

# Small-bore chest tubes seem to perform better than larger tubes in treatment of spontaneous pneumothorax

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## ABSTRACT

**INTRODUCTION:** The aim of this study was to compare the efficacy and complications of surgical (large-bore) chest tube drainage with smaller and less invasive chest tubes in the treatment of non-traumatic pneumothorax (PT).

**MATERIAL AND METHODS:** This was a retrospective study of 104 cases (94 patients) of non-traumatic PT treated with chest tubes – either by pulmonary physicians (daytime and weekdays) using small-bore chest tubes, or by orthopaedic surgeons (remaining time slots) using large-bore chest tubes.

**RESULTS:** A total of 62 had primary spontaneous PT, 30 had secondary spontaneous PT and 12 had iatrogenic PT. A total of 62 patients were treated with large-bore (20-28 Fr) chest tubes placed with traditional thoracotomy, 42 patients were treated by a pulmonary physician, and in 30 of these cases a True-Close thoracic vent (11-13 Fr) was inserted. Patients treated with surgical chest tubes were comparable with patients treated with smaller chest tubes in terms of demographic data and type and size of PT. Compared with patients treated with smaller chest tubes, patients with surgical large-bore tubes had more complications (27.4% versus 9.5%;  $p = 0.026$ ), a lower success rate (56.5% versus 85.7%;  $p = 0.002$ ), and longer duration of chest tube (8.3 versus 4.9 days;  $p = 0.001$ ) and of hospitalisation (11.8 versus 6.9 days;  $p = 0.004$ ).

**CONCLUSION:** We found small chest tubes to be superior to large-bore chest tubes with regard to short-term outcomes in the treatment of non-traumatic PT.

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Pneumothorax (PT) is defined as air in the pleural cavity. PT can be classified as traumatic, iatrogenous, primary spontaneous (PSP) and secondary spontaneous (SSP). PSP occurs in patients without predisposing lung disease. SSP occurs in patients with a predisposing lung disease, most commonly chronic obstructive pulmonary disease (COPD) [1]. The incidence of PT in Denmark is unknown. According to a British study, PT leads to hospitalization in approximately 11 cases per 100,000 in the population each year [2].

Recommendations with regard to management of PT depend on the type and size of PT and of the symptoms like pain and dyspnoea [3-5]. The British Thoracic Society (BTS) and the Danish Lung Society (DLS) encourage simple needle aspiration of air as first choice treatment for PSP. Simple aspiration is recommended for SSP only if the patient has no symptoms, and if PT size is less than 2 cm both apically and laterally. In case of simple aspiration without effect and in SSP with either symptoms or a size exceeding 2 cm both apically and laterally, drainage with the use of a chest tube is recommended. The knowledge of management strategies is scarce. In general, DLS recommends small-sized chest tubes (8-14 Fr) placed with Seldinger technique (tube with guidewire) [4, 6], whereas surgeons in Denmark recommend large-bore tubes (20-28 Fr) inserted with traditional thoracotomy and digital exploration [7]. Differences in effect and short-term outcome of these techniques have not previously been studied.

The aim of this study was to calculate the incidence of non-traumatic PT managed by chest-tube drainage and to describe the types of chest tubes and techniques employed. Furthermore, we aimed to compare the efficacy and complications of surgically inserted (large-bore) chest tube drainage with smaller chest tubes inserted by the Seldinger technique in patients with non-traumatic PT.

## MATERIAL AND METHODS

### Study design

The present study was a retrospective case-control study of all admitted patients at Hvidovre Hospital, from 1 April 2009 to 31 December 2011. Patients were identified using diagnosis codes (DJ939 Pneumothorax UNS, DJ931 Other spontaneous pneumothorax, DJ938 Other type of pneumothorax and DT812T Unintended pneumothorax due to puncture).

Patients with PT are referred to Hvidovre Hospital from two regional hospitals (Amager Hospital and Glostrup Hospital) which yields a catchment area of approximately 480,000 citizens. Approximately 380,000 of these citizens are more than 15 years old. Included were patients who were at least 16 years upon admission with

