



Efficacy and Cost-Effectiveness of Portable Small-Bore Chest Tube (Thoracic Egg Catheter) in Spontaneous Pneumothorax

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Background: Primary spontaneous pneumothorax is commonly treated with chest tube insertion, which requires hospitalization. In this study, we evaluated the efficacy, costs, and benefits of a portable small-bore chest tube (Thoracic Egg; Sumitomo Bakelite Co. Ltd., Tokyo, Japan) compared with a conventional chest tube.

Methods: We retrospectively analyzed all primary spontaneous pneumothorax patients who underwent treatment at Gangnam Severance Hospital between August 2014 and May 2018.

Results: A total of 279 patients were divided into 2 groups: the conventional group (n=236) and the Thoracic Egg group (n=43). Of the 236 patients in the conventional group, 100 were excluded because they underwent surgery during the study period. The efficacy and cost were compared between the 2 groups. There was no statistically significant difference between the groups regarding recurrence (conventional group, 36 patients [26.5%]; Thoracic Egg group, 15 patients [29.4%]; p=0.287). However, the Egg group had statistically significantly lower mean medical expenses than the conventional group (433,413 Korean won and 522,146 Korean won, respectively; p<0.001).

Conclusion: Although portable small-bore chest tubes may not be significantly more efficacious than conventional chest tubes, their use is significantly less expensive. We believe that the Thoracic Egg catheter could be a less costly alternative to conventional chest tube insertion.

Keywords: Pneumothorax, Chest tubes, Egg

Introduction

Pneumothorax is a condition characterized by the presence of air in the pleural space. Its occurrence is generally spontaneous, post-traumatic, or iatrogenic. Primary spontaneous pneumothorax (PSP) occurs in young individuals without lung disease, whereas secondary spontaneous pneumothorax (SSP) occurs in patients with clinical or radiological evidence of underlying lung disease, particularly in those with chronic obstructive pulmonary disease [1]. Although PSP generally has a shorter recovery time and a better prognosis than SSP, choosing the appropriate treatment method (i.e., surgery or conservative treatment) is crucial, as it depends solely on the patient's situation [2,3].

At many institutions, the standard treatment method for PSP is chest tube insertion, which requires hospitalization.

However, this treatment method is controversial. According to the British Thoracic Society guidelines, performing needle aspiration first reduces hospitalization time and healthcare costs for PSP patients [3]. The American College of Chest Physicians recommends hospitalization after chest tube insertion, regardless of tube size, for clinically stable patients with large pneumothoraces [2]. The Japan Society for Pneumothorax and Cystic Lung Diseases Guidelines Committee has not reached a full consensus on this matter and currently recommends a variety of options [4].

In the present study, we evaluated the efficacy, costs, and benefits of portable small-bore chest tube (Thoracic Egg; Sumitomo Bakelite Co. Ltd., Tokyo, Japan) treatment for PSP without hospitalization and compared them with those of conventional chest tube (CCT) treatment requiring hospitalization.



Methods

In this retrospective study, which took place after the introduction of the Thoracic Egg catheter (TEC) in Korea, we analyzed the medical records of all patients who visited the emergency department or the outpatient clinic of the thoracic surgery department and were diagnosed with first-time PSP between August 2014 and May 2018. These patients were given the choice between CCT insertion with hospitalization and TEC insertion via a portable small-bore chest tube without hospitalization. The patients made this decision after they were provided with careful explanations of the advantages and disadvantages of each method. Based on their choice, patients were divided into either the CCT group or the TEC group for a comparative analysis. Patients with SSP, recurrent PSP, signs of pleural effusion or hemothorax on chest X-rays, or hemodynamic instability were excluded from the present study. Medical records, including patient characteristics and outpatient records and images, were reviewed and analyzed. This study was reviewed and approved by the Institutional Ethics Committee and Review Board of Gangnam Severance Hospital (IRB approval no., 3-2018-0261). The requirement for informed consent was waived due to the retrospective nature of the analysis. The TEC was approved by the Korean Ministry of Food and Drug Safety in December 2016 and has been used in Japan for the past 20 years.

