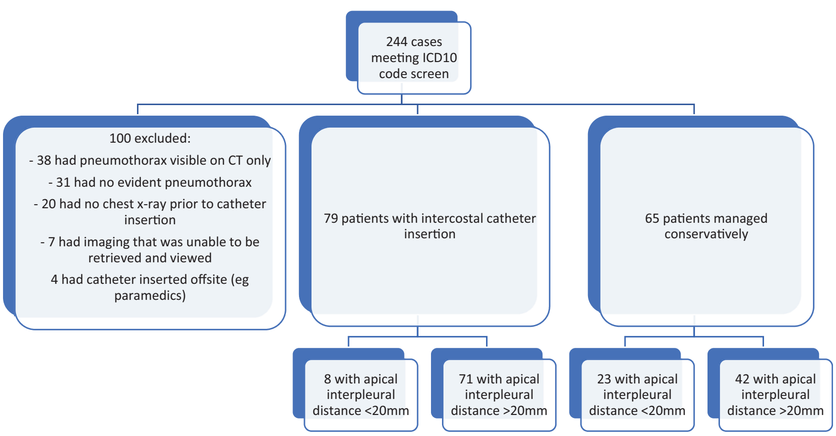

Figure 1. *Flowchart of patient assessment and categorisation.*

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TABLE 1. *Demographics of the two groups including pneumothorax characteristics*

	Conservative (*n* = 65)	Intercostal catheter (*n* = 79)	*P*-value
Male, *n* (%)	45 (69)	56 (71)	0.83
Median age, years (IQR)	49 (27)	44 (25.5)	0.29
Ethnicity, *n* (%)			
Caucasian	47 (72)	63 (89)	0.29
Aboriginal and/or Torres Strait Islander	14 (22)	15 (19)	0.7
Other	4 (5)	1 (1)	0.11
Current smoker, *n* (%)	30 (46)	35 (44)	0.83
Ex-smoker, *n* (%)	25 (38)	33 (42)	0.69
Never smoker, *n* (%)	10 (15)	11 (14)	0.8
Underlying lung disease, *n* (%)	10 (15)	11 (14)	0.8
Concurrent haemothorax, *n* (%)	12	20	0.32
Median heart rate at presentation, bpm (IQR)	83 (21)	80 (26)	0.73
Median systolic blood pressure at presentation, mmHg (IQR)	125 (33)	123 (24)	0.58
Median respiratory rate at presentation, per min (IQR)	18 (6)	20 (10)	0.51
Median Glasgow Coma Score at presentation (IQR)	15 (0)	15 (1)	0.4
Chest X-ray orientation			
Posteroanterior erect	38	13	<0.01
Anteroposterior erect	13	37	
Supine	14	29	
Presence of rib fractures	27	40	0.27
Median number of rib fractures (range)	0 (0–9)	1 (0–6)	
Aetiology, *n* (%)			
Fall	20 (31)	14 (18)	0.06
Assault	18 (28)	15 (19)	0.21
Motor vehicle crash	5 (8)	16 (20)	0.03
Motorbike crash	7 (11)	13 (16)	0.33
Sport including bicycling	9 (14)	13 (16)	0.67
Other	6 (9)	8 (10)	0.85

IQR, interquartile range.

TABLE 2. *Tabulated results data for conservative and intervention groups*

	Conservative (*n* = 65)	Intervention (*n* = 79)	*P*-value
Mean % of hemithorax occupied by pneumothorax (95% CI)	25.9 (22.1–29.7)	45.9 (39.7–50.5)	<0.05
Mean pneumothorax size at apex, mm (95% CI)	26.8 (20.3–33.4)	49.1 (41.2–57.0)	<0.05
Number with interpleural distance >20 mm at apex	42	71	<0.05
Median length of stay, days (IQR)	3 (4)	6 (7)	<0.05

CI, confidence interval; IQR, interquartile range.

The baseline demographics of both groups are described in Table 1. There was a statistically significant difference in pneumothorax size between the two groups, with the conservatively managed group having a mean interpleural distance at the apex of 26.8 mm (95% CI 20.3–33.4 mm) and mean size of 25.9% (95% CI 22.1–29.7%) of the hemithorax *versus* an apical distance of 49.1 mm (95% CI 41.2–57.0 mm) and size of 45.9% (95% CI 39.7–50.5%) of the hemithorax in the intervention group ($P < 0.05$ for

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TABLE 3. *Revised Trauma Score (RTSc) and Injury Severity Score (ISS) for conservative and intervention groups (reduced cohort)*

	Conservative ($n = 60$)	Intervention ($n = 68$)	P-value
Mean RTSc (95% CI)	6.8 (6.4–7.2)	7.4 (7.0–7.8)	<0.05
Median ISS (IQR)	11 (8.75)	17 (12)	<0.05

CI, confidence interval; IQR, interquartile range.

difference between both apical interpleural distance and percentage size) (Table 2). Kappa statistic for interobserver variability on size assessment 0.64 (ICC group; substantial agreement) and 1.0 (conservative group; perfect agreement).

No patient initially managed conservatively required a delayed pleural procedure (either needle aspirate or ICC insertion) or had any other documented complication. One patient in the intervention group developed a soft tissue infection at the site of ICC insertion and one patient had a documented haemothorax develop after ICC insertion.

