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Official publication of the American College of Chest Physicians



Management of Spontaneous Pneumothorax

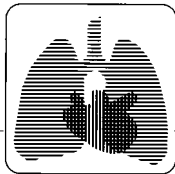
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Chest 2001;119:590-602
DOI 10.1378/chest.119.2.590

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consensus conference

Management of Spontaneous Pneumothorax*

An American College of Chest Physicians Delphi Consensus Statement

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Objective: Provide explicit expert-based consensus recommendations for the management of adults with primary and secondary spontaneous pneumothoraces in an emergency department and inpatient hospital setting. The use of opinion was made explicit by employing a structured questionnaire, appropriateness scores, and consensus scores with a Delphi technique. The guideline was designed to be relevant to physicians who make management decisions for the care of patients with pneumothorax.

Options: Decisions for observation, chest tube placement, surgical interventions, and radiographic imaging.

Outcomes: Effectiveness of pneumothorax resolution, duration of and patient tolerance of care, and pneumothorax recurrence.

Evidence: Literature review from 1967 to January 1999 and Delphi questionnaire submitted in three iterations to a multidisciplinary physician panel.

Values: The guideline development group determined by consensus the relevant outcomes to be considered in developing the Delphi questionnaire.

Benefits, harms, and costs: The type and magnitude of benefits, harms, and costs expected for patients from guideline implementation.

Recommendations: Management decisions vary between patients with primary or secondary pneumothoraces, with observation of small pneumothoraces being appropriate only for primary pneumothoraces. The level of consensus varies regarding the specific interventions indicated, but agreement exists for the general principles of care.

Validation: Recommendations were peer reviewed by physician experts and were reviewed by the American College of Chest Physicians (ACCP) Health and Science Policy Committee.

Implementation: The guideline recommendations will be published in printed and electronic form with distribution of synopses for patients and health care providers. Contents of the guideline will be incorporated into continuing medical education programs.

Sponsors: The ACCP.

(*CHEST* 2001; 119:590–602)

Key words: consensus; Delphi; guideline; management; pneumothorax; practice guideline; spontaneous pneumothorax

Abbreviations: ACCP = American College of Chest Physicians; BTS = British Thoracic Society

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†A complete list of the consensus group is located in Appendix 1. Additional information about the questionnaire, consensus tables, and other data are available at www.chestnet.org/publications/18098/index.html.

Manuscript received June 2, 2000; revision accepted September 14, 2000.

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Spontaneous pneumothoraces, which occur in the absence of thoracic trauma, are classified as primary or secondary.¹ Primary spontaneous pneumothoraces affect patients who do not have clinically apparent lung disorders. Secondary pneumothoraces occur in the setting of underlying pulmonary disease, which most often is COPD.

Although primary and secondary spontaneous pneumothoraces affect > 20,000 patients per year in the United States² and account for nearly \$130,000,000 in health-care expenditures each year,³ generally accepted and methodologically sound guidelines for the care of these patients do not exist. Consequently, observational studies demonstrate extensive practice variation in the management of this relatively common condition.⁴

To address this variation in care, the American College of Chest Physicians (ACCP) commissioned the development of a practice guideline for the management of spontaneous pneumothorax. The guideline committee recognized that insufficient data existed from randomized controlled trials to develop an evidence-based document and that recommendations would largely derive from expert opinion. Because informal approaches for developing expert-based statements are subject to extensive bias, the guideline developers selected the Delphi technique⁵ to formalize the expert panel's consensus process and explicitly state opinion. The methodology for this consensus guideline provides clinicians with a description of the level of consensus achieved for each treatment recommendation and identifies clinical settings wherein multiple options for care exist. The guideline pertains to adult patients with primary spontaneous pneumothorax and patients with secondary pneumothorax associated with COPD. Many of the recommendations will have relevance to secondary pneumothoraces affecting patients with underlying lung disorders other than COPD.

MATERIALS AND METHODS

The guideline development process used the Delphi method to create and quantify group consensus (Fig 1). The Delphi method was developed by RAND Corporation (Santa Monica, CA) researchers in the 1950s.⁵ Characteristics of the Delphi method are anonymity, controlled feedback, and statistical group response.⁶ Anonymity derives from the absence of face-to-face interaction. Participants respond independently to questionnaires, and responses are communicated to other participants without being attributed to specific individuals. Controlled feedback occurs during several questionnaire iterations. Opinions expressed during one round of the questionnaire are returned to the group during the next round in the form of statistical summaries. The statistical group response is the final stage of the Delphi method with the group consensus expressed as a statistical score. The results of the questionnaire are expressed using summary decision rules that quantify the level of consensus and the appropriateness of management recommendations.⁷

Guideline Development Committee and Expert Panel Members

The ACCP Health and Science Policy Committee selected the content chairman, the content co-chairman, and the methodology chairman. The chairmen selected six members of a multidisciplinary guideline development committee on the basis of the members' previous publications on the topic of pneumothorax.