In cases where patients chose CCT with hospitalization (the CCT group), a 12F catheter (Argyle suture rib trocar catheter; Covidien, Mansfield, MA, USA) was inserted at the fifth intercostal space on the anterior axillary line prior to hospitalization. Among these patients, surgery was subsequently performed if prolonged air leakage was observed for more than 5 days, if the patient chose surgery due to concerns of recurrence, or if lung expansion was unsuccessful according to serial chest X-ray.

In cases where patients instead chose the portable thoracic drainage device (the TEC group), the Thoracic Egg was applied. The Thoracic Egg consists of a flexible 9F silicone catheter with two 1-way Heimlich valves and a small plastic chamber (Fig. 1). In brief, a 5-mm skin incision was made under local anesthesia; following a test puncture, a catheter was inserted in the third to fifth intercostal space on the anterior axillary line. After pleural puncture, the needle was removed from the catheter, and the catheter was inserted into the thoracic cavity, which was then fixed to the chest wall and connected to a plastic chamber using adhesive tape. Thirty minutes to 1 hour after Thoracic Egg insertion, a chest X-ray examination was performed. Pa-

tients were discharged after (1) confirmation of the position of the catheter in the thoracic cavity, (2) resolution of symptoms, and (3) confirmation of lung expansion. Patients were advised to visit our outpatient clinic within 1 week from discharge, at which time the catheter was removed. The TEC was removed from all patients at the outpatient clinic; however, patients were admitted as inpatients upon request.

In the CCT group, medical expenses were calculated based on the total days prior to discharge. In the TEC group, medical expenses were calculated by the members of the outpatient clinic and emergency department including the period until the day of device removal. These expenses included the catheter, which was assigned a cost of 100,000 Korean won (KRW). In Korea, the cost of the Thoracic Egg has not yet been established; hence, we estimated the cost based on its usage in Japan.

Descriptive statistics were used to compare the variables between the 2 groups, using the chi-square test or the Fisher exact test for categorical variables and the Student t-test for continuous variables. All statistical analyses were performed using IBM SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA).

Results

In this study, a total of 279 patients were included for analysis: 236 patients in the CCT group and 43 patients in the TEC group. The mean follow-up duration was 24.1 months in the CCT group and 35.5 months in the TEC group. There were no significant differences between the CCT and TEC groups with respect to age, sex, body mass index, and laterality. Among those in the CCT group, 100 patients (42.4%) underwent surgery during hospitalization. However, no patients in the TEC group underwent surgery. The catheter indwelling time was 2.8 days in the CCT group and 6.1 days in the TEC group, constituting a statistically significant difference ($p < 0.001$) (Table 1).

To facilitate a better comparison, we excluded patients who underwent surgery in the CCT group and compared those in the CCT group who only underwent chest tube treatment with those in the TEC group with respect to recurrence during follow-up. We found that 36 patients (26.5%) in the CCT group and 15 patients (34.9%) in the TEC group experienced recurrence. The difference was not statistically significant ($p = 0.287$). However, medical expenses were significantly lower in the TEC group (mean, 433,413 KRW) than in the CCT group (mean, 522,146 KRW; $p < 0.001$) (Table 2).

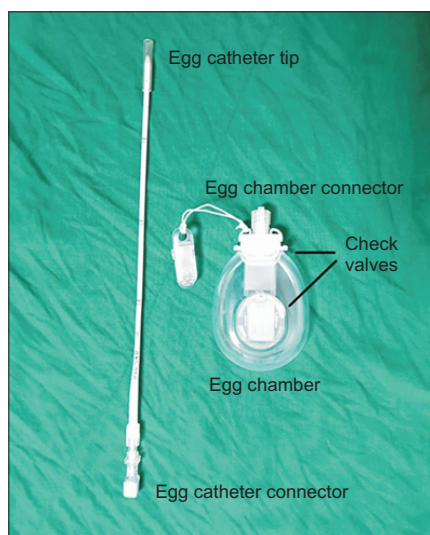


Fig. 1. Thoracic Egg catheter and chamber.

