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Conservative versus Interventional Treatment for Spontaneous Pneumothorax

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ABSTRACT

BACKGROUND

Whether conservative management is an acceptable alternative to interventional management for uncomplicated, moderate-to-large primary spontaneous pneumothorax is unknown.

METHODS

In this open-label, multicenter, noninferiority trial, we recruited patients 14 to 50 years of age with a first-known, unilateral, moderate-to-large primary spontaneous pneumothorax. Patients were randomly assigned to immediate interventional management of the pneumothorax (intervention group) or a conservative observational approach (conservative-management group) and were followed for 12 months. The primary outcome was lung reexpansion within 8 weeks.

RESULTS

A total of 316 patients underwent randomization (154 patients to the intervention group and 162 to the conservative-management group). In the conservative-management group, 25 patients (15.4%) underwent interventions to manage the pneumothorax, for reasons prespecified in the protocol, and 137 (84.6%) did not undergo interventions. In a complete-case analysis in which data were not available for 23 patients in the intervention group and 37 in the conservative-management group, reexpansion within 8 weeks occurred in 129 of 131 patients (98.5%) with interventional management and in 118 of 125 (94.4%) with conservative management (risk difference, −4.1 percentage points; 95% confidence interval [CI], −8.6 to 0.5; P=0.02 for noninferiority); the lower boundary of the 95% confidence interval was within the prespecified noninferiority margin of −9 percentage points. In a sensitivity analysis in which all missing data after 56 days were imputed as treatment failure (with reexpansion in 129 of 138 patients [93.5%] in the intervention group and in 118 of 143 [82.5%] in the conservative-management group), the risk difference of −11.0 percentage points (95% CI, −18.4 to −3.5) was outside the prespecified noninferiority margin. Conservative management resulted in a lower risk of serious adverse events or pneumothorax recurrence than interventional management.

CONCLUSIONS

Although the primary outcome was not statistically robust to conservative assumptions about missing data, the trial provides modest evidence that conservative management of primary spontaneous pneumothorax was noninferior to interventional management, with a lower risk of serious adverse events. (Funded by the Emergency Medicine Foundation and others; PSP Australian New Zealand Clinical Trials Registry number, ACTRN12611000184976.)

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*A complete list of the PSP investigators is provided in the Supplementary Appendix, available at NEJM.org.

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A Quick Take is available at NEJM.org

The annual rate of hospitalization for spontaneous pneumothorax among persons 15 years of age or older in England is approximately 140 per million.[1] One third of cases are primary, with no known previous pneumothorax or clinically apparent underlying lung disease.[1,2] There is considerable heterogeneity in the management of primary spontaneous pneumothorax,[3-5] but the most common treatment is interventional drainage, sometimes progressing to surgical intervention. However, the insertion of a chest tube is often painful[6,7] and can cause organ injury, bleeding, and infection.[8] Insertion of a chest tube often involves hospitalization, with a reported mean length of stay of 4 days in patients with a first presentation with spontaneous pneumothorax.[9-11] Surgery, if the air leak continues, has additional risks, complications, and costs.[11-13]

An alternative approach is conservative management, with intervention reserved for patients for whom the pneumothorax becomes physiologically significant.[14] Conservative management is supported by evidence from a historical cohort study[15]; however, there are not directive data from randomized, controlled trials that have compared conservative with interventional management[16] to determine their relative benefits and risks. We hypothesized that conservative management could be an effective and acceptable therapeutic option, with a similar percentage of patients with full lung reexpansion within 8 weeks as compared with interventional management, as well as a shorter length of hospital stay, fewer interventions and associated complications, and a lower risk of pneumothorax recurrence.

Methods

Trial Design and Oversight

The Primary Spontaneous Pneumothorax (PSP) trial was a multicenter, prospective, randomized, open-label, noninferiority trial that was conducted at 39 metropolitan and rural hospitals in Australia and New Zealand. The protocol was approved by national and state ethics committees and was published previously.[17] The statistical analysis plan was published online[18]; the protocol and statistical analysis plan are available with the full text of this article at NEJM.org. All the patients provided written informed consent.