The chairmen met with the project development committee to organize the Delphi process and to select members of the expert panel. Panel members were selected from specialty fields proportionally related to the distribution of publications on the management of pneumothorax among specialty and subspecialty journals. This proportionality was determined by a MEDLINE literature search from 1966 to 1997 (see below). Experts were eligible for selection if they had published a peer-reviewed article on pneumothorax during the previous 5 years. Each member provided a written statement disclosing the existence of any corporate relationships related to the care of patients with pneumothoraces. The distribution of panel members among medical specialties were as follows: pulmonary/critical care, 12 members (38%); thoracic surgery, 12 members (38%); general surgery, 1 member (3%); interventional radiology, 3 members (9%); and emergency medicine, 4 members (13%).

Literature Search

A MEDLINE literature search of English language articles was performed for the period from 1966 to 1997. The MeSH heading of spontaneous pneumothorax was combined with the terms *randomized controlled trials*, *meta-analysis*, and *guidelines*. Recent review articles were searched for additional randomized controlled trials. Retrieved articles were distributed to panel members. The literature search was repeated during each of the three iterations of the Delphi questionnaire, with the last literature search occurring in January 1999. Retrieved articles were graded by the two content chairmen on the basis of the articles' study designs (Table 1).⁸ The methodology chairman resolved grading disagreements with a majority vote.

Additional articles were identified by the panel members and were communicated to the development group through the Delphi questionnaire. Abstracts of these articles were distributed to the panel during the next round of the questionnaire.

Delphi Questionnaire

The guideline development committee met to design a questionnaire that would query panel members about management decisions in the care of patients with primary spontaneous pneumothoraces and secondary pneumothoraces due to COPD. The committee constructed a decision tree for the care of patients with pneumothoraces and selected decision branch points for inclusion into the questionnaire that were considered by the committee to be key management practices. The committee did not discuss the appropriateness of these practices so as to avoid influencing the questionnaire development or bias members in attendance who would later respond to the questionnaire.

Most questions were case-based scenarios with multiple management options presented as choices (Fig 2). Panel members were asked to respond to the appropriateness of each option using a 9-point Likert scale (Table 2). A few questions were open-ended, multiple choice, or requested a "yes" or "no" response.

The multidisciplinary experts were allowed to skip questionnaire items by indicating that they did not have sufficient knowledge or experience to respond to a particular question. Panel members also were asked to indicate whether their re-

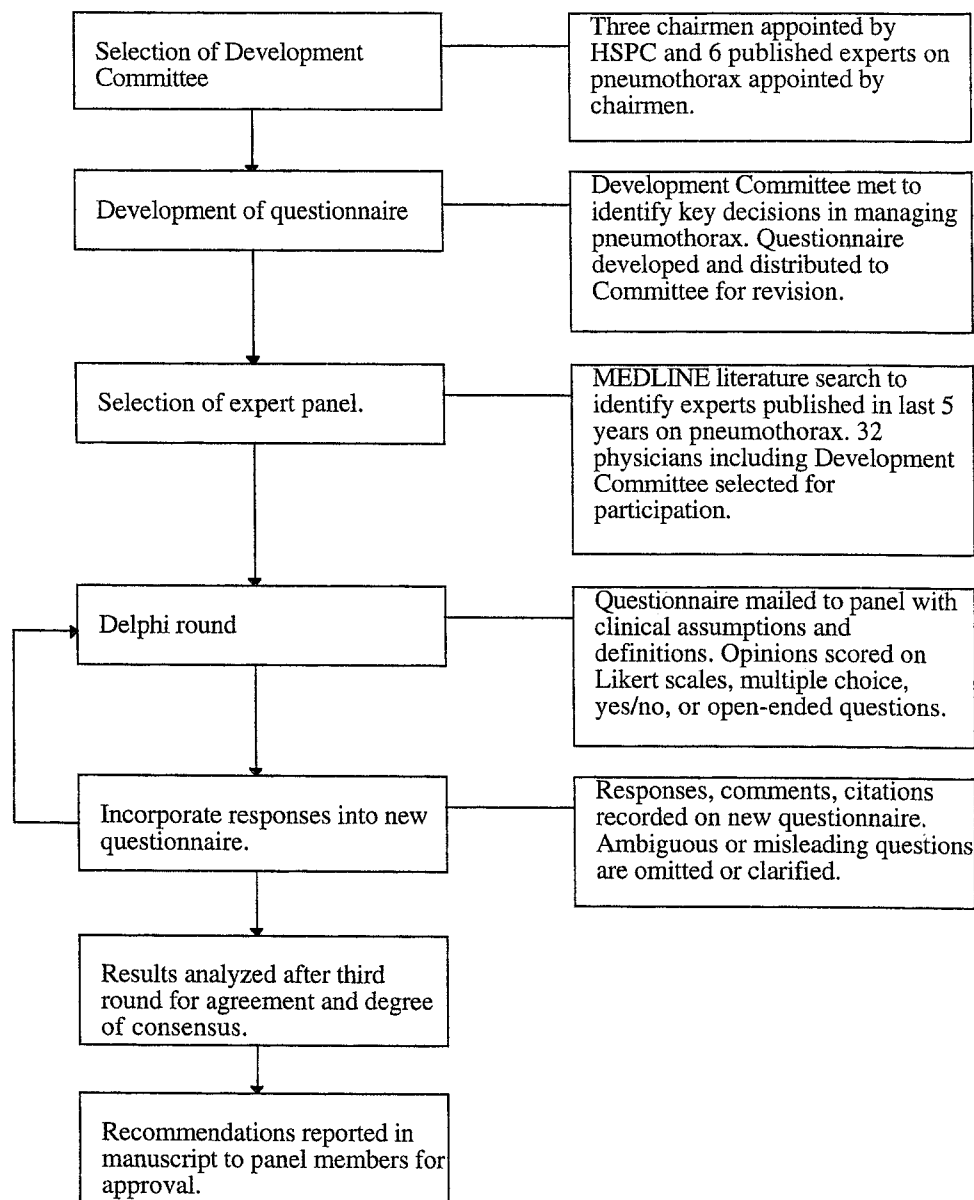


FIGURE 1. Steps of the Delphi method. HSPC = Health and Science Policy Committee of ACCP.

sponses were based on opinion or an interpretation of published investigations. Panel members were provided a space to present an argument or literature citations in support of their opinions.