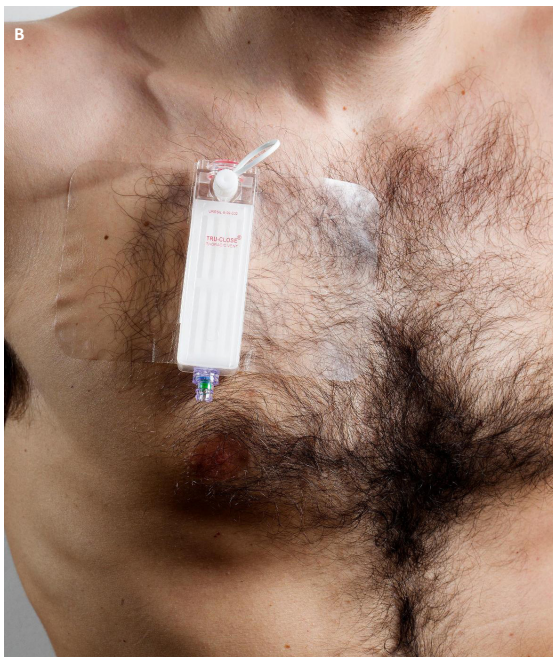
## ORIGINAL ARTICLE

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**FIGURE 1**

True-Close thoracic vent (A) placed in second intercostal space in the mid-clavicular line (B).



on how to determine PT size on conventional thoracic X-ray [8]. A simple method is to measure the distance from the apex of the lung to the cupula. A more accurate estimate is obtained by measuring both the apical and the lateral distance between the lung and the thoracic wall. Thus, the BTS considers a PT "large" if the air gap between the lung and the chest wall is greater than 2 cm apically as well as laterally. We decided to use an algorithm that takes into consideration the size of PT apically and laterally:

- Small PT (score 1): Apex to cupula distance < 3.0 cm and adherent laterally
- Medium PT (score 2): Apex to cupula distance 3-5 cm or < 3 cm combined with lateral or basal PT
- Large PT (score 3): Apex to cupula distance > 5 cm or 3-5 cm combined with lateral or basal PT.

#### Types of chest tubes and insertion technique

At Hvidovre Hospital, non-traumatic PTs are managed by chest physicians during regular hours (08.00-15.00) on weekdays, and by orthopedic surgeons in the remaining periods.

Chest physicians used the Seldinger technique. In general, a True-Close thoracic vent with Heimlich valve, size 11-13 Fr, was inserted into the second intercostal space in the midclavicular line in PT without pleural effusion (Figure 1). A Potex chest tube, size 10-20 Fr, was generally used by chest physicians when patients had hydropneumothorax.

Surgeons used Portex chest tubes, size 20-28 Fr, inserted through a small thoracotomy in the fourth or fifth intercostal space in the anterior or midaxillary line [7].

spontaneous or iatrogenic PT managed with either aspiration or chest tube insertion. The exclusion criteria were conservative treatment of PT and traumatic PT. Patients with PT were also excluded if they were referred to Hvidovre Hospital with a chest tube already in place.

One episode of PT was defined as admission and discharge without re-admission for PT within seven days from discharge. Drainage was considered successful when chest radiograph showed no or minimal residual air in the pleural space.

Data were collected using the national Danish electronic chart database (OPUS) and the radiology database (WEB 1000). The project was approved by the Danish Data Protection Agency, file no. 2012-41-0554.

#### Size of pneumothorax

Computed tomography of the lungs is the golden standard in the assessment of PT size. There is no consensus

#### Statistics

Data were analysed with the statistical package SPSS version 13.0, SPSS Inc., Chicago, USA. The  $\chi^2$ -test, two sample t-tests and Mann-Whitney U tests were used as appropriate to compare differences between groups. A two-sided p-value of < 0.05 was considered significant.

*Trial registration:* The project was approved by the Danish Data Protection agency, file no. 2012-41-0554.

#### RESULTS

##### Patients

The study period saw a total of 104 episodes of non-traumatic PT in 94 patients managed by chest tube. A total of 62 had PSP, 30 had SSP, and 12 had iatrogenic PT (Table 1). Including two PSP patients referred from Glostrup Hospital already with a chest tube inserted, the incidence of PSP was 10.0 annual episodes per 100,000