Discussion

Many outpatient studies of PSP treatment have been conducted. Ho et al. [5] showed that 60% of PSP patients underwent successful treatment using needle aspiration or a Heimlich valve and 12F chest tube. They also showed that there was no statistically significant difference with respect to the size of the tube; however, smaller tubes have been shown in some previous studies to result in less pain and greater stability [5-7]. Therefore, we believe that the TEC used in this study is highly suitable for treating PSP.

According to the results of the present study, chest tube indwelling time was significantly shorter in the CCT group than in the TEC group. This may be attributable to serial follow-up and care during the hospitalization of the CCT patients. Since the majority of PSP patients in this study were in their late teens to mid-20s, the purpose of outpatient follow-up was to minimize patient disconnect with everyday life (i.e., school and social life) [4,6,8]. We believe the TEC to be highly suitable in such circumstances. Although it may be difficult to precisely calculate the socio-economic effect or to perform an exact cost-benefit analysis of TEC for the treatment of PSP, we firmly believe that this device may be particularly advantageous for younger PSP patients without any underlying disease.

Karasaki et al. [6] showed that the TEC had a resolution rate of 95.8% and a recurrence rate of 32.9%. Our findings were similar, with a resolution rate of 100% and a recurrence rate of 29.4%. Moreover, Woo et al. [9] found that thoracic egg insertion can provide social and economic

Table 1. Comparison of baseline characteristics between groups

Characteristic	Conventional chest tube group	Thoracic Egg catheter group	p-value
Age (yr)	28.3±15.5	27.7±15.2	0.797
Gender (male)	200 (83.0)	41 (95.3)	0.062
Body mass index (kg/m ²)	20.20±2.89	20.27±2.96	0.912
Laterality (right:left)	101:135	21:22	0.463
Underwent surgery	100 (42.4)	0	<0.001
Catheter indwelling time (day)	2.8±1.2	6.1±2.6	<0.001
Follow-up duration (mo)	24.1±11.6	35.5±12.1	<0.001

Values are presented as mean±standard deviation or number (%).

Table 2. Comparison of recurrence and total costs between groups, excluding patients who underwent surgery

Variable	Conventional chest tube group (n=136)	Thoracic Egg catheter group (n=43)	p-value
Recurrence	36 (26.5)	15 (34.9)	0.287
Total cost (Korean won)	522,146±398,270	433,413±105,632	<0.001

Values are presented as mean±standard deviation or number (%).

benefits for patients. In the present study, TEC insertion was performed in the emergency department, rather than in the outpatient clinic. Despite the added cost of using the emergency department, the mean overall medical expenses for those in the TEC group were significantly lower than that for those in the CCT group.

The TEC has some limitations. Given its thinness, it is prone to kinking and may easily become disconnected from the chamber [6]. Moreover, it can cause infection from self-dressing and insufficient pain control. However, there were no such complications in our study, as we provided patients with thorough education as well as appropriate antibiotics and analgesics. It is worth noting that this lack of complications may be attributable to the fact that our patients were all young and healthy with good compliance. Another limitation is that we were unable to observe exactly when the lung fully expanded and pneumothorax was completely resolved in patients receiving TEC insertion, because their follow-up date depended on their availability for a visit to the outpatient clinic. Therefore, it was difficult to draw an accurate comparison of chest tube indwelling time between the TEC and CCT groups. In addition, concerns may exist regarding whether the location of the TEC interferes with lung expansion, although no cases triggered such concern in this study. An-

other limitation of this study may be the inevitability of selection bias, as it took place at a single institution and patients chose to be admitted for treatment or to receive treatment at the outpatient clinic. A future, large-scale, prospective randomized trial is needed to overcome these limitations.

In conclusion, in this study, we found that a portable small-bore chest tube may not be significantly more efficacious than a CCT. However, given that CCT usage normally requires hospitalization, while use of a portable small-bore chest tube does not, the latter produces significantly lower medical expenses. Therefore, we believe that the TEC could be a less costly alternative to CCT insertion, especially for young, otherwise healthy PSP patients.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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