The questionnaire listed on its face page definitions of terms and clinical assumptions (Tables 3, 4).

Administration of the Questionnaire

The first Delphi questionnaire was mailed to the panel members with a request for its completion and return within 2 weeks. Responses on the returned questionnaires were summarized. A second questionnaire was developed that included a summary of the panel members' responses to each of the first questionnaire's items, a synopsis of the panel members' comments, and a list of the articles cited by the panel members in support of their questionnaire responses. Questionnaire items that were identified by the panel members as ambiguous were refined.

Summaries of item responses were placed adjacent to the specific item and were described as follows. The number of panel members responding to each item was listed. Bar and dot symbols were placed adjacent to the Likert scales to indicate median responses, middle 50% range, and the range for all responses. Similar summary statistics were presented for open-ended questions that requested a numeric response. A number reported the proportion of panel members responding "yes" or "no" to an item. Panel members were provided with a key for each questionnaire that explained the data summary techniques.

This second questionnaire was mailed to panel members. Responses to the second questionnaire's items, the panel members' comments, and cited literature were summarized and incorporated into a third questionnaire that was mailed to the panel members. Bar and dot symbols (Fig 2) were placed over the Likert scales to indicate median responses, the middle 50% range, the middle 80% range, and outlier responses. The third

Table 1—Levels of Evidence for Studies Evaluating Treatment Effectiveness*

Level of Evidence and Grade	Study Design
Level I	Large, randomized trials with clear-cut results; low risk of false-positive (α) error or false-negative (β) error
Level II	Small, randomized trials with uncertain results; moderate to high risk of false-positive and/or false-negative error
Level III	Nonrandomized, contemporaneous control
Level IV	Nonrandomized, historical control subjects, and expert opinion
Level V	Case series, uncontrolled studies, and expert opinion
Grade A	Supported by at least two level I investigations
Grade B	Supported by only one level I investigation
Grade C	Supported by level II investigations only
Grade D	Supported by at least one level III investigation
Grade E	Supported by level IV or level V evidence

*Adapted from Taylor.⁸

mailing included printed copies of the abstracts from the articles cited by panel members in support of their responses to specific questionnaire items.

Description of Level of Consensus and Degree of Evidence-Based Support

Responses to the third questionnaire's items that used the 9-point Likert scale were summarized and applied to *a priori*

definitions to determine levels of consensus (Table 5). Evidence cited in the questionnaire by panel members to support their questionnaire responses also was cited in the guideline text with an evidence grade.

Description of Appropriateness of Management Options

Management options were graded regarding appropriateness using the summary results of the Likert scale (Table 6). Depending on the panel recommendations and the level of consensus achieved, the guideline uses the words "must," "should," and "may" to identify recommendations that are standards (must), guidelines (should), or options (may) for care⁹ (Table 6). This language is keyed directly to the panel members' scored responses. Management approaches are described as inappropriate when a high degree of consensus indicated that the intervention must not be employed for any patient in any clinical circumstance. Because of the lack of high-grade evidence in the management of pneumothorax and the expert-opinion basis of the guideline, few interventions are described as inappropriate.

Although based on previously reported approaches,^{10,11} methods for assessing and reporting the level of consensus and appropriateness were developed during this project and are unique to this guideline statement.

RESULTS AND MANAGEMENT RECOMMENDATIONS

Literature Search

The literature search retrieved nine articles,^{12–20} which included eight randomized controlled trials^{12–19} (Table 7), no meta-analyses, and one practice

- 6. A young previously healthy patient presents with a primary spontaneous pneumothorax. The patient fits your criteria for chest tube placement (see prior questions). The patient IS NOT at significant risk of a substantial air leak (i.e. not in danger of mechanical ventilation, or not already placed on mechanical ventilation). Your choice of a chest tube:

