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REVIEW ARTICLE

Review of management of primary spontaneous pneumothorax: Is the best evidence clearer 15 years on?

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Abstract

In 1993 *Emergency Medicine Australasia* (then *Emergency Medicine [Fremantle]*) published a therapeutic review on the management of spontaneous pneumothorax. That review found a lack of high-quality evidence on which to base management decisions and a variety of therapeutic options without clear superiority one over another. Now, almost 15 years later, the present paper aims to revisit the evidence base to see if management choices are clearer.

Key words: outcome, *pneumothorax*.

Introduction

By definition primary spontaneous pneumothoraces (PSP) arise in otherwise healthy people without lung disease and without any apparent precipitating event. Reported incidence is 18–28/100 000 per year for men and 1.2–6/100 000 per year for women.[1,2] Many patients do not seek medical advice for several days, 46% waiting more than 2 days before presentation despite symptoms.[3]

Despite the absence of underlying pulmonary disease, subpleural blebs and bullae are likely to play a role in the pathogenesis since they are found in up to 90% of cases of cases at thoracoscopy or thoracotomy and in up to 80% of cases on CT scanning of the thorax.[4,5]

In 1993 a therapeutic review on the management of spontaneous pneumothorax was published.[6] It found a lack of clarity around the best management options, due largely to a lack of high-quality evidence. The aim of the present paper is to re-examine the evidence base to see if management choices are clearer.

Quantification of pneumothorax size

The plain postero-anterior chest radiograph has been shown to be a poor method for quantifying the size of a pneumothorax, usually underestimating size.[7] This is largely because its two dimensional image is a poor representation of what is really a quite complexly shaped space. Several alternative methods have been proposed.

In Europe, a commonly used method for estimating pneumothorax size is the Light Index.[8,9] This method assumes that the volume of the lung and of the hemithorax are roughly proportional to the cube of their diameters. It suggests that the volume of a pneumothorax can be calculated (in %) as $100 - ((\text{average diameter of lung}^3/\text{average diameter of hemithorax}^3) \times 100)$. In common practice, these diameters are measured at the hila.[9] Recently this method has been reported to be

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inaccurate, underestimating pneumothorax size particularly for moderate and large pneumothoraces.[10] This is likely to be due to the underlying assumption that the lung and thorax can be approximated by spheres.

Another method, preferred in the USA, is the Rhea method.[11] It uses the average of the interpleural distances measured in centimetres at the apex, midpoint of the upper half of the lung and midpoint of the lower half of the lung on an erect chest X-ray radiograph to estimate pneumothorax size in per cent using a nomogram. A recent validation study has found this method to be acceptably accurate for smaller pneumothoraces but prone to significantly underestimate the size of larger pneumothoraces.[12]

Recently more sophisticated methods for estimating the volume of a pneumothorax have been developed using helical computerized tomography.[13] From these data, Collins *et al.*[13] have derived a formula using interpleural distances on the erect X-ray radiograph to estimate pneumothorax size (size in % = 4.2 + 4.7 × (sum of interpleural distances in cm at apex, midpoint of upper half of collapsed lung and midpoint of lower half of collapsed lung)). This method, although more robust in development, has yet to be externally validated.

A shared weakness of the available size estimation methods is that where they have been derived from patient data, derivation sets are small and mainly comprised of smaller pneumothoraces. Most have not been validated.

Although traditionally expiratory chest X-ray radiographs have been used for the detection of pneumothoraces, presumably because of an assumption that expiration enhances contrast between lung parenchyma and pleural air,[14] studies now suggest they do not increase detection of clinically relevant pneumothoraces.[14,15]

For clarity and accuracy, reference to pneumothorax sizes estimated by the Collins's method will be used when possible in this review. This calculation is cumbersome for everyday use; however, practical cut-offs approximating 20% and 60% hemithorax volume can be derived, with a total of the sum of the interpleural distances described above of 3.5 cm estimating pneumothorax size as 20% and a total of 12 cm estimating pneumothorax size as 60%.

Management options

Patients with respiratory compromise, hypoxia or clinical evidence of tension clearly require evacuation of air from the pleural space by way of a pleural catheter. That said, there is some disagreement about the size of catheter required[16] and whether aspiration is sufficient or whether ongoing drainage is preferable.[17] The more challenging patient is the one without these clinical features. This review will focus primarily on this group.

