CLINICAL RESEARCH



Pneumothorax[[1]](#footnote-1) is a common respiratory disease that is usually treated by needle aspiration, chest tube drainage or surgical intervention. With the latter two options usually performed by surgeons, needle aspiration is the principal method employed by internal medicine practitioners. Minimally-invasive chest tubes can be inserted in Internal Medicine departments, offering some of the advantages of both needle aspiration and chest tube drainage. We have been using this method to treat pneumothorax over recent years, and in this report will assess its efficacy and cost and whether there is any value in expanding its usage.

1. Subjects and methods

1.1 Subjects: 46 patients admitted to our hospital between 1 March 2005 and 31 August 2006 for their first episode of unilateral spontaneous pneumothorax, comprising cases of primary pneumothorax with no underlying disease, and cases of pneumothorax secondary to underlying lung disease. In order to reduce the impact of hospital costs on our study, patients with concomitant lung infection or any other complications requiring treatment were excluded.

1.2 Grouping: The 46 patients were divided into two groups using a random number table. Group A was treated with pleural drainage by central venous catheter, and Group B was treated with routine needle aspiration. All subjects signed an informed consent form, and were approved by the hospital’s ethics committee.

1.3 Equipment: 14 ga central venous catheters, single-use chest bottles and single-use drainage bags were used for chest tube drainage.

1.4 Staff requirements: Chest tube drainage and needle aspiration were carried out by three trained specialist physicians; the procedures were scheduled in random order prior to being carried out. A radiologist was responsible for the chest X-ray reports, which were also checked by the chief physician. The radiologist was not informed of which treatment arm the patients belonged to.

1.5 Methods: (1) Puncture site selection: The same principle was used to select the puncture sites in both groups. This was usually the second intercostal space on the mid-clavicular line, unless contraindicated, in which case the first or third intercostal space was selected. (2) Chest tube drainage method: i) Catheterisation method: The Seldinger technique was used. Routine skin disinfection, anaesthetic needle inserted into the thoracic cavity, hollow trocar inserted the same direction until air observed returning from the chest. Soft wire fed through the trocar lumen (guidewire), held in place once approximately 10 cm inside the body and trocar removed. Rigid plastic expanding needle passed along the wire to expand all tissue layers in the chest, before an indwelling tube (central venous catheter) fed through to approximately 10 cm inside the body, at which point the guidewire is removed. A sterile, transparent dressing used to secure the outer end of the indwelling catheter to the skin. ii) Aspiration and drainage method: Once the indwelling catheter is secured in place, an initial aspiration of 500-600 ml can be performed. Following this, aspiration can be carried out twice a day, 500-600 ml each time, until no more air can be aspirated. Continuous drainage during aspiration intervals, with the chest bottle replaced every day. iii) Catheter removal conditions and efficacy indicators: When no more air can be aspirated, or when less than 50 ml is aspirated in a single occasion, and where tests show lung recruitment, the catheter can be blocked and the patient observed for 24 h. If the subsequent chest X-ray confirms lung recruitment, the catheter can be removed. When examining the chest X-ray, if the compressed lung tissue is less than 30% (same as “pneumothorax extent”, see below) the treatment is deemed effective. (3) Needle aspiration method: i) Single-use drainage bags were used, with needle aspiration carried out in the conventional way. 800-1000 ml taken in the first aspiration. ii) Subsequent aspiration conditions and efficacy indicators: Chest X-ray examined 24 h after initial aspiration; extent of pneumothorax >30% indicates that further aspiration is necessary, with the aim of aspirating as much air as possible. Another chest X-ray is taken after 24 h after this, and if pneumothorax is still greater than 30%, a third needle aspiration will be carried out. This sequence is repeated until the chest X-ray shows pneumothorax of under 30%. Treatment is considered effective if the chest X-ray shows pneumothorax of under 30% within five needle aspiration procedures. If pneumothorax is still >30% after five aspirations, internal medicine is considered ineffective and the patient is referred for surgery. (4) Discharge conditions and follow-up: 24 hours after Group A’s second chest X-ray, and 24 hours after Group B’s final chest X-ray, observation ceased and patients were discharged from hospital provided their condition was stable. After discharge there was one week of follow-up and one additional chest X-ray. (5) Other treatment measures: During the hospitalisation period, oxygen therapy was given to promote pneumothorax absorption. Antibiotics were given to prevent infection in Group A while the tube was embedded, and to Group B during needle aspiration.

1.6 Statistical methods: T-testing was used to compare inter-group means.

2. Results

2.1 General condition upon admission: There were 23 patients in each arm. Group A comprised 22 male subjects and 1 female subject with a median age of 28.9 years; Group B comprised entirely of male subjects with a median age of 27.3 years. Type of pneumothorax: Group A comprised 18 cases of

primary pneumothorax and 5 cases of secondary pneumothorax, whilst Group B comprised 19 cases of primary pneumothorax and 4 cases of secondary pneumothorax. Group A comprised 14 cases of left-sided pneumothorax and 9 cases of right-sided pneumothorax, with a mean extent of 65.5%; Group B comprised 13 cases of left-sided pneumothorax and 10 cases of right-sided pneumothorax, with a mean extent of 66.2%.