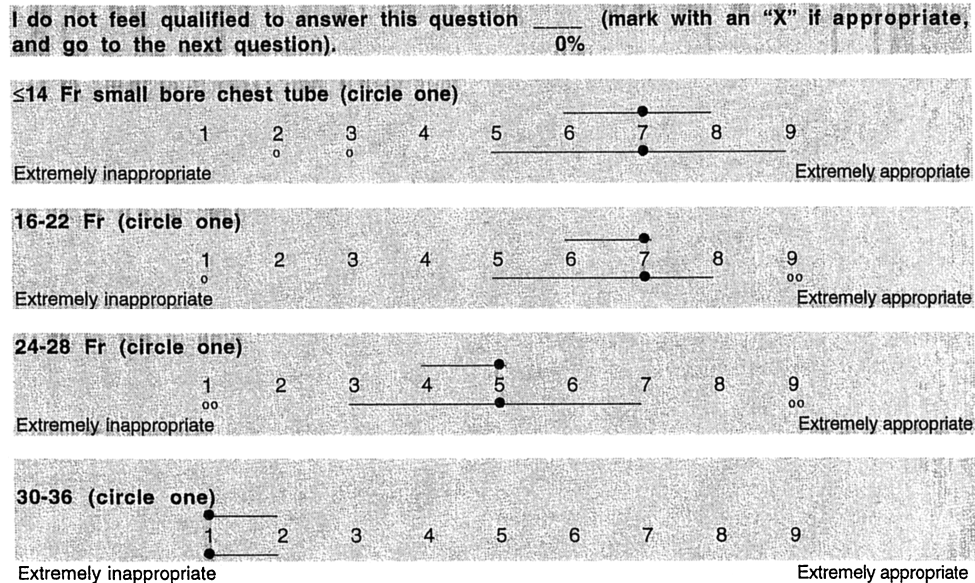


FIGURE 2. A sample item on the questionnaire showing the statistical summaries of the panel members' responses from the previous round. The solid dots above and below the Likert scales indicate the median responses. The bars above and below the Likert scale show the middle 50% and the middle 80% responses, respectively. The open dots represent outlier responses.

Table 2—Expert Opinion Ratings

Likert Scale	Definition
9	Extremely appropriate: treatment of choice (may have more than one per question).
7 and 8	Appropriate: a first-line treatment you would often use.
4–6	Equivocal: a second-line treatment you would sometimes use (eg, after first line had failed).
2 and 3	Usually inappropriate: at most, a third-line treatment you would rarely use.
1	Extremely inappropriate: a treatment you would never use.

guideline.²⁰ The analysis of the retrieved articles indicated that all of the guideline recommendations were grade E (lowest grade of evidence).

Delphi Technique

Three questionnaire iterations were completed with 100% participation in the first iteration, 97% participation (31 of 32) in the second iteration (a thoracic surgeon dropped out), and 94% participation (30 of 32) in the third iteration (two thoracic surgeons dropped out). The guideline incorporates the consensus opinions of the 30 members who

completed all three questionnaires. The degree of consensus increased or remained stable during the Delphi process for most questionnaire items (68%).

Primary Spontaneous Pneumothorax

Clinically Stable Patients With Small Pneumothoraces: Clinically stable patients with small pneumothoraces should be observed in the emergency department for 3 to 6 h and discharged home if a repeat chest radiograph excludes progression of the pneumothorax (good consensus). Patients should be provided with careful instructions for follow-up within 12 h to 2 days, depending on circumstances. A chest radiograph should be obtained at the follow-up appointment to document resolution of the pneumothorax. Patients may be admitted for observation if they live distant from emergency services or follow-up care is considered unreliable (good consensus). Simple aspiration of the pneumothorax or insertion of a chest tube is not appropriate for most patients (good consensus), unless the pneumothorax enlarges. The presence of symptoms for > 24 h does not alter the treatment recommendations.

Clinically Stable Patients With Large Pneumothoraces: Clinically stable patients with large pneumo-

Table 3—Questionnaire Definition of Terms

Terms	Definition
Spontaneous pneumothorax	No antecedent traumatic or iatrogenic cause
Primary spontaneous pneumothorax	No clinically apparent underlying lung abnormalities or underlying conditions known to promote pneumothorax (eg, HIV disease)
Secondary spontaneous pneumothorax	Clinically apparent underlying lung disease
Pneumothorax size	Determined by distance from the lung apex to the ipsilateral thoracic cupola at the parietal surface as determined by an upright standard radiograph
Small pneumothorax	< 3 cm apex-to-cupola distance
Large pneumothorax	≥ 3 cm apex-to-cupola distance
Patient age groups, yr	
Young	18–40
Older	≥ 40
Clinical stability	
Stable patient	All of the following present: respiratory rate, < 24 breaths/min; heart rate, > 60 beats/min or < 120 beats/min; normal BP; room air O ₂ saturation, > 90%; and patient can speak in whole sentences between breaths
Unstable patient	Any patient not fulfilling the definition of stable
Drainage tubes	
Small chest tube or small percutaneous catheter	≤ 14F
Moderate-sized chest tube	16F to 22F
Large chest tube	24F to 36F
Simple aspiration	Insertion of a needle or cannula with removal of pleural air followed by immediate removal of the needle or cannula
Sclerosis (pleurodesis) procedure	
Chemical pleurodesis	Intrapleural instillation of a sclerosing agent through a chest tube or percutaneous catheter
Open or surgical pleurodesis	Pleurodesis performed with a thoracoscope or through a limited or full thoracotomy

Table 4—Clinical Assumptions

Patients will comply with treatment recommendations and can obtain prompt emergency medical care
Questions related to secondary spontaneous pneumothoraces pertain to patients with underlying COPD
Patients have no comorbidities not mentioned in the case scenarios
Pneumothorax is the cause of the patient's presenting clinical manifestations
Care recommendations do not consider patient preferences
First-time pneumothorax unless otherwise indicated

thoraces should undergo a procedure to reexpand the lung and should be hospitalized in most instances (very good consensus). The lung should be reexpanded by using a small-bore catheter ($\leq 14F$) or placement of a 16F to 22F chest tube (good consensus). Catheters or tubes may be attached either to a Heimlich valve (good consensus) or to a water seal device (good consensus) and may be left in place until the lung expands against the chest wall and air leaks have resolved. If the lung fails to reexpand quickly, suction should be applied to a water-seal device. Alternatively, suction may be applied immediately after chest tube placement for all patients managed with a water seal system (some consensus).