Patients 14 to 50 years of age were eligible for the trial if they had a unilateral (i.e., in one lung) primary spontaneous pneumothorax of 32% or more on chest radiography according to the Collins method (sum of interpleural distances, >6 cm).[19] (Details regarding the Collins method and the calculation of pneumothorax size are provided in Figs. S1 and S2 in the Supplementary Appendix, available at NEJM.org.) Full exclusion criteria are listed in the Supplementary Appendix.

Randomization

Patients were randomly assigned in a 1:1 ratio to either interventional management of the pneumothorax (intervention group) or conservative management (conservative-management group), with stratification according to trial site; randomization was performed with the use of an adaptive biased-coin (urn) technique.[20] The University of Western Australia hosted a Web-based randomization system (FileMaker Server Advanced). The nature of the randomized treatment approaches meant that the trial-group assignments were not masked to all the patients and the clinicians involved in their care.

Trial Treatments

All the patients received standard care with analgesia (acetaminophen, ibuprofen, and oral or intravenous opioids) as needed and oxygen supplementation if oxygen saturation as measured by pulse oximetry (Spo_2) was less than 92% while the patient was breathing ambient air.

Intervention Group

A small-bore (≤12 French) Seldinger-style chest tube was inserted and attached to an underwater seal, without suction. A chest radiograph was obtained 1 hour later. If the lung had reexpanded and the underwater drain no longer bubbled, the drain was closed with the use of a three-way stopcock. Four hours later, if the patient s condition was stable and a repeat chest radiograph showed that the pneumothorax had not recurred, the drain was removed and the patient was discharged. If the initial drain insertion did not result in resolution on radiography (often called radiographic resolution) or if the pneumothorax recurred under observation, the stopcock was opened, the underwater seal drainage was recommenced, and the patient was ad-

mitted to the hospital. Subsequent interventions were at the discretion of the attending clinicians.

Conservative-Management Group

Patients were observed for a minimum of 4 hours before a repeat chest radiograph was obtained. After observation, if patients did not receive supplementary oxygen and were walking comfortably, they were discharged with analgesia and written instructions. Interventions were allowed in the conservative-management protocol under the following conditions: clinically significant symptoms persisted despite adequate analgesia; chest pain or dyspnea prevented mobilization; a patient was unwilling to continue with conservative treatment; the patient s condition became physiologically unstable (systolic blood pressure of <90 mm Hg, heart rate in beats per minute greater than or equal to systolic blood pressure in millimeters of mercury, respiratory rate of >30 breaths per minute, or Spo_2 of <90% while the patient was breathing ambient air); or a repeat chest radiograph showed an enlarging pneumothorax along with physiological instability. In these situations, subsequent interventions were at the discretion of the attending clinicians.

FOLLOW-UP ASSESSMENTS

All the patients had an in-person, unmasked clinical assessment between 24 and 72 hours after randomization and were assessed again at 2-week, 4-week, and 8-week follow-up visits. These visits included a chest radiograph (if the pneumothorax had not resolved on the previous radiograph) and a structured questionnaire regarding symptoms, analgesia use, and patient satisfaction. Pneumothorax recurrence was assessed 6 and 12 months after randomization by telephone calls to the patients and by clinical-record searches.

OUTCOMES

The primary noninferiority outcome was complete radiographic resolution of primary spontaneous pneumothorax (full lung reexpansion), as determined by the treating physician, within 8 weeks after randomization. Data on patients in whom the 8-week visit occurred after 56 days were treated as missing, unless a later chest radiograph showed a persisting pneumothorax, thereby confirming treatment failure. Two sensitivity analyses were undertaken: in one analysis, the 8-week window was extended to 63 days and data on patients in whom the 8-week visit occurred after 63 days were treated as missing, unless a later chest radiograph showed a persisting pneumothorax, thereby confirming treatment failure; in the other analysis, data on patients in whom the 8-week clinic visit occurred after 56 days were imputed as failure.