TABLE 1

	PSP	SSP	Iatrogenic	All
Patients, n	62	30	12	104
Age of patients, years, mean (range)	35.1 (17-88)	52.8 (17-91)	78.5 (60-92)	45.1 (17-92)
Males, %	80.6	63.3	66.7	74.0
Current smokers, %	42.6	43.3	8.3	38.8
First episode of PT, %	61.3	51.5	100	64.4
Same-sided PT of recurrent PT	23/24	11/13	0/0	34/37
Right-sided PT, %	59.7	63.6	58.3	59.6
Hydropneumothorax, %	4.8	18.2	75	16.3
Pressure PT, %	4.9	3.4	0	3.9
Total lung collapse, % (n = 102)	29.5	15.6	8.3	22.5
Size score, <sup>a</sup> mean (SD)	2.70 (0.50)	2.45 (0.63)	2.45 (0.69)	2.60 (0.57)
Non-surgical technique, %	33.9	45.5	58.3	40.4
Surgical technique, %	66.1	54.5	41.7	59.6
<i>Size of first test tube, %</i>				
≤ 14 Fr	32.3	42.4	45.5	36.9
> 14 Fr	67.7	57.6	54.5	63.1
Chest tube fell out or displacement, %	8.1	13.3	25.0	11.5
Subcutaneous emphysema, %	8.1	16.7	8.3	10.6
Wound infection, %	4.8	16.7	8.3	8.7
Bleeding, %	4.9	10.0	8.3	6.8
Suction employed, % (n = 100)	52	45	50	50
Duration of chest tube drainage in our department, days, mean (range)	6.5 (1-49)	7.3 (1-24)	7.9 (1-20)	6.9 (1-49)
<i>Success with management, %</i>				
One chest tube and successful drainage	74.2	63.3	50	68.3
More than one chest tube and successful drainage	4.8	10.0	8.3	6.7
Discharged without resolution	1.6	3.3	0	4.8
Referral to department of thoracic surgery with chest tube	19.4	13.3	25.0	15.4
Died during hospitalisation	0	10.0	16.7	4.8
Duration of hospital stay in our department, days, mean (range)	8.5 (1-81)	12.1 (1-60)	10.9 (1-23)	9.8 (1-81)

Patient characteristics, management and short-term outcomes according to type of pneumothorax.

PSP = primary spontaneous pneumothorax; PT = pneumothorax; SD = standard deviation; SSP = secondary spontaneous pneumothorax.

a) See methods.

in males and 2.3 per 100,000 in females. The incidence of SSP was 3.6 per 100,000 in males and 2.1 per 100,000 in females. In total, the incidence of non-traumatic PT managed by chest tube drainage was 10.0 per 100,000 annually.

Four (3.9%) patients had pressure pneumothoraces (three PSP and one SSP), and 23 (22.5%) patients had a completely collapsed lung. There was a tendency towards larger PTs in patients with PSP than in patients with SSP (mean size score = 2.70 versus 2.45;  $p = 0.2$ ). There were no cases of bilateral PT.

The patients and the type and size of PT treated by surgeons and pulmonary physicians were not significantly different between the two groups (Table 2).

#### Types of chest tubes and placement techniques

There were no cases of PT treated with simple aspiration. The pulmonary physicians treated 30 of 42 patients using a Tru-Close thoracic vent (Table 2). In three cases, the chest physicians used a large Portex drainage (> 14 Fr), in seven cases a small Portex drainage (≤ 14

Fr), and in two cases a pigtail catheter, which was used in the management of hydrothorax complicated by an iatrogenic PT.

The orthopaedic surgeons were responsible for the chest tube placement in 62 patients, all of whom received a large-bore chest tube (> 14 Fr) inserted by surgical technique.

Chest tubes were either inserted by a pulmonary physician or by the orthopaedic surgeon on duty, both of whom were trained in these procedures. In either case, this would imply chest tube placement by an attending or a resident physician.

#### Complications

Patient discontinuation or simple displacement of chest tubes was seen in 12 patients (11.5%) and only occurred in one case with a Tru-Close thoracic vent, which was significantly lower than the corresponding rate for patient discontinuation or displacement of other chest tubes ( $p < 0.001$ ) (Table 3). Patients with SSP had a higher frequency of drain-related subcutaneous em-

 TABLE 2

Patient characteristics, management and short-term outcomes according to the use of surgically or non-surgically technique.

