

## Original Article

## Conservative versus invasive treatment of primary spontaneous pneumothorax: a retrospective cohort study

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**Aim:** The best management of primary spontaneous pneumothorax is unclear. Conservative treatment has been proposed, but no studies comparing conservative with invasive management have been carried out where pneumothorax size has been numerically quantified. This study aimed to evaluate the feasibility of conservative management for primary spontaneous pneumothoraces of any size.

**Methods:** Retrospective cohort study of adult patients with primary spontaneous pneumothorax treated at an Australian tertiary hospital from 2006–2011, carried out by case-note and chest radiograph review. Patient demographics, smoking status, and outcome data were collected. Pneumothorax size was calculated using the Collins method, based on the sum of interpleural distances.

**Results:** One hundred and twenty-seven episodes from 116 patients were identified. Males (86) comprised 75% of patients, and the median age at presentation was 37 years. Eighty-two percent of cases (106) were ever-smokers. Of the episodes in which pre-treatment radiographs were available, 53 were treated conservatively and 58 invasively with tube thoracostomy, and all were clinically stable. When cases were stratified by pneumothorax size, age, sex, ethnicity, and smoking status had no effect on outcome. Compared to invasive treatment, conservative management resulted in no complications, an equal recurrence rate, and a significantly shorter length of stay.

**Conclusions:** Our results suggest that it may be feasible to adopt a conservative approach as the first-line treatment of primary spontaneous pneumothorax in clinically stable patients. However, given the limitations of this study, a large randomised controlled trial is required to conclusively prove this assertion.

**Key words:** Collins, conservative, pneumothorax

## INTRODUCTION

THERE IS NO evidence-based optimal treatment for primary spontaneous pneumothorax, a rare pleural disease with an estimated incidence rate of 18–28 per 100,000 in males and 1.8–6.0 per 100,000 in females.<sup>1</sup> Existing guidelines vary in their recommendations, and in their definitions of what constitutes a “large” pneumothorax warranting intervention.<sup>2</sup>

Except in “small” pneumothoraces, invasive treatment with either aspiration or tube thoracostomy is recommended by current consensus guidelines.<sup>3,4</sup> The lack of clear guidance has resulted in no uniform management strategy, with clinician discretion being the prime determinant of treatment

method.<sup>5–8</sup> Heterogeneity among guidelines has also made meta-analyses of trials comparing available treatment options difficult.

Although there have been a number of studies comparing aspiration and tube thoracostomy,<sup>9–12</sup> there are few published reports on conservative treatment of primary spontaneous pneumothorax. Up until the mid-20th century, primary spontaneous pneumothorax was managed conservatively; after this period conservative management was largely abandoned in favour of rapid lung re-expansion.<sup>13</sup> However, it has been proposed that rapidly re-expanding the collapsed lung adversely affects stopping the air leak, which is the principal cause of the pneumothorax.<sup>14</sup>

Lately, therefore, conservative management has been suggested as a viable option in clinically stable patients with “large” pneumothoraces.<sup>15–17</sup> Objective pneumothorax size has been found to be an independent predictor of treatment failure,<sup>18</sup> but no studies of outcomes comparing conservative with invasive management exist in which pneumothorax size has been numerically ascertained.

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In this study, we aimed to investigate the hypothesis that in clinically stable patients, conservative management is a feasible alternative to invasive treatment in pneumothoraces of equal percentage pneumothorax size. We also aimed to examine patient factors that may potentially influence outcome.

## METHODS

### Study design

**T**HIS WAS A retrospective cohort study carried out by explicit case-note and chest radiograph review.

### Setting

The study was carried out at Cairns Base Hospital, a tertiary teaching hospital in Cairns, Queensland, Australia. The hospital is the only referral centre for an area of 350,000 km<sup>2</sup> with approximately 250,000 inhabitants, 15% of whom are Aboriginal or Torres Strait Islander. It also houses the only high-level Emergency Department and the sole Department of Thoracic Medicine in its catchment area.