Secondary outcomes included a per-protocol analysis of the primary outcome; complete lung reexpansion within 8 weeks, as reviewed by two radiologists who were unaware of the trial-group assignments; the time until complete resolution of symptoms, defined as no pain and no analgesia use; pneumothorax recurrence, defined as an ipsilateral pneumothorax after a previous chest radiograph had confirmed complete resolution 24 hours or more after removal of all chest tubes; adverse events; serious adverse events; the length of hospital stay in the first 8 weeks; the number of invasive procedures and radiologic investigations; the number of days off from work; persistent air leak, defined as chest-tube drainage for 72 hours or more; and patient satisfaction, measured as a response to the question How satisfied or dissatisfied are you with the results of treatment for your pneumothorax overall? on a six-point Likert scale: very dissatisfied, dissatisfied, slightly dissatisfied, slightly satisfied, satisfied, or very satisfied.

STATISTICAL ANALYSIS

A sample of 274 patients was required to detect an absolute noninferiority margin of −9 percentage points, under the assumption of resolution of the pneumothorax by 8 weeks in 99% of the patients in the intervention group (one-sided alpha level of 5% and power of 95%). Noninferiority was tested by generating a two-sided 95% confidence interval and using the lower 2.5% tail to compare the observed data. In the absence of any previously established noninferiority margin, the steering committee of respiratory and emergency physicians reasoned that a success rate of 90% in the conservative-management group as compared with an anticipated 99% success rate in the intervention group after 8 weeks would be acceptable to both doctors and patients. Allowing for a 20% dropout rate, we planned to recruit up to 342 patients.

The primary analysis was based on logistic

regression of complete cases at 8 weeks. Estimation of percentage points and absolute risk differences together with a binomial noninferiority test were used for the primary outcome. The original statistical analysis plan did not specify the window for the 8-week visit nor define how missing radiographic data were to be handled for the primary outcome. These issues were recognized post hoc to be important, because the intent of the trial was to establish whether there was resolution at the time of the 8-week visit. This goal was addressed by treating data on the primary outcome as missing in patients in whom the 8-week visit occurred after 56 days and by undertaking two sensitivity analyses to help determine the effects of informative censoring and treating of missing data as treatment failure.

Other categorical variables were analyzed by estimation of absolute risk differences and relative risks and a two-sided test. Count variables were analyzed by estimation of relative rates. Kaplan Meier curves and a Cox proportional-hazards estimate of the hazard ratio were used for the time until radiographic resolution, the time until symptom resolution, and the time until ipsilateral pneumothorax recurrence. Ordinal regression was used for the Likert-scaled satisfaction ratings. Logistic regression was used to assess subgroup effects. SAS software, version 9.4, was used for all analyses.

RESULTS

PATIENTS

From July 2011 through March 2017, a total of 316 patients underwent randomization (154 patients to the intervention group and 162 to the conservative-management group) (Fig. 1). The baseline characteristics of the patients are shown in Table 1 and Table S1. In the conservative-management group, 137 of 162 patients (84.6%) did not undergo any intervention, but 25 patients (15.4%) did, with reasons shown in Table S2. In the intervention group, 10 patients (6.5%) declined any intervention, and their care was managed conservatively. There were 16 patients (5 in the intervention group and 11 in the conservative-management group) in which the 8-week assessments occurred between 56 and 63 days; in 6 additional patients (1 in the intervention group and 5 in the conservative-management group), the 8-week assessment was conducted after 9 weeks (Fig. S3).