Reliable patients who are unwilling to undergo hospitalization may be discharged home from the emergency department with a small-bore catheter attached to a Heimlich valve if the lung has reexpanded after the removal of pleural air (good consensus). Follow-up should be arranged within 2 days. The presence of symptoms for > 24 h does not alter management recommendations.

Clinically Unstable Patients With Large Pneumothoraces: Unstable patients with large pneumothoraces should undergo hospitalization with insertion of a chest catheter to reexpand the lung (very good consensus). Most patients should be treated with a

16F to 22F standard chest tube (good consensus) or with a small-bore catheter (good consensus), depending on the degree of clinical instability. A 24F to 28F standard chest tube may be used if the patient is anticipated to have a bronchopleural fistula with a large air leak or requires positive-pressure ventilation (good consensus). A water seal device can be used without suction initially (good consensus), but suction should be applied if the lung fails to reexpand with water seal drainage. Suction may be alternatively applied immediately after chest tube placement (some consensus). Some patients may be managed with a small-bore catheter attached to a Heimlich valve if clinical stability can be obtained with immediate evacuation of the pleural space (good consensus). A water seal device should be substituted for the Heimlich valve and suction applied if the lung fails to reexpand (good consensus).

Chest Tube Removal: Chest tubes should be removed in a staged manner so as to ensure that the air leak into the pleural space has resolved (good consensus). The first stage requires that a chest radiograph demonstrates complete resolution of the pneumothorax and that there is no clinical evidence of an ongoing air leak. Any suction applied to the chest tube should be discontinued (good consensus).

Fifty-three percent of panel members would never clamp a chest tube to detect the presence of an air leak after reexpansion of the lung. The remaining panel members would clamp the chest tube approximately 4 h after the last evidence of an air leak. Regardless of whether the tube was or was not clamped, panel members would repeat a chest radiograph 5 to 12 h after the last evidence of an air leak (62% of members) to ensure that the pneumothorax had not reoccurred in preparation for pulling the chest tube. Other panel members would wait ≤ 4 h (10%), 13 to 23 h (10%), or 24 h (17%) before repeating a chest radiograph.

Table 5—Consensus Definitions*

Term	Definition
Perfect consensus	All respondents agree on an answer
Very good consensus	Median and middle 50% (interquartile range) of respondents are found at one integer (<i>eg</i> , median and interquartile range are both at 8) or 80% of respondents are within one integer of the median (<i>eg</i> , median is 8, 80% respondents are from 7 to 9)
Good consensus	50% of respondents are within one integer of the median (<i>eg</i> , median is 8, 50% of respondents are from 7 to 9) or 80% of the respondents are within two integers of the median (<i>eg</i> , median is 7, 80% of respondents are from 5 to 9).
Some consensus	50% or respondents are within two integers of the median (<i>eg</i> , median is 7, 50% of respondents are from 5 to 9) or 80% of respondents are within three integers of the median (<i>eg</i> , median is 6, 80% of respondents are from 3 to 9).
No consensus	All other responses.

*Definitions refer to Likert scale (Nos. 1 to 9) for responses. See Table 2.

Table 6—Management Definitions*

Management Options	Median (Middle 50% Range)	Strength of Recommendation
Preferred management in most circumstances	7–9 (7–9)	“Must” if perfect consensus; “should” otherwise
Acceptable management in many circumstances	7–9 (4–9)	“Should” if no preferred management exists; “may” if a preferred management exists
Acceptable management in certain circumstances	4–6 (4–9)	“May”
Acceptable management in rare circumstances	2 and 3 (1–≤ 4)	“May”
Inappropriate management	(1–3)	“Must not” if perfect consensus; “should not” otherwise
Indeterminate	All other median and range combinations including “no consensus”†	No management recommendation

*Median scores for responses to questionnaire items asking for ranking of appropriateness are given on a scale of 1 to 9. See Table 2 for definitions.
†See Table 5.

Persistent Air Leaks: For patients with persistent air leaks, the panel recommended continued observation for 4 days for spontaneous closure of bronchopleural fistula (median, 4 days; interquartile range, 3 to 5 days; middle 80% range, 2 to 6 days). Patients with air leaks persisting beyond 4 days should be evaluated for surgery to close the air leak and to perform a pleurodesis procedure to prevent pneumothorax recurrence (very good consensus). Although the relative value of thoracoscopy compared to a limited thoracotomy has not been clearly defined, the panel selected thoracoscopy as the preferred management (very good consensus). Patients should not undergo the placement of an additional chest tube or bronchoscopy with attempts to seal endobronchial sites of air leaks (very good consensus). Most patients should not be managed with chemical pleurodesis by instilling sclerosing agents through the chest tube except in special circumstances in which surgery is contraindicated or patients refuse an operative procedure (very good consensus). If chemical pleurodesis is performed, doxycycline or talc slurry is the preferred sclerosing agent (good consensus).

