Outpatient Treatment of Pneumothorax with a Thoracic Vent: Economic Benefit

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Key Words

Pneumothorax · Pleural disease · Lung · Outpatient treatment · Chest tubes · Thoracic vent

Abstract

Background: Since rising medical costs currently represent a growing problem worldwide, finding cost-effective treatment options is important. In our hospital, outpatient treatment of pneumothorax using a thoracic vent began in December 2012. **Objectives:** We aimed to test our hypothesis that outpatient treatment of pneumothorax with a thoracic vent can reduce medical expenses. **Methods:** Patients were classified into four groups based on treatment: thoracic vent with or without surgery or conventional intercostal chest tube drainage with or without surgery. We compared mean medical expenses, duration of hospitalization and number of physician visits among these four groups. **Results:** During a 2-year period, 65 patients were treated with a thoracic vent (36 patients) or conventional intercostal chest tube drainage (29 patients). Patients treated with a thoracic vent who underwent surgery had a shorter mean duration of hospitalization (5.0 ± 1.3 vs. 10.3 ± 3.4 days; $p < 0.0001$) and lower overall cost, at JPY $971,830.00 \pm 81,291.80$ (USD $10,400.40 \pm$

$1,464.90$) versus JPY $1,179,791.10 \pm 198,383.10$ (USD $13,888.90 \pm 1,965.30$; $p < 0.0001$) compared with conventional intercostal chest tube drainage. Nonsurgical patients treated with a thoracic vent had lower overall costs, at JPY $79,960.00 \pm 25,643.60$ (USD 890.10 ± 352.30) versus JPY $268,588.80 \pm 94,636.50$ (USD $2,932.80 \pm 903.50$; $p < 0.0001$) compared with conventional intercostal chest tube drainage. No serious complications were observed. **Conclusions:** Outpatient thoracic vent treatment can significantly reduce medical expenses and thereby have a major economic impact.

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Introduction

Increasing healthcare costs are currently a problem worldwide. Consequently, it is important to reduce medical expenses and the duration of hospitalization. We hypothesize that outpatient treatment of pneumothorax has the potential to reduce the duration of hospitalization and thus bring about a major reduction in medical expenses.

Pneumothorax is classified as spontaneous, traumatic or iatrogenic. Primary spontaneous pneumothorax is a

relatively common disease that typically occurs in tall young men. In general, conservative therapy, needle aspiration, chest tube drainage, and surgery are used to treat pneumothorax [1–4]. Patients treated with conventional intercostal chest tube drainage (CITD) usually have to remain hospitalized during treatment. Since many patients are workers or students, they would have to stop working or miss classes during treatment. Needle aspiration and minimally invasive chest tube drainage are not significantly different with regard to success and recurrence rates, but they involve a shorter hospital stay than CITD [5–16].

In many hospitals, only needle aspiration is used for outpatient treatment of pneumothorax. Although needle aspiration is simple to perform, it is difficult to determine whether there is an air leak [17]. Furthermore, it offers no protection against persistent air leaks or the development of tension pneumothorax. Consequently, minimally invasive chest tube drainage is more useful.

Several hospitals have been treating pneumothorax using a minimally invasive approach with a thoracic vent (TV) [18, 19]. Since TV therapy does not require hospitalization, it is advantageous for patients. At our hospital, outpatient treatment of pneumothorax using the TRUCLOSE TV (Davis and Geek, Wayne, N.J., USA) began in December 2012. To date, there have been only a few published reports about the economic benefits of TV [20]. Herein we investigated the economic benefits of TV for patients and hospitals.

Materials and Methods

Subjects

Patients who presented with spontaneous or traumatic pneumothorax without pleural effusions [21] between April 2012 and March 2014 were considered candidates for this retrospective study. Starting in December 2012, patients with pneumothorax were treated with TV. The indications for CITD treatment of pneumothorax are as follows: (1) large-sized pneumothorax, (2) pleural adhesion or (3) pleural effusion. We excluded patients with tension pneumothorax, hemopneumothorax, or pyothorax. The decision for surgical management was made during the course of outpatient observation. The indications for surgical treatment were as follows: (1) recurrence, defined as the patient having had a prior pneumothorax in his or her medical history, (2) persistent air leak, defined as an air leak persisting for >48 h or (3) patient preference for surgery to prevent recurrent pneumothorax (fig. 1).