PRIMARY OUTCOME

In the complete-case analysis, in which data were treated as missing in patients if the 8-week visit occurred after 56 days, 129 of 131 (98.5%) in the intervention group had resolution within 8 weeks, as compared with 118 of 125 (94.4%) in the conservative-management group (risk difference, −4.1 percentage points; 95% confidence interval [CI], −8.6 to 0.5; P=0.02 for noninferiority); the lower boundary of the 95% confidence interval was within the noninferiority margin of −9 percentage points. In the sensitivity analyses, noninferiority for resolution was maintained when the 8-week clinic visit was extended to 63 days (134 of 136 patients [98.5%] in the intervention group and 129 of 136 [94.9%] in the conservative-management group) (risk difference, −3.7 percentage points; 95% CI, −7.9 to 0.6) but not when the missing data after 56 days were imputed as failure (129 of 138 patients [93.5%] in the intervention group and 118 of 143 [82.5%] in the conservative-management group) (risk difference, −11.0 percentage points; 95% CI, −18.4 to −3.5).

SECONDARY OUTCOMES

Radiographic Resolution

The median time until radiographic resolution was 16 days (interquartile range, 12 to 26) in the intervention group and 30 days (interquartile range, 25 to 54) in the conservative-management group (hazard ratio, 0.49; 95% CI, 0.39 to 0.63) (Fig. S4). There were 10 patients who were assigned to interventional management who declined the intervention, and in the per-protocol analysis, 124 of 126 patients (98.4%) in the intervention group had resolution within 8 weeks as compared with 123 of 130 patients (94.6%) in the conservative-management group (risk difference, −3.8 percentage points; 95% CI, −8.3 to 0.7). Radiologists were more likely than treating clinicians to assess a radiograph obtained at the 8-week visit as not showing resolution, with a risk difference of −5.9 percentage points (95% CI, −8.8 to −2.9) (Table S3). For the patients in whom the radiograph obtained at the 8-week visit was available to the radiologists, the radiologists who were unaware of the trial-group assignments assessed 114 of 124 patients