Conservative management

Conservative treatment was the mainstay of management of PSP until the 1940s. It was then largely rejected in favour of intercostal catheter (ICC) drainage because it was believed that the latter resulted in a more rapid re-expansion of the lung and the assumption that this yielded a better outcome for the patient.[18] This logic has been challenged,[19,20] and there is now a move back towards the use of conservative management in selected cases.[21]

It is been widely accepted that small PSP (usually defined as 20% or less volume) in patients without respiratory compromise can be managed conservatively.[9,17,22,23] It has been shown that 70–80% of pneumothoraces estimated as being smaller than 15% have no persistent air leak and recurrence in those managed with conservative management alone is less than in patients treated with intercostal tube drainage.[24] There are very limited data about outcome for patients with larger PSP treated conservatively; however, success rates of the order 90% has been reported.[19,25,26]

The rate of resolution/reabsorption of PSP was previously estimated as 1.25–1.8% of the volume of hemithorax every 24 h.[18,26] These estimates were based on small samples and mathematical estimation models. Recent data, based on CT volumetrics and a larger sample of patients, estimate the rate of re-expansion at 2.2%.[20] Importantly that study also found significant between and within patient variation in re-expansion rate, with a tendency for larger pneumothoraces to re-expand at a faster rate.

The disadvantages of conservative treatment include the risk of unrecognized tension, the risk of deterioration, delay in the instigation of other therapy, interruption of employment/school in some patients and potentially longer time to cessation of symptoms. The advantages of the conservative approach include the avoidance of the need for hospitalization and associated cost savings,[19,26,27] minimal interruption to employment in selected candidates, avoidance of the risks and discomfort associated with some of the more invasive therapies and good patient acceptance.

Most patients in this group who 'fail' conservative management and require intercostal tube drainage have secondary pneumothoraces.[24]

Simple aspiration

Aspiration of PSP by the placement of a needle, or more often a catheter, into the pleural space and aspiration of the pleural air is popular in some regions. The aim of this treatment is to convert a larger PSP into one that can safely be managed conservatively. Successful re-expansion of the lung after simple aspiration is of the order of 50–83%.[28–38] A recent randomized controlled trial showed that simple aspiration was as successful in treating first primary pneumothoraces as immediate intercostal tube drainage (59% *vs* 63%).[30]

Successful aspiration has been shown to depend on age (under 50 years: 70–81% success, over 50 years: 19–31% success) and the size of the pneumothorax (<3 L aspirated: 89% success, >3 L: no success; >50% size on chest film: 62% success, <50% size on chest film: 77% success).[28,29,31,32,35,39] There is a modest gain (up to 83% overall success) with a second or third attempt at aspiration.[39–42]

Few complications are reported resulting from the use of aspiration and all are minor: vasovagal reactions, local subcutaneous emphysema and occasional problems with catheter kinking, blockage or dislodgement.[27,41,43] It has been suggested that aspiration might carry a risk of empyema; however, none have been formally reported. There are also no reported cases of lung laceration or of re-expansion pulmonary oedema.

Attempts to compare aspiration with ICC drainage have been scarce. A meta-analysis that included three randomized controlled trials with a total of 194 patients found that aspiration resulted in shorter hospital stay. They found success hard to compare because of variation in endpoints, but for the composite endpoint of success at 1 week found no difference.[44] A subsequently published study also found similar treatment success rates.[38]

ICC drainage

Intercostal catheters, traditionally between 10 and 40F in size, can be inserted by an anterior, axillary or postero-apical approach. For practical and cosmetic reasons, an axillary approach is the most favoured currently. Primary success rates of 66–97% have been reported.[16,38,45–49] Reported duration of hospital admission ranges from 7 to 9 days.[16,50,51]

Potential disadvantages of ICC range from chest and abdominal visceral trauma from sharp trocars[52] (now not favoured for insertion) to practical management issues such as the bulkiness of the underwater seal bottle system that must be kept upright. Available data suggests that the rate of aberrant placement is 4–9%[53,54] and empyema risk has been estimated at 1%.[53] Other potential complications include bronchopleural fistulae, arteriovenous fistulae, perforation of the internal mammary artery, pulmonary or mediastinal blood vessels, focal lung infections, re-expansion pulmonary oedema and lung infarction. There are insufficient data to quantify the risk of these complications.

Pleural catheter options

In some centres, pleural catheters (usually 8–16F) have been combined with the use of one-way valves (e.g. Heimlich valves) with good results.[25] These allow the patient to ambulate and are easier to nurse. In a retrospective study, Vedam *et al.*[16] found that small-bore pleural catheters were as effective as large ICC in initial resolution of PSP.

A variant of small-bore catheter drainage is the use of a pigtail catheter. A study comparing pigtail catheters to ICC reports that duration of drainage, mean hospital stay, evacuation rate and total cost were similar.[55] Another reports success rates at 24 h of 61% and at 1 week of 85% with an average length of stay of 2.3 days.[56]

They also allow the possibility of outpatient management. This has been the subject of a number of case series and small studies with reported success rates of 74–100%.[25,49,57,58] A randomized controlled trial comparing small catheter with vent with ICC found that 70% of the small catheter group could be managed as outpatients and that success rates were similar.[49] Failure rate for outpatient treatment has been reported as 4.5%.[58]

Reported success rates for the various strategies are summarized in Table 1.