### Participants

Study subjects were clinically stable (i.e., in no risk of haemodynamic compromise) patients with primary spontaneous pneumothorax presenting to the Cairns Base Hospital Emergency Department in the years 2006–2011. Only adult patients (minimum age 15 years) were included. Patients found on case-note review to have secondary spontaneous pneumothoraces, that is, those who developed pneumothoraces on the background of existing lung disease, were excluded. If no information was found to suggest a secondary cause, the pneumothorax was assumed to be primary spontaneous.

### Data collected, sources, and measurements

Subjects were identified by searching an Emergency Department administrative database. Patient demographic data, smoking status, pneumothorax size, treatment type, and outcomes were collected. Pneumothorax size was calculated on review of chest radiographs using the regression formula derived from the method of Collins. This formula is given as  $4.2 + 4.7(A + B + C)$  where  $A + B + C$  is the sum of the interpleural distances at the apex and the midpoints of the upper and lower halves of the collapsed lung, respectively.<sup>19</sup>

### Outcome measures

Outcome data collected included length of hospital stay, symptom-directed acute re-presentations, recurrences

(defined as a new pneumothorax on the same side) within 24 months, and development of complications post-treatment.

### Statistical analysis

The data were analysed using descriptive statistics with SPSS version 11.5 (IBM, Chicago, IL, USA). Student's unpaired *t*-test was used for comparison of parametric data, whereas the Mann–Whitney *U*-test was used for non-parametric data. The  $\chi^2$ -test was used for comparison of proportions. A *P*-value of <0.01 was considered significant; a higher significance threshold was selected due to our small sample size. Where information for a particular variable was unobtainable, the corresponding case was excluded from analyses involving that variable.

### Ethical approval

This study was carried out in accordance with the principles of the amended Declaration of Helsinki. Ethical approval was obtained from the Cairns and Hinterland Health Service District Human Research Ethics Committee (approval number HREC/10/QCH/78–685 LR).

## RESULTS

**O**NE HUNDRED AND twenty-seven unique episodes of primary spontaneous pneumothorax from 116 patients were identified. No cases of tension pneumothorax were recorded. Only cases who were clinically stable and not haemodynamically compromised at presentation were included in this study. One hundred and thirteen chest radiographs taken at presentation were available for review, and 111 episodes received treatment.

The majority of patients (73, or 65%) were of European descent, although there were a significant number of Aboriginal/Torres Strait Islander patients (18, or 15%) consistent with the ethnic make-up of the catchment population; 75% (86) of the subjects were male. The median age was 37 years, with the modal age range being 21–30 years. Eighty-five (62%) episodes occurred in current smokers, with a further 27 (20%) in ex-smokers.

Fifty-three episodes were treated conservatively and 58 invasively. No cases were treated with aspiration, therefore invasive treatment in our study comprised solely of tube thoracostomy.

Eight cases who received conservative therapy had chest radiographs post-presentation showing complete resolution. A further six cases had chest radiographs showing a reduction in the size of the pneumothorax within 2 weeks. Thirty-nine invasively managed cases had chest radiographs showing full lung re-expansion. For the entire cohort, the

**Table 1.** Outcomes and patient factors in 127 cases of primary spontaneous pneumothorax, by treatment type and pneumothorax size

Pneumothorax size	Treatment type	Age, years (median ± IQR)	Sex (male versus female)	Ethnicity (white versus other)	Smoking status (ever versus never)	Length of stay (mean ± SD)	Recurrences in 24 months	Episodes with complications
<25.0%	Conservative (n = 5)	46.0 ± 16.0	P = NS	P = NS	NA	0.4 ± 0.9	0	0
	Invasive (n = 3)	31.0 ± 27.0				5.0 ± 5.2	1	1
25.0–49.9%	Conservative (n = 30)	35.0 ± 32.8	P = NS	P = NS	P = NS	0.4 ± 1.0	4	0
	Invasive (n = 13)	50.0 ± 40.0				8.4 ± 5.5	0	4
50.0–74.9%	Conservative (n = 8)	31.5 ± 38.5	P = NS	P = NS	P = NS	1.4 ± 2.2	1	0
	Invasive (n = 17)	59.0 ± 21.0				5.7 ± 4.3	1	5
≥75.0%	Conservative (n = 9)	26.0 ± 12.0	P = NS	P = NS	P = NS	0.9 ± 2.0	1	0
	Invasive (n = 25)	37.0 ± 18.0				7.0 ± 4.8	4	6