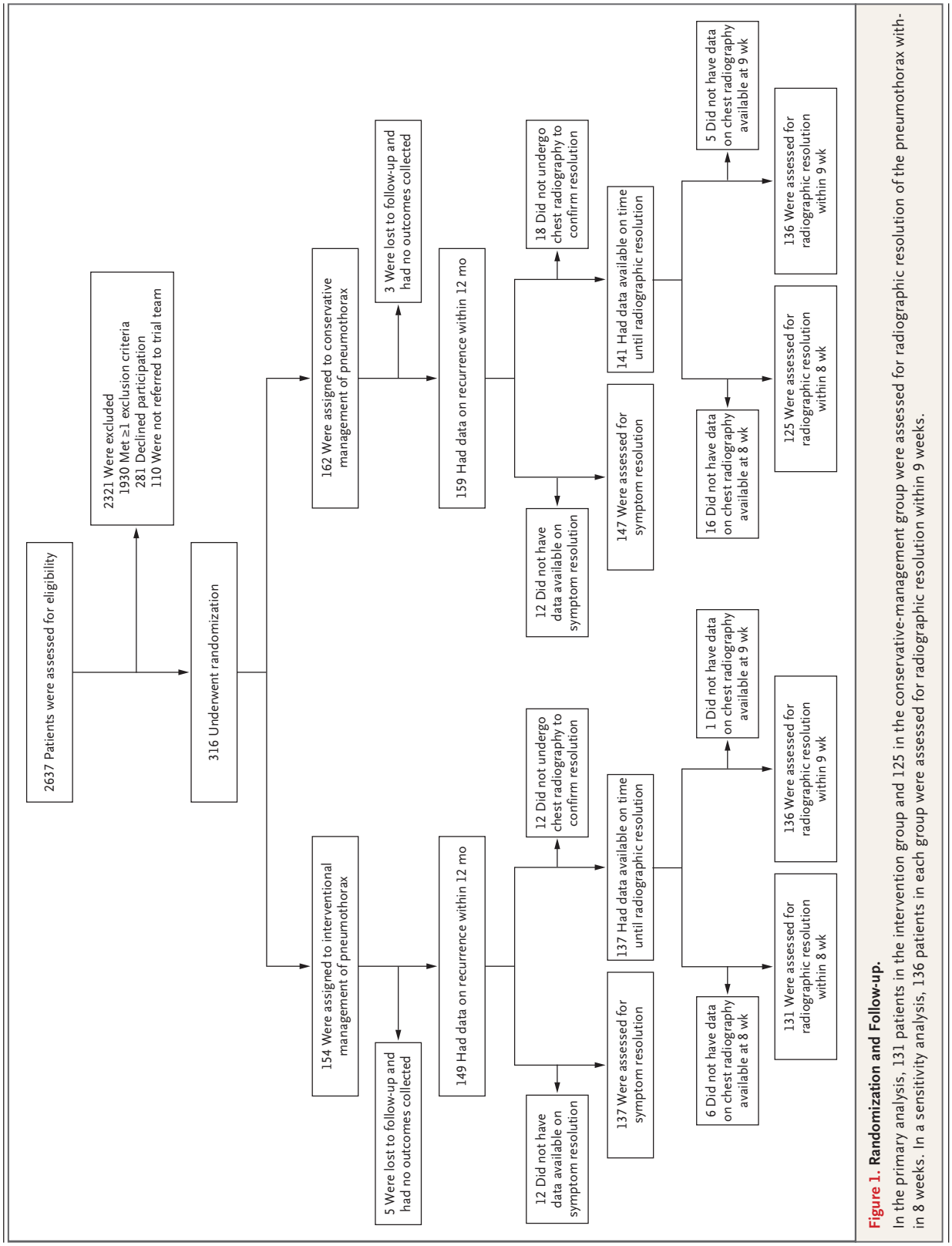

Figure 1. Randomization and Follow-up.

In the primary analysis, 131 patients in the intervention group and 125 in the conservative-management group were assessed for radiographic resolution of the pneumothorax within 8 weeks. In a sensitivity analysis, 136 patients in each group were assessed for radiographic resolution within 9 weeks.

Table 1. Characteristics of the Patients at Baseline.*

Characteristic	Interventional Management (N=154)	Conservative Management (N=162)
Age		
No. with data	154	162
Mean yr	26.4±8.7	26.1±8.7
Male sex no. (%)	130 (84.4)	142 (87.7)
Height		
No. with data	141	154
Mean cm	176.6±9.4	179.5±8.9
Weight		
No. with data	142	154
Mean kg	67.0±13.2	68.6±13.1
Body-mass index		
No. with data	141	153
Mean	21.4±3.7	21.3±3.5
Symptom duration		
No. with data	153	160
Mean hr	44.5±90.3	33.8±61.3
Pneumothorax size		
No. with data	154	162
Mean % of lung according to Collins formula	67.5±22.6	63.6±23.4
Pneumothorax on right side no. (%)	88 (57.1)	89 (54.9)
Heart rate		
No. with data	132	149
Mean beats per min	73.3±11.9	77.5±14.4
Systolic blood pressure		
No. with data	134	148
Mean mm Hg	117.8±13.2	119.8±13.1
Respiratory rate		
No. with data	134	144
Mean breaths per min	17.0±2.6	16.9±3.3
Oxygen saturation		
No. with data	134	148
Mean %	97.6±1.6	97.2±2.0
Chest-pain score		
No. with data	119	138
Mean	2.4±2.2	2.1±2.1
Borg dyspnea index		
No. with data	112	133
Mean	1.2±1.2	1.7±1.4
Pack-yr of tobacco smoking		
No. with data	141	145
Mean	8.1±23.3	4.8±7.8
Smoking history no./total no. (%)		
Current	75/152 (49.3)	68/160 (42.5)
Past	19/152 (12.5)	16/160 (10.0)
Never	58/152 (38.2)	76/160 (47.5)

* Plus minus values are means ±SD.
The body-mass index is the weight in kilograms divided by the square of the height in meters.
A score of 0 indicated no chest pain, 5 moderate pain, and 10 the worst possible pain.
The Borg dyspnea index measures perceived breathlessness on a scale from 0 (none) to 10 (maximum).