Pneumothorax Recurrence Prevention: Except for patients with persistent air leaks, procedures to prevent the recurrence of a primary spontaneous pneumothorax should be reserved for the second pneumothorax occurrence (85% of panel members). Fifteen percent of panel members, however, would offer patients an intervention to prevent a recurrence after the first pneumothorax. Patients’ preferences and interests in continuing activities that would place them at high risk if a pneumothorax reoccurred (eg, scuba diving or flying) should be considered in deciding the timing of the intervention. Thoracoscopy is the preferred intervention for

preventing pneumothorax recurrence (very good consensus). The instillation of sclerosing agents through a chest tube is an acceptable approach for pneumothorax prevention in patients who wish to avoid surgery and for patients who present increased surgical risk (eg, bleeding diathesis) (good consensus). Success rates with chemical pleurodesis, however, are only 78 to 91% compared to success rates of 95 to 100% with surgical interventions.³

Patients selected for surgical prevention of pneumothorax recurrence should be managed by thoracoscopy (very good consensus). The panel could not agree on the utility of limited (axillary) thoracotomy in recurrence prevention. The panel noted that clinical trials that include patients with primary spontaneous pneumothorax do not demonstrate the superiority of thoracoscopy vs limited thoracotomy in pneumothorax prevention^{12,21}; the panel’s preference for thoracoscopy was based on practice preferences.

Thoracoscopy can be performed with or without video assistance. Patients with apical bullae visualized at surgery should undergo intraoperative bullectomy (very good consensus). Bullectomy should be performed by staple bullectomy (very good consensus). Options for eliminating bullae include electrocoagulation, laser ablation, or hand sewing, depending on institutional expertise and experience with these procedures. Intraoperative pleurodesis should be performed in most patients with parietal pleural abrasion limited to the upper half of the hemithorax (good consensus). Parietal pleurectomy (some consensus) is an acceptable alternative pleurodesis technique. No consensus was reached regarding the utility of talc poudrage in primary spontaneous pneumothorax recurrence prevention.

Chest Imaging With CT: The panel did not rec-

Table 7—Characteristics of Randomized Controlled Spontaneous Pneumothorax Trials*

Study	Cohorts and Patient Characteristics	Results Summary
General treatment trials		
Ma et al ¹⁴	Short-wave diathermy treatment vs observation; n = 11 in each group	Air absorption rate significantly greater with short-wave diathermy
Andrivet et al ¹⁷	28 patients treated with thoracic drainage and 33 with needle aspiration	Higher success rate for patients undergoing thoracic drainage than with needle aspiration; no difference in mean length of hospital stay
Harvey and Prescott ¹⁹	Simple aspiration (n = 35) vs intercostal tube drainage (n = 38)	Longer hospital stay and greater daily pain in patients with intercostal tube drains
Engdahl et al ¹⁶	Indwelling chest drains with interpleural bupivacaine (n = 11) vs saline solution placebo (n = 11)	Visual analog pain scale scores lower in the bupivacaine group
Pleurodesis trials		
Light et al ¹⁵	Spontaneous pneumothorax patients with chest tubes randomized to intrapleural tetracycline (n = 113) vs control group (n = 116)	5-year study period: pneumothorax recurrence rates lower in the tetracycline group
Almind et al ¹⁸	Spontaneous pneumothorax patients in three treatment groups: simple drainage (n = 34); drainage/tetracycline (n = 33); and drainage/talc (n = 29)	Talc with significant pneumothorax recurrence reduction compared to simple drainage; tetracycline recurrence reduction no different than other two groups.
van den Brande and Staelens ¹³	Primary spontaneous pneumothorax only: 10 patients with drainage + tetracycline/glucose; 10 patients with drainage alone	Pleurodesis with reduction in early but not late recurrences
Surgical trial		
Waller et al ¹²	30 patients with VATS vs 30 patients with posterolateral thoracotomy for persistent air leak or pneumothorax recurrence	Greater postoperative decline in lung function in thoracotomy group; no difference in postoperative stay, recurrence, or morphine use; longer operating time for VATS

*VATS = video-assisted thoracoscopic surgery.

ommend the routine use of chest CT imaging for patients with a first-time pneumothorax (good consensus). The panel did not achieve consensus regarding the utility of chest CT scans for evaluating patients with recurrent pneumothoraces, persistent air leaks, or planned surgical interventions. Chest CT may be indicated to evaluate the presence of pulmonary disorders, such as interstitial lung disease, that are suspected clinically but are not apparent on standard radiographs.

Age Considerations: The questionnaire did not query the panel regarding the importance of age in making management decisions.

Secondary Spontaneous Pneumothorax

Clinically Stable Patients With Small Pneumothoraces: Clinically stable patients with small pneumothoraces should be hospitalized (good consensus). Patients should not be managed in the emergency department with observation or simple aspiration without hospitalization (very good consensus). Hospitalized patients may be observed (good consensus) or treated with a chest tube (some consensus), depending on the extent of their symptoms and the course of their pneumothorax. Some of the panel

members argued against observation alone because of a report of deaths with this approach.²² Patients should not be referred for thoracoscopy without prior stabilization (very good consensus). The presence of symptoms for > 24 h did not alter the panel members' recommendations.