Table 1. Summary of success rates for management strategies for PSP

Strategy	Success rate
Conservative	90%[19,25,26]
Aspiration	50–83%[28–38]
ICC	66–97%[16,38,45–49]
Small-bore/pigtail catheter	74–100%[25,49,57,58]

ICC, intercostal catheter; PSP, primary spontaneous pneumothoraces.

Published guidelines

There are three published guidelines on the management of PSP, unfortunately with different recommendations.

British Thoracic Society (BTS)

In an effort to standardize treatment of PSP, the BTS published guidelines for their treatment in 1993.[59] These were updated in 2003.[17]

These guidelines chose to classify the size of a pneumothorax as 'small' or 'large' depending on the presence of a visible rim of <2 cm between the lung margin and the chest wall, but do not define where this measurement should be taken. Based on Collins's formula,[13] this would make the cut-off between 'small' and 'large' at approximately 14% of hemi-thorax volume. The justification seems to be based on the Light formula[8] that has not been validated and has been shown to be inaccurate.[10] There is no distinction made for isolated apical pneumothoraces.

Recommendations:

- Patients with small (<2 cm) PSP not associated with breathlessness should be considered for discharge with early outpatient review. These patients should receive clear written advice to return in the event of worsening breathlessness (Evidence level B)
- Simple aspiration is recommended as first line treatment for all PSP requiring intervention (Evidence level A)
- Repeated aspiration is reasonable for PSP when the first aspiration has been unsuccessful (i.e. patient still symptomatic) and a volume of <2.5 L has been aspirated on the first attempt (Evidence level B)
- If simple aspiration or catheter aspiration drainage of any pneumothorax is unsuccessful in controlling symptoms, then an intercostal tube should be inserted (Evidence level B)
- There is no evidence that large tubes (20–24F) are any better than small tubes (10–14F) in the management of pneumothoraces. The initial use of large (20–24F) intercostal tubes is not recommended (Evidence level B)

The BTS guidelines document the following as areas requiring research:

Prospective randomized controlled trials comparing conservative management with aspiration ± tube drainage for PSP larger than 2 cm on the chest radiograph, use of small catheter/Heimlich valve kits *versus* intercostal tube drainage following failed aspiration in PSP and small catheter aspiration *versus* conventional aspiration or tube drainage.

American College of Chest Physicians[22]

These guidelines were developed by literature review from 1967 to January 1999 and a Delphi questionnaire submitted in three iterations to a multidisciplinary physician panel. In this guideline, small pneumothoraces are defined as less than 3 cm apical distance, approximately equivalent to a volume of at least 18% by Collins's formula.[13]

Recommendations:

- Clinically stable patients with small pneumothoraces should be observed in the emergency department for 3–6 h and discharged home if a repeat chest radiograph excludes progression of the pneumothorax (good consensus)
- Clinically stable patients with large pneumothoraces should undergo a procedure to re-expand the lung and should be hospitalized in most instances (very good consensus). The lung should be re-expanded by using a small-bore catheter (14F) or placement of a 16F to 22F chest tube (good consensus)
- Simple aspiration is appropriate rarely in any clinical circumstance

Belgian Society of Pneumology[9]

For this guideline, a large pneumothorax is defined as one where there is a pleural gap along the entire length of the lateral chest wall on chest X-ray radiograph. They equate this with a minimum 20% size based on the Light formula.[8] It is not possible to calculate a cut-off size using the Collins's formula[13] because of insufficient information.

Recommendations:

- In the case of a small and minimally symptomatic PSP, observation and outpatient follow up is recommended (Evidence level C)
- In the case of symptomatic and/or large PSP, initial treatment is evacuation of air either by simple aspiration or the introduction of a small-bore catheter attached to a Heimlich valve or underwater seal (Evidence level B)
- In the case of failure of simple manual aspiration, intercostal tube drainage using a small tube (maximum 16F) is recommended (Evidence level C)

Current guideline recommendations are summarized in Table 2. There is agreement regarding the management of small PSP but all have different approaches to larger PSP.

Table 2. Comparison of guideline recommendations (clinically stable patients)

Guideline	Small PSP	Large PSP
BTS[17]	Conservative management as outpatient	Simple aspiration
ACCP[22]	Observation in ED followed by conservative management as an outpatient	Pleural catheter insertion (small bore or ICC) and drainage
Belgian Society of Pneumology[9]	Conservative management as outpatient	Aspiration or Pleural catheter insertion (small bore or ICC) and drainage

ACCP, American College of Chest Physicians; BTS, British Thoracic Society; ICC, intercostal catheter; PSP, primary spontaneous pneumothoraces.

Comment

Available evidence suggests that we are not much further advanced than we were in the development of a truly evidence-based approach to stable patients with PSP. Several strategies seem to have similar success rates (although 'success' is variably defined) and there are few high-quality studies that robustly investigate success rate, adverse events, costs and patient acceptance. A well-designed, randomized controlled trial is needed to address the outstanding questions.

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Competing interests

Anne-Maree Kelly is on the Australasian Editorial Board of *Emergency Medicine Australasia*.

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