Table 2. Secondary Outcomes.*

Outcome	Interventional Management (N=154)	Conservative Management (N=162)	Relative Risk (95% CI)	Risk Difference (95% CI)
One or more procedures no. (%)	145 (94.2)	25 (15.4)	6.10 (4.24 8.77)	78.1 (72.0 85.4)
Chest drainage for ≥72 hr no./total no. (%)	78/153 (51.0)	15/162 (9.3)	5.51 (3.32 9.14)	41.7 (32.6 50.8)
Suction no. (%)	52 (33.8)	12 (7.4)	4.56 (2.53 8.20)	26.4 (17.9 34.9)
At least one CT scan no./total no. (%)	28/146 (19.2)	12/154 (7.8)	2.46 (1.31 4.66)	11.4 (3.7 19.1)
Hospital revisit no. (%)	41 (26.6)	28 (17.3)	1.54 (1.01 2.36)	9.3 (0.3 18.4)
Any adverse event no. (%)	41 (26.6)	13 (8.0)	3.32 (1.85 5.95)	18.6 (10.5 26.7)
Any serious adverse event no. (%)	19 (12.3)	6 (3.7)	3.30 (1.37 8.10)	8.6 (2.7 14.6)
Pneumothorax recurrence within 12 mo no./total no. (%)	25/149 (16.8)	14/159 (8.8)	1.90 (1.03 3.52)	8.0 (0.5 15.4)
No. of chest radiographs per patient	10.9±7.1	6.4±3.9	1.7 (1.6 1.8)	4.5 (3.2 5.8)
No. of surgical procedures per patient	0.3±0.5	0.1±0.2	4.21 (2.10 8.41)	
Length of hospital stay in first 8 wk days				
Mean	6.1±7.6	1.6±3.5	2.8 (1.8 3.6)‖	
Median (IQR)	3.8 (0.8 9.3)	0.2 (0.2 0.8)		
Days off from work				
Mean	10.9±12.7	6.0±7.3	2.0 (1.0 3.0)‖	
Median (IQR)	6.0 (2.0 14.0)	3.0 (1.0 8.0)		

* Plus minus values are means ±SD. CT denotes computed tomographic, and IQR interquartile range.
Shown is the risk difference between the intervention group and the conservative-management group, as measured in percentage points, unless otherwise indicated.
Shown is the relative rate.
Shown is the mean difference in the number of chest radiographs.
In the intervention group, 34 video-assisted thoracic surgeries were performed in 33 patients and 6 thoracotomies were performed in 6 patients. In the conservative-management group, 10 video-assisted thoracic surgeries were performed in 10 patients.
‖ Shown is the Hodges Lehmann location shift for the intervention group minus the conservative-management group.

(91.9%) in the intervention group and 109 of 115 (94.8%) in the conservative-management group as having resolution, whereas clinicians assessed 123 of 124 patients (99.2%) in the intervention group and 114 of 115 (99.1%) in the conservative-management group as having resolution.

Symptom Resolution

Complete resolution of symptoms by 8 weeks was reported in 128 of 137 patients (93.4%) in the intervention group and in 139 of 147 (94.6%) in the conservative-management group (risk difference, 1.1 percentage points; 95% CI, −4.4 to 6.7). The time until symptom resolution did not differ substantially between the two groups, with a median time of 15.5 days (95% CI, 12 to 23) in the intervention group and 14.0 days (95% CI, 12 to 19) in the conservative-management group (hazard ratio, 1.11; 95% CI, 0.88 to 1.40) (Fig. S5).

Recurrence

Recurrence during the first 12 months was more frequent in the intervention group than in the conservative-management group: 25 of 149 patients (16.8%) as compared with 14 of 159 (8.8%) (absolute risk difference, 8.0 percentage points; 95% CI, 0.5 to 15.4) (Table 2). The time until pneumothorax recurrence during the first 12 months was longer in the conservative-management group than in the intervention group (hazard ratio, 0.59; 95% CI, 0.34 to 1.02) (Fig. S6).