Clinically Stable Patients With Large Pneumothoraces: Clinically stable patients with large pneumothoraces should undergo the placement of a chest tube to reexpand the lung and should be hospitalized (very good consensus). Patients should not be referred for thoracoscopy without prior stabilization with a chest tube (very good consensus). The presence of symptoms for > 24 h did not alter the panel members' recommendations.

Clinically Unstable Patients With Pneumothoraces of Any Size: Patients should undergo placement of a chest tube to reexpand the lung and should be hospitalized (very good consensus). Patients should not be referred for thoracoscopy without prior stabilization with a chest tube (very good consensus).

Chest Tube Management: The size of chest tubes used for patients with secondary pneumothoraces

depends on clinical circumstances.

Unstable patients (very good consensus) and patients who appear to be at risk for large pleural air leaks because they require mechanical ventilation (good consensus) should be managed with a 24F to 28F chest tube. Larger chest tubes were not considered necessary by the panel members (some consensus).

Stable patients who are not at risk for large air leaks should be managed with 16F to 22F chest tubes (good consensus), although a small-bore catheter ($\leq 14F$) may be acceptable in certain circumstances, which would include small pneumothoraces and patient preference (good consensus). Some members of the panel were concerned with the risk for occlusion of a small-bore catheter.

Attachment of the chest tube to a water seal device with (some consensus) or without (good consensus) suction is acceptable management for most patients. Patients treated with water seal alone should be managed with suction if the lung fails to reexpand (good consensus). A Heimlich valve (good consensus) may be used, although the panel considered a water seal device to be a better option for most patients.

Pneumothorax Recurrence Prevention: Most members (81%) of the panel recommend an intervention to prevent pneumothorax recurrence after the first occurrence because of the potential lethality of secondary pneumothoraces.²³⁻²⁶ The remaining 19% of panel members would perform an intervention to prevent recurrence after the second spontaneous pneumothorax. The preferred management for pneumothorax recurrence prevention is surgical (very good consensus) because of the lower recurrence rates with these interventions compared to the instillation of a sclerosing agent through a chest tube.³ The instillation of a sclerosant through a chest tube, however, may be used in certain circumstances (good consensus) based on patients' contraindications to surgery, management preferences, or a poor prognosis from the patient's underlying disease.

Medical or surgical thoracoscopy is preferred management (very good consensus), although a muscle-sparing (axillary) thoracotomy is an acceptable alternative (good consensus). A standard thoracotomy through a lateral or median sternotomy approach is not appropriate therapy for most patients (good consensus).

Most members of the panel recommend bullectomy and a procedure to produce pleural symphysis during the surgical intervention. Staple bullectomy was the preferred procedure for bullectomy (very good consensus). Other methods for bullectomy

were ranked as indeterminate to inappropriate, with levels of consensus that ranged from no consensus to good consensus. Acceptable interventions to produce pleural symphysis included parietal pleurectomy (some consensus), talc insufflation (poudrage) (some consensus), and parietal pleural abrasion (good consensus). Fibrin pleurodesis and intraoperative instillation of sclerosing agents other than talc were considered to be rarely acceptable (some consensus). Parietal pleurectomy or parietal pleural abrasion limited to the upper half of the hemithorax constitutes the preferred therapy for most patients (good consensus).

For producing pleural symphysis by instillation of a sclerosing agent through a chest tube, doxycycline (good consensus) and talc slurry (very good consensus) were the preferred agents. Minocycline was considered to be an acceptable alternative agent for some patients (good consensus), but bleomycin was considered rarely acceptable (good consensus).

Assessment of Pulmonary Function: The performance of pulmonary function tests to assist management decisions is considered inappropriate (perfect consensus) for patients presenting with secondary pneumothoraces. Performing forced expiratory maneuvers during the acute phase of a pneumothorax is ill-advised and may produce inaccurate results.

Seventy-seven percent of the panel members indicated, however, that results from previously performed pulmonary function tests would assist patient selection for an intervention to prevent a pneumothorax recurrence in special circumstances (good consensus). Those circumstances include patients with relatively good pulmonary function with a strong desire to avoid a procedure to prevent a recurrence. Such patients would most likely tolerate another spontaneous pneumothorax with a low risk of death. Conversely, a patient with poor lung function who decides to avoid recurrence prevention should be counseled that such a decision would be ill-advised.

Persistent Air Leaks: For patients with persistent air leaks who are selected for observation with prolonged chest tube drainage because they initially refuse a surgical procedure, the panel recommended continued observation for 5 days (median, 5 days; interquartile range, 4 to 7 days; middle 80% range, 2 to 7 days) before encouraging the patient to accept a surgical intervention. More prolonged delays may decrease the effectiveness of thoracoscopy²⁷ and increase the cost of care.²⁸ The recommendations for surgical interventions for patients with prolonged air leaks are similar to those for recurrence prevention

(see above). The panel concluded that the instillation of chemical agents through a chest tube to produce a pleural symphysis in managing persistent air leaks was appropriate management for patients who were not operative candidates (good consensus). If this technique was used, doxycycline (good consensus) and talc (very good consensus) were the preferred agents.

Chest Tube Removal: For patients treated with a chest tube without referral for a surgical intervention to prevent a recurrence, management decisions for removing the chest tube are similar with a few exceptions to those for patients with a primary pneumothorax.