There was a significant difference in length of stay, with the conservative group having a median of 3 days (IQR 4 days) *versus* 6 days (IQR 7 days) in the intervention group. There was a statistically significant difference in both mean RTSc ($n = 68$ for ICC group, mean score 6.8; $n = 60$ for the conservative group, mean score 7.4, $P < 0.05$) and median ISS ($n = 68$ for ICC group, median score 17; $n = 60$ for the conservative group, mean score 11, $P < 0.05$) (Table 3). Reduced patient numbers here are due to pneumothoraces that occurred when the hospital transitioned from paper to electronic medical records and loss of data. Comparing mechanism of injury, only motor vehicle crashes showed a significant difference between groups with more having an ICC inserted than managed conservatively (16 *vs* 5, $P = 0.03$).

TABLE 4. *Breakdown of reasoning for, and pathophysiology of the intercostal catheter group* (n = 79)

ICC indication	Number ($n = 79$) (%)
No indication documented	27 (34)
Hypoxia	19 (24)
To facilitate intervention, of which	
Invasive ventilation/prior to transfer to operating theatre	7 (9)
Prior to aeromedical transfer to larger tertiary centre	4 (5)
'Traumatic'	7 (9)
'Dyspnoeic'	6 (8)
'Size'	5 (6)
'Presence of subcutaneous emphysema'	1 (1)
'Hypotension'	1 (1)
'Enlarging'	1 (1)
'Risk'	1 (1)

Text within quotation marks is a direct text extraction from the individual patient notes explaining why the ICC was inserted. ICC, intercostal catheter.

The reason for ICC insertion is listed in Table 4. Of the ICC group, 27 of 79 (34%) did not have a clearly documented medical rationale for insertion, and 22 of 79 (28%) had only a subjective reason cited (e.g. 'dyspnoea' or 'traumatic').

Discussion

We present retrospective data suggesting that conservative management of traumatic pneumothoraces with an apical interpleural distance greater than 20 mm in stable patients who do not otherwise meet intervention criteria (e.g. due to significant hypoxia, prior to flight, etc) can be safe and may not require a delayed intervention.

The conservatively managed cohort in the present study had a much larger pneumothorax at initial diagnosis (median apical distance 26.1 mm and 65% with apical distance >20 mm) compared to the conservatively managed group in other studies, such as Walker *et al.* (median apical distance of 5.5 mm and 6% >20 mm).[3] Somewhat surprisingly, none of our conservatively managed patients required an ICC.

Limitations

The present study has limitations. The retrospective design brings selection bias, and the heterogeneity of trauma severity (as evidenced in the significant between group difference in the ISS and RTSc) would also influence the clinical decision to insert an ICC. A difference in management approach when stratified by mechanism of injury (i.e. motor vehicle crashes) also contributes here with the assumption that a motor vehicle crash is likely to have more serious, or multi-system pathology.

Chest X-rays in the trauma patient can be supine, rather than erect. The methods used in X-ray analysis in this paper are derived from erect imaging. However, as a pneumothorax with an apical interpleural distance of x cm on a supine film is typically bigger (with regards to percentage of hemithorax) than a pneumothorax with the same apical interpleural distance on an erect film,[9] this means that we are potentially underestimating the size of our

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pneumothoraces. The implications of this limitation are that our pneumothoraces – both conservatively and ICC managed – may be larger than what the percentage determined via the Collins method indicates.

Point-of-care ultrasound of the pleural interface can also be used to assess for the presence of a pneumothorax by detecting a combination of positive signs (e.g. lung point, exaggerated A lines) and negative signs (absence of lung sliding and absence of B lines).[10] Pleural ultrasound is incorporated into the extended Focussed Assessment with Sonography for Trauma protocol. While this technique can be useful in the emergency/trauma setting due to the 'bedside' nature of the test, it has limitations including practitioner skill and the ability to gain a suitable sonographic window for assessment – this can be an issue in some situations for example in the presence of subcutaneous emphysema due to the difference in acoustic impedance between air and soft tissue. Although quantification of pneumothorax size can be estimated where the lung point is visible,[11] this may not be applicable in all trauma settings due to concurrent injuries giving limited scanning windows. Pleural ultrasound for pneumothorax was not routinely done at our institution during the time interval of the present study hence it not being included however this technique should be considered for future prospective work in this field.

There are also strengths to the presented data. The use of only an apical distance (as opposed to either the larger of the apical or hilar distance on X-ray or the largest perpendicular interpleural distance from a computed tomography scan) gives rise to the possibility of these pneumothoraces actually being larger than measured, especially when considering some of these patients would have had a supine chest film making the apical interpleural distance artifactually smaller. Interobserver variability assessment on measured sizes showed significant agreement, with the perfect measure for the conservative group illustrating a limitation of the Kappa statistic with relatively small patient numbers.

Although the requirement of the pneumothorax to be visible on chest X-ray led to the exclusion of a moderate number of patients it also provides a pragmatic component to the data lacking in earlier research. X-rays are much more widely available in Australian rural, regional and economically disadvantaged health services, and if a pneumothorax cannot be visualised on chest X-ray then it is likely to not be the cause of significant cardiopulmonary symptoms in most people. It also allows for simple and accurate quantification of pneumothorax size.

Interestingly a sizable minority of the ICCs inserted only had subjective reasons cited. This raises the possibility of potentially unnecessary pleural procedures having been performed within this patient population.

Conclusion

Our data provide support for conservative management of traumatic pneumothoraces in the right patient, with none of the conservatively managed patients (initial pneumothorax measure up to 33 mm apical interpleural distance) requiring a later intervention. We propose that prospective studies to find predictors of conservative management failure could be done safely and ultimately lead to management changes in the acute trauma patient.

Competing interests

None declared.

Data availability statement

Data sharing not applicable – no new data generated.

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