IQR, interquartile range; NA, not applicable; NS, not significant; SD, standard deviation.

mean length of stay in cases treated conservatively was 0.6 days (95% confidence interval, 0.19–0.91), compared with 6.5 days (95% confidence interval, 5.3–7.7) in cases treated invasively ( $P = 0.006$ ).

Complications were found only in those episodes treated with tube thoracostomy. In particular, five cases (8%) developed haemothorax, three (5%) had skin or soft tissue infection, three developed (5%) empyemata, three (5%) had subcutaneous emphysema, and one (2%) converted to a tension pneumothorax. Twenty-two invasively treated cases proceeded to have pleurodesis, compared to two in those managed conservatively. Persistent air leaks were found in four (6%) cases who had tube thoracostomies. One case that was initially managed conservatively proceeded to have a non-emergent tube thoracostomy the same week.

Six conservatively treated cases (11%) had recurrences of their primary spontaneous pneumothoraces; of the invasively treated cases, an equal number (10%) had recurrences. There were no symptom-directed acute re-presentations in either group.

Table 1 summarises these findings, stratified by pneumothorax size.

## DISCUSSION

PRIMARY SPONTANEOUS PNEUMOTHORAX is a relatively rare condition; in our study, two cases on average were seen in the Emergency Department each month. As such there is a lack of evidence to guide the management of primary spontaneous pneumothorax, and current guidelines vary in their recommendations.<sup>3,4</sup> On the basis of a previous semiquantitative study on conservative treatment of primary spontaneous pneumothorax,<sup>16</sup> we aimed to evaluate the feasibility of conservative management of this condition. In particular, we were interested in whether conservative treatment had a better safety profile, as well as whether it would be a feasible alternative to invasive treatment, in pneumothoraces of equal size. In our study, no episodes were treated with aspiration, therefore invasive treatment equated to tube thoracostomy.

The Collins method<sup>19</sup> gives a better estimate of pneumothorax size compared to the methods in current use that rely solely on one measurement of interpleural distance, as the regression formula is derived by correlating plain radiographic measurements with the actual volume of the pneumothorax ascertained using computed tomography. No study evaluating treatment of primary spontaneous pneumothorax has adopted the sizing of pneumothoraces by this method, nor has any internationally used management guideline. Ours is the first study to have done so, and represents an

important addition to the evidence for conservative treatment of primary spontaneous pneumothorax.

The vast majority of primary spontaneous pneumothoraces in our study were considered large, and therefore warranted invasive treatment, according to the two major guidelines in current use. British Thoracic Society guidelines, which are also in use in Australia, state that a large pneumothorax is one with a rim of air  $\geq 2$  cm from the chest wall.<sup>3</sup> This would have resulted in all but four of our 127 episodes, or 97%, being treated invasively. American College of Chest Physicians guidance is relatively less strict, defining a large primary spontaneous pneumothorax as one where the apical interpleural distance is  $\geq 3$  cm.<sup>4</sup> One hundred cases would therefore have had intercostal tubes inserted if its guidelines were to be followed.

The ideal primary endpoint in studies of pneumothorax treatment is success, that is, whether the collapsed lung achieves full re-expansion. We were unable to use this outcome measure as post-treatment chest radiographs were unavailable for the majority of episodes. Given the limitations of the study design, differences in the rate of full lung re-expansion were unable to be demonstrated. Nevertheless, that nearly one-quarter of episodes managed conservatively had post-treatment chest radiographs showing improvement lends support for further study of this management option.