Forty-one percent of panel members would never clamp a chest tube to detect the presence of an air leak after reexpansion of the lung. The remaining panel members would clamp the chest tube 5 to 12 h after the last evidence of an air leak. Regardless of whether the tube was or was not clamped, panel members would repeat a chest radiograph 13 to 23 h after the last evidence of an air leak (63% of members) to ensure that the pneumothorax had not reoccurred in preparation for pulling the chest tube. Other panel members would wait \leq 4 h (4%), 5 to 12 h (18%), or 24 h (15%).

Chest Imaging With CT: The panel could not develop recommendations for the use of chest CT scanning after the first occurrence of a pneumothorax. Obtaining a chest CT scan was considered acceptable management for patients with pneumothorax recurrence (good consensus), during management of a persistent air leak (some consensus), and for planning a surgical intervention (some consensus). Chest CT scans might be especially useful if lung volume reduction surgery was being considered as an adjunctive procedure.

Age Considerations: Ninety percent of the panel members did not incorporate the patient's age into the determination of management decisions.

COMPARISON TO PREVIOUS GUIDELINES

Only one previous guideline exists for the management of pneumothorax.²⁰ A panel of two physicians representing the Standards of Care Committee of the British Thoracic Society (BTS) developed this guideline by disseminating a draft to 450 physician members of the BTS. The two authors modified the draft on the basis of the 1,052 comments received from 150 responding physicians. The guideline methodology did not use a formal literature search.

The audience of the BTS guideline was hospital-based doctors who were not respiratory specialists but who directed the initial management of patients with pneumothoraces.

Both the present ACCP and the BTS guidelines base treatment recommendations on the severity of symptoms and the degree of lung collapse, as determined by chest radiographs. Symptom assessments in the BTS guideline, however, are based only on the presence or absence of obvious deterioration in usual exercise tolerance (termed significant dyspnea). The BTS statement also uses a different method for grading the degree of lung collapse that includes levels of small (small rim of air around lung), moderate (lung collapsed halfway toward heart border), and complete pneumothorax (airless lung).

The BTS statement emphasizes the utility of observation without pleural drainage as initial management for patients without significant dyspnea who have (1) small or moderately sized primary pneumothoraces or (2) small secondary pneumothoraces. Simple aspiration with immediate catheter removal is the initial intervention recommended for the remaining patients. The placement of a chest tube with water-seal drainage without suction is recommended only for patients who fail simple aspiration. The present ACCP guideline consensus process found simple aspiration to be appropriate rarely in any clinical circumstance, although two panel members argued that simple aspiration is usually effective for stable patients.

In the BTS statement, hospitalization is recommended only for patients with secondary pneumothoraces. No specific recommendations are provided for patients with persistent air leaks or for patients who require surgery.

STRENGTHS AND LIMITATIONS OF THE GUIDELINE

The present guideline used the Delphi method, which combines limited evidence with expert opinion and inference in a manner that limits group bias to the greatest degree possible.²⁹ The guideline adhered to evidence-based medicine principles of being relevant to specific circumstances and patients.³⁰ Because the recommendations are largely expert opinion based, however, they do not represent sufficiently strong evidence to form the basis for health-care policy.³¹ Physicians applying these recommendations in patient care should consider the assumptions presented to the panel members (Table 4) and the unique problems presented by individual patients who require a flexible clinical approach.

GUIDELINE IMPLEMENTATION AND CONSENSUS DATA

The complete guideline and the consensus tables for the entire questionnaire are available on the internet (www.chestnet.org/publications/18098/index.html). A summary of the guideline and algorithms are available on the Internet and are available for distribution by the ACCP. A quick reference guide also will be available.

PRIORITIES FOR FUTURE RESEARCH

The extensive search of the literature underscores the paucity of high-grade data from clinical trials on which recommendations for the care of patients with pneumothoraces can be based. Major limitations of the literature include the following: pooling of patients with primary and secondary pneumothoraces; nonstandardized interventions; lack of information on clinical course (natural history of untreated pneumothorax in different clinical settings); risk stratification on the basis of factors such as the severity of underlying lung disease, age, and comorbidities; absence of health-related quality-of-life outcomes and the patient's perspective regarding different treatment options; and the relative cost-effectiveness of approaches to care.

These issues call for prospective studies that have adequate sample sizes and follow-up periods to show effects. Study end points should include the relevant clinical outcomes, such as mortality, morbidity, patient perceptions, functional status, and cost.

ACKNOWLEDGMENTS: The guideline developers acknowledge Sydney Parker, PhD, and Beth Welch of the ACCP for their assistance in coordinating the panel's activities; Celia Barbieri, MS, of the University of Arizona Phoenix-based campuses for managing the database and questionnaire analyses; and Carolyn Davis of the University of Mississippi for secretarial support.

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Questionnaire Design Review: Gerard Silvestri, MD, Associate Professor of Medicine, Division of Pulmonary and Critical Care Medicine, Medical University of South Carolina, Charleston, SC.

APPENDIX 2: ADDITIONAL REFERENCES CITED BY THE PANEL IN THE QUESTIONNAIRE ITERATIONS

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Management of Spontaneous Pneumothorax*

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Chest 2001;119; 590-602
DOI 10.1378/chest.119.2.590

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