Adverse Events

A total of 41 patients in the intervention group and 13 in the conservative-management group

had at least one adverse event (relative risk, 3.32; 95% CI, 1.85 to 5.95); 19 patients in the intervention group and 6 in the conservative-management group had a serious adverse event (relative risk, 3.30; 95% CI, 1.37 to 8.10) (Tables 2 and 3). Most adverse events in both groups were directly attributable to either insertion of the chest tube or having the tube in place. One death occurred in the conservative-management group by suicide at a time when the pneumothorax had resolved.

Other Secondary Outcomes

The chest tube remained in place for 72 hours or more in 78 patients in the intervention group and in 15 patients in the conservative-management group (relative risk, 5.51; 95% CI, 3.32 to 9.14), and suction was performed in 52 patients in the intervention group and in 12 patients in the conservative-management group (relative risk, 4.56; 95% CI, 2.53 to 8.20) (Table 2 and Table S4). The relative rate of progression to surgery in the intervention group as compared with the conservative-management group was 4.21 (95% CI, 2.10 to 8.41) (Table 2). The mean (±SD) length of hospital stay in the first 8 weeks for patients in the intervention group was 6.1±7.6 days, with a mean of 10.9±12.7 days off from work in the same period, as compared with 1.6±3.5 days and 6.0±7.3 days, respectively, for patients in the conservative-management group (Hodges Lehmann location shift [intervention group minus conservative-management group], 2.8 [95% CI, 1.8 to 3.6] for length of hospital stay and 2.0 [95% CI, 1.0 to 3.0] for days off from work) (Table 2 and Tables S5 and S7). The odds ratio for satisfaction with interventional management as compared with conservative management was 0.68 (95% CI, 0.43 to 1.07), with a lower odds ratio consistent with less satisfaction with interventional management. There was no evidence of treatment-effect modification (interaction) according to prespecified subgroups defined by age, clinician-estimated size of pneumothorax, symptom duration, or smoking status (Table S8).

DISCUSSION

This randomized, controlled trial of conservative as compared with interventional management of moderate-to-large primary spontaneous pneumothorax provides modest, but statistically fragile, evidence that conservative management was noninferior to interventional management for radiographic resolution within 8 weeks, with the use of a 9-percentage-point margin; the time until complete resolution of symptoms did not differ substantially between the two approaches. Conservative management spared 85% of the patients from an invasive intervention and resulted in fewer hospitalization days, a lower likelihood of prolonged chest-tube drainage, less need for surgery, and fewer adverse events and serious adverse events than interventional management. The percentage of patients with early pneumothorax recurrence was also lower in the conservative-management group.

Our trial challenges the fundamental concept of whether initial routine drainage is required in all patients with primary spontaneous pneumothorax. It was conducted at 39 centers across a spectrum of rural, urban, secondary, and tertiary health care settings, and after a standardized initial approach to randomized treatment, subsequent interventions were undertaken by treating clinicians as per their usual practice. Only patients with moderate-to-large primary spontaneous pneumothorax, for which most clinicians would intervene, were included. Recruitment was limited to those with a first episode of primary spontaneous pneumothorax (on the affected side) to avoid the confounding effects of previous treatments. The age range of 14 to 50 years reduced the likelihood that patients with secondary pneumothorax would be included.

Our trial has several limitations. It was not possible to mask trial-group assignments to patients or clinicians. Treating clinicians were more likely than the independent radiologists who were unaware of the trial-group assignments to report full radiographic resolution in the group receiving interventional management, which biased the primary-outcome findings in favor of interventional treatment. Although we used multiple radiographic examinations to identify pneumothorax recurrence, it is possible that some episodes of recurrence may have been missed, and there may have been different thresholds for presentation with recurrent symptoms between the two groups. Conservative management was associated with fewer pneumothorax recurrences than interventional management,

with divergence in the frequency of recurrence occurring during the first 3 months after initial presentation with primary spontaneous pneumothorax. Some of these early recurrences may have represented an ongoing slow leak despite initial reinflation or may have been due to rapid expansion of the lung (and hence the visceral pleural wound), with or without the use of suction, resulting in physical impairment of healing contrary to the view that adhesions may form between the visceral pleura and the parietal pleura if the lung is reexpanded.