TV patients were hospitalized for a few days before elective surgery. We performed preoperative preparations between hospital admission and surgical intervention in surgical TV patients.

In both groups, the decision for surgery was made within 1 week. Follow-up was performed after catheter removal or hospital

discharge. Informed consent was obtained from all patients. The institutional review boards of Chigasaki Municipal Hospital approved this study on April 15, 2013 (project approval No. 2013-05).

CITD Management

In all patients who underwent CITD, 20-Fr chest tubes were inserted through the fifth intercostal space under local anesthesia. Closed underwater seal drainage was performed.

Appearance and Management of the TV

The external dimensions of the TV are 9 cm in length, 2.5 cm in width and 2 cm in depth. The TV consists of a flexible 13-Fr urethane catheter with a removable in-line trocar connected to a one-way valve. Since there is no need to connect the drain to a seal device, hospitalization can be avoided. A signal diaphragm indicates when the trocar has initially entered into the pleural space during insertion and reflects pressure changes in the pleural space (fig. 2). Since monitoring for air leaks is possible, the TV can be removed after confirmation that any air leaks have resolved. If necessary, the TV can be connected to a seal device.

All TVs were inserted under local anesthesia through the second intercostal space in the midclavicular line on an outpatient basis. We prescribed nonsteroidal anti-inflammatory drugs for pain relief during treatment. Patients who underwent TV treatment required little pain medication.

Calculation of Costs

Patients were classified into four groups: TV with or without surgery or CITD with or without surgery. We retrospectively compared the duration of hospitalization, preoperative duration of hospitalization, hospital medical expenses, hospital medical expenses per day, number of physician visits, hospital outpatient expenses, hospital outpatient expenses per day, and overall cost among these four groups.

In the cost analysis, we calculated medical expenses based on the true and actual costs incurred by our patient cohort and the cost of the TV device – approximately JPY 50,000 (USD 563.80). In Japan, medical fees are based on a fixed schedule regulated by the government.

All of the variables mentioned above were compared with Student's *t* test across the treatment groups. A *p* value <0.05 was considered statistically significant.

Results

Patient Characteristics

During a 2-year period, 65 patients were treated with either TV (*n* = 36) or CITD (*n* = 29). TV insertion was relatively straightforward and took approximately 15–20 min on an outpatient basis in all TV patients. Most patients (62/65, 95.4%) had spontaneous pneumothorax. Patient characteristics are summarized in table 1. CITD patients were older, especially those in the nonsurgical group. Whereas all the patients in the CITD group were hospitalized, all the patients in the TV group avoided hospitalization on the day of TV insertion.

Fig. 1. Algorithm for the treatment of pneumothorax.

Fig. 2. Schematic diagram of the TV.

Patients Treated with Surgery

Of the 65 patients, 38 patients underwent surgery in addition to TV ($n = 21$) or CITD ($n = 17$). The mean duration of hospitalization among TV patients was 5.0 ± 1.3 versus 10.3 ± 3.4 days for CITD patients ($p < 0.0001$). The mean preoperative duration of hospitalization for TV patients was 1.7 ± 1.0 versus 5.5 ± 3.1 days for CITD patients ($p < 0.0001$). The mean interval between device insertion and surgical intervention for TV patients was 7.8 ± 3.3 versus 8.3 ± 2.7 days for CITD patients ($p = 0.6536$).

The mean hospital medical expenses per day for TV patients were JPY $165,269.60 \pm 32,142.10$ (USD $1,775.80 \pm 320.60$) versus JPY $112,020.80 \pm 27,497.90$ (USD $1,320.80 \pm 299.20$) for CITD patients ($p < 0.0001$). The mean overall cost associated with TV was lower, at JPY $971,830.00 \pm 81,291.80$ (USD $10,400.40 \pm 1,464.90$) versus JPY $1,179,797.10 \pm 198,383.10$ (USD $13,888.90 \pm 1,965.30$; $p < 0.0001$). All patients underwent video-assisted thoracic surgery. Compared with patients in the CITD group, patients in the TV group had shorter duration of hospitalization and lower overall medical expenses. However, hospital medical expenses per day were higher in TV patients than in CITD patients. Table 2 summarizes the differences in the duration of hospitalization and medical expenses between TV and CITD patients treated with surgery.