Therefore, our main outcome measures were length of stay, symptom-directed acute re-presentations, recurrences within 2 years, and development of post-treatment complications. We stratified episodes by pneumothorax size, using 25% increments. We divided the pneumothoraces in this manner, as the British Thoracic Society guidelines estimate a 2-cm rim of air seen on chest radiography to correlate with 50% lung collapse.<sup>3</sup> This is a strength of our study, as it allows comparison of patient characteristics and outcomes for a given size range. As shown in Table 1, in our cohort, age, sex, smoking status, and ethnicity had no influence on outcome in any of the four subgroups differentiated by size.

Furthermore, the proportion of recurrences 2 years after treatment was also equivalent in cases treated conservatively to those treated with tube thoracostomies. Recurrences in the conservatively treated group were more prevalent in pneumothoraces sized between 25% and 50% which, according to the consensus guidelines in use, would not have been treated invasively to begin with. As our hospital is the only acute tertiary referral centre for the region, all complications, recurrences, and re-presentations would be initially seen at our Emergency Department, thus the chances of not detecting serious post-treatment complications and recurrences are low. Our findings therefore suggest that in our cohort, at least in terms of the outcome measures studied, conservative therapy is as good as tube thoracostomy even in “large”

pneumothoraces  $>50\%$ . In our cohort, patients initially treated conservatively who developed a recurrence presented either after full lung re-expansion was evident, or after an interval of at least 3 months. This lends credence to the fact that the re-presentations are due to true recurrences, rather than symptomatic residual pneumothorax.

Equally importantly, in this cohort conservative treatment resulted in a markedly lower complication rate compared to invasive therapy. Serious complications such as conversion to tension pneumothorax and development of empyema were not seen in conservatively treated cases, and only one case managed conservatively required eventual tube thoracostomy, though not emergently. Conservative treatment also lessens the risk of psychological trauma arising from the development of complications, as well as from the tube thoracostomy procedure itself.

One reason so many conservatively-managed cases did not have chest radiographs showing total lung re-expansion is that these patients had follow-up delegated to their general practitioners, or told not to re-present unless they became symptomatically worse. General practitioners in Australia are able to request chest radiographs, and hence monitor the progress of pneumothorax resolution radiologically and clinically. This reduces demand for outpatient appointments.

Conservative management also significantly reduced the length of hospital stay in all but pneumothoraces of  $<25\%$ , and in pneumothoraces between 50% and 75% the difference was weakly significant ( $P = 0.014$ ). For the entire cohort, the mean length of stay was 10-fold shorter for episodes treated conservatively, and this difference was significant. Conservative management would therefore appear to be a safe alternative to tube thoracostomy and hospital admission, thus relieving pressure on hospital beds. We did not carry out a cost-benefit analysis but the savings to the hospital system from admission avoidance, along with the increased productivity derived from a faster return by patients to gainful activity, would suggest that conservative management may be economically beneficial.

One limitation of our study is its retrospective design. Omissions in medical record-keeping and unavailability of images were therefore beyond our control. In addition, cases were not randomised or matched, and no power calculations were carried out, therefore conclusions about generalisability and validity should be made with caution. It is important to stress that the aim of the study was to gauge the suitability to further study conservative management as first-line treatment, not make definitive conclusions.

Nevertheless, in our cohort of patients, conservative management appears to be safer than treating with tube thoracostomy, for primary spontaneous pneumothoraces of any size. The results in patients treated conservatively are also

encouraging, in terms of the outcome measures used in this study. A conservative approach as the initial treatment in clinically stable patients may therefore be justified; however, we believe a large-scale randomised controlled trial of conservative versus invasive management, with defined follow-up periods, is essential to conclusively prove this assertion. A cost-benefit analysis would also be useful to ascertain the economic benefits of conservative primary spontaneous pneumothorax management.

## CONFLICT OF INTEREST

NONE.

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