	Surgical technique	Non-surgical technique	Difference, p-value
n	62	42	–
Age of patients, years, mean (range)	42.1 (17-92)	49.7 (17-91)	0.08
Males, %	75.8	71.4	0.62
Current smokers, %	37.1	41.5	0.66
First episode of PT, %	64.5	64.3	0.98
Same-sided PT of recurrent PT	20/22	14/15	0.97
Right-sided PT, %	64.5	52.4	0.22
Hydropneumothorax, %	16.1	16.7	0.94
Pressure PT, %	3.3	4.9	0.68
<i>Type of pneumothorax, %</i>			
PSP	66.1	50.0	0.1
SSP	25.8	33.3	0.41
Iatrogenic	8.1	16.7	0.18
Size score <sup>a</sup> , mean (SD)	2.67 (0.43)	2.50 (0.50)	–
First chest tube > 14 Fr, %	100	7.1	–
First chest tube ≤ 14 Fr, Tru-Close thoracic vent, %	0	71.4	–
First chest tube ≤ 14 Fr portex, %	0	16.7	–
First chest tube ≤ 14 Fr pig-tail, %	0	4.8	–
Chest tube fell out or displacement, %	11.3	11.9	0.92
Subcutaneous emphysema, %	14.5	4.8	0.11
Wound infections, %	12.9	2.4	0.06
Bleeding, %	9.8	2.4	0.14
Subcutaneous emphysema, wound infections or bleeding, %	27.4	9.5	0.026
Suction employed, % (n = 100)	63	28	< 0.001
Duration of chest tube drainage in our department, days, mean (range)	8.3 (1-49)	4.9 (1-18)	0.001
<i>Success with management</i>			
One chest tube and successful drainage, %	56.5	85.7	0.002
More than one chest tube and successful drainage, %	11.3	0	0.024
Discharged without resolution, %	3.2	7.1	0.36
Referral to department of thoracic surgery with chest tube, %	22.6	4.8	0.013
Died during hospitalisation, %	6.5	2.5	0.34
Duration of stay in our department, days, mean (range)	11.8 (1-81)	6.9 (1-41)	0.004

PSP = primary spontaneous pneumothorax; PT = pneumothorax; SD = standard deviation; SSP = secondary spontaneous pneumothorax.

a) See methods.

physema, wound infection and bleeding than patients with PSP – 33.3% versus 14.5% ( $p = 0.037$ ). These complications (at least one) were more common in patients treated with surgically placed large-bore chest tubes than in the patient subgroup managed by pulmonary physicians (27.4% versus 9.5%,  $p = 0.026$ ).

#### Short-term progress

Most patients had only one chest tube inserted and were discharged with a fully expanded lung (Table 1). In five patients, the lung failed to unfold and patients were not referred to the thoracic surgeons as they were deemed to be suffering from trapped lung. Five patients died during the management of PT: two had cancer, two had COPD and one had pulmonary tuberculosis.

Compared to chest tubes managed by the pulmonary physician, patients with surgically inserted chest tubes had longer hospital stays (11.8 versus 6.9 days;

$p = 0.004$ ) and were less frequently treated successfully with the first chest tube (56.5% versus 85.7%,  $p = 0.002$ ) (Table 2).

#### DISCUSSION

The incidence of PT in our sample was 10 per 100,000, which corresponds well to the 11 per 100,000 previously reported in a British epidemiologic study [2]. We found a low incidence of iatrogenous PT, which is most likely attributable to the fact that we do not perform percutaneous tumour diagnostic or bronchoscopy with transbronchial biopsy, where the risk of iatrogenous PT is well-known [9]. The patients in this study were identified by a search of diagnosis codes. Since the inclusion criterion was diagnosis of PT at discharge from the hospital, there is a risk of underestimation in our study design.

The incidences of PSP and SSP in Denmark have not previously been studied. We found that the incidence of



TABLE 3

	Tru-Close thoracic vent	Portex or pig-tail chest tube	Difference, p-value
n	30	12	
Age of patients, years, mean (range)	47.4 (17-91)	55.7 (24-89)	0.45
Males, %	73.3	66.7	0.67
Current smokers, %	44.8	33.3	0.50
First episode of PT, %	56.7	83.3	0.16
Right-sided PT, %	50.0	58.3	0.63
Hydropneumothorax, %	3.3	50.0	0.001
Pressure PT, %	3.3	8.3	0.51
Type of pneumothorax, %			
PSP	60.0	25.0	0.09
SSP	36.7	25.0	0.72
Iatrogenic	3.3	50.0	0.001
Size score <sup>a</sup> , mean	2.48	2.55	0.53
Chest tube fell out or displacement, %	3.3	33.3	0.018
Subcutaneous emphysema, %	6.7	0	0.11
Wound infection, %	3.3	0	0.06
Bleeding, % (n = 103)	0	8.3	0.14
Subcutaneous emphysema, wound infection or bleeding, %	10.0	8.3	1.0
Suction employed, % (n = 40)	20	50	0.07
Duration of stay in our department, days, mean (range)	5.3 (1-18)	3.8 (1-8)	0.49

PSP = primary spontaneous pneumothorax; PT = pneumothorax; SSP = secondary spontaneous pneumothorax.

a) See methods.