Patients Who Did Not Undergo Surgery

Of the 65 patients, 27 patients did not undergo surgery (15 TV, 12 CITD). The mean overall cost associated with

Table 1. Patient characteristics

	Surgical patients ($n = 38$)		Nonsurgical patients ($n = 27$)	
	TV ($n = 21$)	CITD ($n = 17$)	TV ($n = 15$)	CITD ($n = 12$)
Age, years				
Mean	29.1	39.2	42.7	64.7
Range	16–73	18–77	19–69	29–83
Gender (M/F)	17/4	15/2	12/3	8/4
Laterality (left/right)	10/11	9/8	9/6	7/5
Etiology of pneumothorax (spontaneous/traumatic)	21/0	17/0	14/1	10/2
Collapse size (moderate/large)	21/0	11/6	15/0	9/3

Collapse size: the collapse size of the pneumothorax was calculated as follows: the atelectatic lung area detected on the posteroanterior chest X-ray was subtracted from the area of the hemithorax, and the result was divided by the area of the hemithorax. Moderate: $80\% >$ pneumothorax collapse size $\geq 20\%$. Large: pneumothorax collapse size $\geq 80\%$.

TV was JPY $76,960.00 \pm 25,643.60$ (USD 890.10 ± 352.30) versus JPY $268,588.80 \pm 94,636.50$ (USD $2,932.80 \pm 903.50$) for CITD ($p < 0.0001$). Patients treated with CITD were hospitalized for 5.8 ± 2.4 days on average. The mean duration of TV drainage was 6.3 ± 1.8 days. All patients who underwent TV were treated on an outpatient basis. The duration of hospitalization, hospital medical expenses, hospital medical expenses per day, number of physician visits, hospital outpatient expenses, hospital outpatient expenses per day, and overall cost for patients who did not undergo surgery are summarized in table 3.

During this period, 1 patient in the TV group developed the complication of TV occlusion. No other serious complications occurred.

Discussion

In many hospitals, only needle aspiration is used to treat pneumothorax on an outpatient basis. Although needle aspiration is a simple procedure, there are some associated problems. It is difficult to determine whether there is an air leak after needle aspiration, and it offers no protection against persistent air leaks or the development of tension pneumothorax. Thus, minimally invasive chest tube drainage is considered more clinically advantageous. Given the efficacy of minimally invasive chest tube drainage, TV was introduced as a new modality for the treatment of spontaneous pneumothorax in 1991. Roeggla et

Table 2. Duration of hospital stay and costs based on the type of pneumothorax treatment in surgical patients

	TV (n = 21)	CITD (n = 17)	p value
Duration of hospitalization, days	5.0±1.3	10.3±3.4	<0.0001
Preoperative duration of hospitalization, days	1.7±1.0	5.5±3.1	<0.0001
Drainage time after surgical treatment, days	1.3±0.6	1.9±1.2	0.0582
Hospital medical expenses, JPY	874,259.5±82,187.7 (9,359.9±1,416.2)	1,162,994.1±197,736.1 (13,685.2±1,914.4)	<0.0001
Hospital medical expenses per day, JPY	165,269.6±32,142.1 (1,775.8±320.6)	112,020.8±27,497.9 (1,320.8±299.2)	<0.0001
Number of physician visits, days	3.8±2.0	2.9±2.0	0.1490
Hospital outpatient expenses, JPY	97,570.5±17,789.4 (1,040.5±194.1)	16,797.6±11,471.0 (203.6±146.4)	<0.0001
Hospital outpatient expenses per day, JPY	28,466.2±8,967.3 (303.6±99.1)	5,576.8±1,403.4 (66.6±19.4)	<0.0001
Overall cost, JPY	971,830.0±81,291.8 (10,400.4±1,464.9)	1,179,797.1±198,383.1 (13,888.9±1,965.3)	<0.0001

Values in parentheses are USD. We excluded the days that the patients left the hospital from the analysis.
The average exchange rate was JPY 79.79 to USD 1 in 2012 and JPY 97.59 to USD 1 in 2013.