2.2 See table 1 for efficacy in both groups.

**Table 1** Efficacy comparison between Group A and Group B

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Group | No. of patients | Treatment efficacy [% (*n* of effective cases)] | Mean hospitalisation duration (d) | Remaining pneumothorax extent at discharge (%) | Remaining pneumothorax extent 1 week after discharge (%) |
| A | 23 | 100 (23) | 5.32 | 4.17 | 0.53 |
| B | 23 | 91.30 (21) | 7.68 | 18.62a | 7.59b |
| *t* value |  |  | 2.198 | 2.317 | 2.812 |
| *P* value |  |  | <0.05 | <0.05 | <0.01 |

Note: a Treatment was ineffective in 2 cases and patients were transferred to surgery; the pneumothorax extent given here was recorded when they were transferred; b Treatment was ineffective in 2 cases and patients were transferred to surgery, so they were excluded from these calculations

2.3 Economic assessment: (1) Comparison of mean equipment costs during hospitalisation: The main equipment used for Group A was central venous catheters, chest bottles and chest X-rays; according to the standard costing approved by the state pricing department, the equipment cost was RMB 264.79 per person. Drainage bags and chest X-rays were the main equipment used by Group B, costing RMB 233.62 per person. (2) See table 2 for a comparison of the number of days/hours of adjuvant treatment paid for in both groups. The table shows that the number of days of hospitalisation and infection prevention therapy were lower in Group A (at 2.36 d and 2.13 d respectively), and oxygen therapy per patient was 36.7 h less than in Group B.

3. Discussion

Pneumothorax is a common respiratory illness, the spontaneous form of which is frequently seen in young men. Our data show that patients under 40 years of age account for 61.04% of pneumothorax cases in our hospital[1], when they are in the prime of their academic or professional lives. This makes it even more important to improve treatment outcomes, reduce the time spent in hospital, and minimise healthcare costs. Over the long term, the first occurrence of spontaneous pneumothorax is usually treated with multiple needle aspirations, which effectively alleviate the pain experienced by pneumothorax patients although it does require multiple chest X-rays and aspirations, leading to high short-term X-ray exposure and increased medical risk from repeated procedures.

**Table 2** Comparison of adjuvant treatment durations in Group A and Group B

|  |  |  |  |
| --- | --- | --- | --- |
| Group | Mean hospitalisation duration (d) | Mean duration of infection prevention treatment (d) | Mean oxygen therapy duration (h) |
| A | 5.32 | 3.46 | 86.4 |
| B | 7.68 | 5.59 | 133.1 |
| *t* value | 2.198 | 2.553 | 2.736 |
| *P* value | <0.05 | <0.05 | <0.01 |

Treatment alternates between X-ray examinations and aspiration procedures, resulting in longer hospitalisation and higher costs. Research has recently shown that small-bore indwelling catheters are important tools in the treatment of pneumothorax[2-3], and even recommends that small-bore tubes should be the preferred choice in the treatment of certain pneumothorax cases[4]. In the ICU, central venous catheters are used to drain pleural effusions, and offer patients improved tolerance and efficacy with a lower chance of adverse reactions. This presents obvious advantages over needle aspiration, therefore small-bore catheters are recommended instead of needle aspiration for draining pleural effusion in high-risk patients[5]. In consideration of these factors and the relevant research, we opted to use central

venous catheters for pleural drainage, and found this method to be more effective than needle aspiration, with treatment duration and lung recruitment time reduced by an average of 2 days and residual pneumothorax extent after discharge and after the 1-week follow-up significantly lower than in patients treated with needle aspiration. Although the cost of this method is almost identical to that of aspiration, the overall hospitalisation costs are lower due to the shorter course of treatment (which entails less infection prevention, less oxygen therapy and a shorter hospitalisation duration). See Table 3 for a comparative analysis of the advantages and disadvantages of chest catheter drainage and needle aspiration and their potential mechanisms.

**Table 3** Comparison of the advantages and disadvantages of pleural drainage and needle aspiration

|  |  |
| --- | --- |
| Needle aspiration | Pleural drainage |
| Repeated chest puncture | Single catheterisation procedure |
| Repeated procedure, drop in patient compliance | Single procedure, good patient compliance |
| Increased risk of infection | Less chance of infection |
| Increased risk of incidents during puncture | Corresponding drop in probability of an incident |
| Multiple chest X-rays | Single chest X-ray |
| High exposure to radiation | Low exposure to radiation |
| Increased cost | Lower cost |
| Aspiration frequency | Aspiration frequency |
| Maximum once a day | At least twice a day |
| Continuous drainage not possible | Continuous drainage possible |
| Aspiration extent | Aspiration extent |
| Puncture needle is steel and unsuitable for use  with higher negative pressures; needle is  normally positioned in the second intercostal  space, making it hard to aspirate gas from above  this point | The catheter is a soft tube that can be used at  higher negative pressures without damaging the  lung tissue; negative pressure aspiration can  extract gas from the tips of the chest cavity and  reduce the pneumothorax extent |
| No indwelling catheter | Indwelling catheter inserted in the chest |
| Does not cause non-infectious inflammation | Can induce extremely infectious inflammation,  encourage healing of the pleural rupture and  shorten treatment duration |
| No significant discomfort after puncture | Certain amount of discomfort caused by  indwelling catheter, but bearable for the patient  and does not affect catheter retention |

In comparison to conventional chest tube treatment, pleural drainage with a central venous catheter causes minimal trauma and does not require incisions, suturing or invasive fixation, thereby lowering the risk of infection and improving the healing of damage to the chest wall. However, this method is not recommended in cases of tension pneumothorax, as the narrowness of the catheter used makes it difficult to reduce pressure in a short timeframe. This method may also not be the best solution for patients with a low pneumothorax extent (around 30%) who may only require a single aspiration. These two scenarios aside, chest catheterisation is the recommended aspiration method for the first occurrence of spontaneous pneumothorax.

**References**



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