Episodes of pneumothorax managed by chest physicians. Patient characteristics and short-term outcomes according to procedure of chest-tube drainage.

PSP managed by chest tube insertion in our study was 10/100,000 and 2.3/100,000 for men and women. The incidence of SSP was 3.6/100,000 for men and 2.1/100,000 for women. Our numbers slightly deviate from numbers found in an American study, where the authors observed a higher incidence of SSP (6.3/100,000), but a lower incidence of PSP (7.4/100,000) [10].

Guidelines from both the UK and Denmark recommend simple aspiration as initial treatment of PSP and some patients with SSP [4, 5, 11, 12], while the American guidelines only rarely recommend aspiration [3]. A Cochrane review, including only one randomised study, concluded that aspiration has a high success rate that is just as high as chest tube drainage in the treatment of PSP and that it shortens the length of hospitalization [12]. None of our patients had aspiration performed, however; chest physicians used Tru-Close thoracic vents in the treatment of most of their patients. Results and complications after the use of this chest tube are not well-described [13-16]. Martin et al studied the thoracic vent in 84 patients with primarily iatrogenous PT. The drainage time was only 3.3 days with a success rate of 85% [15]. Anbalavanan and Samelson et al both tested the thoracic vent in 17 patients mainly with PSP and found drainage times of 3.2 days and 5.5 days, respectively, and success rates of 100% and 82.4%, respectively [13, 16]. No studies have so far compared the Tru-Close

thoracic vent with large-bore chest tubes, but a retrospective study of 67 patients mainly with PSP compared small-bore chest tubes (9 Fr) with large-bore chest tubes (20-32 Fr) and found a similar drainage time (five days versus seven days) and success rate (72% versus 65%). However the study also, surprisingly, found a tendency towards more complications in the small-bore than in the large-bore chest tube group [17]. In contrast, we found more drainage-related complications in patients with large-bore chest tubes inserted by surgical technique.

We referred 25% of the patients to the department of thoracic surgery for surgical intervention of persistent air leak or failed re-expansion. This corresponds to results reported by Mendis et al, who referred 11 out of 33 patients, and Martin et al, who referred 13 out of 84 patients to the department of thoracic surgery [15, 18]. The question is whether we should have referred more patients earlier in the process? BTS and DLS guidelines recommend referral of patients after five days of unsuccessful treatment. If we had followed these guidelines, we should have referred 36% more of our patients. A study from 2007 has, somewhat surprisingly, shown that many pneumothoraces spontaneously resolve during a 14-day waiting period. BTS guidelines from 2010 have been revised in this regard, and they now recommend a discussion of referral of the patient after five days of unsuccessful treatment [4].



An average drainage time of approximately seven days for our patients was clearly longer than the three to six days previously reported in the literature [15, 19]. This difference can, in part, be explained by the fact that previous studies exclusively used small-bore chest tubes. The average drainage time for our patients with small-bore chest tubes was just below five days. As in previous studies, we found a longer drainage time in patients with SSP than in patients with PSP [19].

We found that, in comparison with surgeon-placed large-bore chest tubes, the small-bore chest tubes inserted by chest physicians resulted in fewer complications and shorter hospital stays. Although this was not a randomized study, patients were comparable with regard to demographic factors and PT characteristics. However, due to the design we cannot rule out that patients treated with large-bore chest tubes had more severe symptoms than patients treated in daytime by a pulmonary physician. Further, as all chest tubes were inserted by trained physicians, either by an attending or a resident physician, we do not suspect that our results are biased due to lack of experience in chest tube placement.

Suction was more often employed in patients with large-bore chest tubes inserted. Suction may be employed more easily when a patient is already relatively immobilised with a chest tube attached to an underwater seal than in more mobilised patients with Tru-Close thoracic vents. However, we cannot rule out that patients treated with large-bore chest tubes may have been more resistant to treatment.

Our findings support the notion that a chest tube with a Heimlich valve facilitates quick mobilisation and out-patient management. We found that the Tru-Close thoracic vent only fell out in one patient.

Our results support the BTS guidelines in recommending a minimally invasive approach in the management of non-traumatic PT. We call for prospective randomised studies comparing the effects of small-bore chest tubes with Tru-Close thoracic vents in spontaneous PT without pleural effusion.

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**CONFLICTS OF INTEREST:** Disclosure forms provided by the authors are available with the full text of this article at [www.danmedj.dk](http://www.danmedj.dk).

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