Table 3. Duration of hospital stay and costs based on the type of pneumothorax treatment in nonsurgical patients

	TV (n = 15)	CITD (n = 12)	p value
Duration of hospitalization, days	–	5.8±2.4	–
Hospital medical expenses, JPY	–	258,219.6±94,347.0 (2,846.3±900.8)	–
Hospital medical expenses per day, JPY	–	45,805.6±4,019.6 (514.7±84.2)	–
Number of physician visits, days	3.4±1.5	1.7±1.2	0.0035
Hospital outpatient expenses, JPY	72,660.4±31,364.3 (890.1±352.3)	10,369.2±9,921.4 (122.3±122.4)	<0.0001
Hospital outpatient expenses per day, JPY	27,195.6±15,275.9 (306.2±156.2)	4,804.2±3,025.8 (54.6±34.0)	<0.0001
Overall cost, JPY	76,960.0±25,643.6 (890.1±352.3)	268,588.8±94,636.5 (2,932.8±903.5)	<0.0001

Values in parentheses are USD. The average exchange rate was JPY 79.79 to USD 1 in 2012 and JPY 97.59 to USD 1 in 2013.

al. [22] and Samelson et al. [23] have suggested that TV is as effective as CITD for the management of iatrogenic and spontaneous pneumothorax.

We hypothesized that outpatient treatment with TV can reduce medical expenses without creating additional disadvantages for patients. The objective of our study was to evaluate the economic effect of outpatient treatment using TV. We found that there was an important economic difference in nonsurgical patients treated with TV versus CITD.

Furthermore, among patients who also underwent surgery, hospital medical expenses, hospital outpatient expenses and overall cost were lower for TV compared with CITD.

We can decide whether surgery is indicated while the patient is being treated on an outpatient basis and whether patients with TV require hospitalization for several days before elective surgery. We determined that surgery was indicated when air leaks persisted for >48 h, which we defined as a 'persistent air leak'. It has been reported that if an air leak persists for >48 h, continued chest tube

suction for up to a total of 10 days yielded few additional pleural closures in patients with primary or secondary spontaneous pneumothorax [24]. Furthermore, air leakage for >5 days before surgery was described as a risk factor for postoperative complications [25].

TV can reduce preoperative and overall duration of hospitalization. In contrast to TV, CITD requires hospitalization, and the decision of whether to operate becomes essential during hospitalization and can potentially lengthen the length of stay. TV patients have the advantage of shorter hospital stays and lower medical expenses.

However, the cost of the TV device is higher than the cost of the CITD drainage tube, which is reflected in the hospital medical expenses. Consequently, hospital medical expenses per day in the surgical group were higher for TV than for CITD patients.

Although hospital medical expenses per day were higher for TV than CITD patients, our results show that in economic terms it is more cost-efficient for a hospital to perform TV rather than CITD when indicated. There-

Table 4. Overall costs for older versus younger patients in the surgical and nonsurgical groups

	Older patients (age ≥ 70 years)	Younger patients (age < 70 years)	p value
Surgical group, JPY	1,308,702.5 $\pm$ 120,874.6 (14,962.8 $\pm$ 2,713.7)	1,140,133.8 $\pm$ 203,908.4 (13,558.5 $\pm$ 1,675.2)	0.1420
Nonsurgical group, JPY	310,695.0 $\pm$ 80,918.3 (3,267.0 $\pm$ 844.1)	238,512.857 $\pm$ 97,578.1 (2,976.6 $\pm$ 603.5)	0.2066

Values in parentheses are USD.

fore, TV offers numerous benefits not only to patients who undergo surgery but also to hospitals.

There was a difference in age between the surgical and nonsurgical patients. CITD patients were older, especially those in the nonsurgical group. Pleural adhesions were more frequently detected by radiography in older patients. Therefore, a higher proportion of older patients underwent CITD. We compared the cost for older patients (age ≥ 70 years) versus younger patients (age < 70 years) in the CITD treatment group. In both the surgical and nonsurgical groups, there were no significant differences in age, as shown in table 4.

Surgical and nonsurgical TV patients can avoid hospitalization on the day of TV insertion. In addition, TV is associated with less pain compared with CITD [26]. Pa-

tients can return for follow-up. Depending on the nature of their schedule, TV patients can remain active and can avoid missing work or classes. Consequently, outpatient treatment with TV provides major economic benefits not only to patients who undergo surgery but also to those who do not.

TV-associated complications that have been reported include device occlusion, bronchopleural fistula and re-expansion pulmonary edema [27, 28]. In this study, one complication was observed in 1 TV patient, which was easily managed by switching the TV. TV is an easy-to-use and safe outpatient treatment.

In conclusion, outpatient TV treatment not only has the advantage of decreasing medical expenses but is also associated with a major economic benefit.

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