A major limitation was that the original statistical analysis plan did not specify the window for the 8-week visit nor define how missing radiographic data were to be handled for the primary outcome. These issues were important, because 22 patients who did not have resolution at their 4-week visit had resolution at the time of their scheduled 8-week visit, which occurred after 56 days. Although this issue was addressed by treating data for the primary outcome as missing in patients in whom the 8-week visit occurred after 56 days and by undertaking two sensitivity analyses to help determine the effects of informative censoring and treating of missing data as treatment failure, these approaches resulted in statistical fragility and need to be considered exploratory. In the sensitivity analysis in which all missing data were imputed as failure, the risk difference for radiographic resolution at 56 days in the conservative-management group was −11 percentage points, with a lower boundary of the 95% confidence interval of −18 percentage points. However, the median time until symptom resolution (approximately 2 weeks) was similar in the two groups, and a small residual pneumothorax is likely to be clinically significant only in the context of air travel. Secondary analyses have not been adjusted for multiple comparisons and should not be used to infer definitive treatment effects.

This trial provides modest evidence that conservative management was noninferior to interventional management for radiographic resolution of moderate-to-large primary spontaneous pneumothorax within 8 weeks. Conservative management spared 85% of the patients from an invasive intervention and incurred fewer days in the hospital or off from work, lower rates of surgery, and a lower risk of serious adverse events

Table 3. Adverse Events (Intention-to-Treat Analysis).

Event	Interventional Management (N=154)	Conservative Management (N=162)
	no. of events	
Total adverse events*	49	16
Predefined adverse events		
Foreign body in chest wall (retained suture)	1	2
Hemothorax	5	3
Infection		
Empyema	1	1
Skin infection	3	1
Unknown site	1	0
Tension pneumothorax	2	1
Other adverse events		
Severe chest pain or breathlessness	11	4
Surgical emphysema	6	0
Lung collapse after removal of chest tube	6‖	0
Persistent cough	2	0
Hypotension or altered conscious state related to procedure	2	0
Reexpansion pulmonary edema	2	0
Equipment disconnection	2	0
Topical skin reaction to chlorhexidine	1	0
Other	4**	4

* A total of 49 adverse events occurred in 41 patients in the intervention group and 16 in 13 patients in the conservative-management group. Serious adverse events (defined as those that resulted in prolonged hospitalization, life-threatening or fatal illness, or intervention to prevent these outcomes) occurred in 19 patients in the intervention group and 6 in the conservative-management group.
The three instances of hemothorax in the conservative-management group were noted as a pleural effusion on the chest radiograph, before insertion of any chest tube. An additional hemothorax was associated with the tension pneumothorax reported in the conservative-management group.
The case of empyema in the conservative-management group and the infection of unknown site in the intervention group were associated with sepsis.
One of the three skin infections in the intervention group was associated with sepsis.
Three cases of tension pneumothorax were reported, one in the conservative-management group (the patient presented again for care 30 hours after initial discharge) and two in the intervention group (one patient had an increase in pneumothorax size while an inpatient that was attributed to a kinked chest tube, and the other presented 4 days after initial discharge); all resolved promptly with insertion or adjustment of the chest tube.
‖ One case was managed conservatively, and five cases were managed with reinsertion of the chest tube with or without video-assisted thoracoscopic pleurodesis.
** There was one case each of bleeding around the site of the chest tube, agitation, numbness around the site of the chest tube, and patient self-discharge with the drain in place.
There was one case each of Horner s syndrome after insertion of the chest tube, death by suicide (unrelated to the trial), nausea and dizziness, and excessive scar tissue around the site of the chest tube.

or pneumothorax recurrence than interventional management.

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A data sharing statement provided by the authors is available with the full text of this article at NEJM.org.

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APPENDIX

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