ORIGINAL ARTICLE

Comparison Between Upper and Lower Chest Zone Drainage of Primary Spontaneous Pneumothorax by Ultrasound-guided Pigtail Catheter

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Purpose. We have found that primary spontaneous pneumothorax (PSP) can be successfully managed with ultrasound-guided pigtail catheter placed in the lower chest zone. This study was to ascertain whether drainage of PSP from the lower chest zone is as effective as drainage from the upper chest zone.

Methods. This was a 6-year retrospective chart analysis of 150 consecutive patients who underwent pigtail drainage as initial treatment of first episode PSP. All enrolled patients underwent chest ultrasound before pigtail catheter insertion. Based on chest radiographs, we arbitrarily divided these patients into two groups according to the position of pigtail insertion. Pneumothorax was drained from the upper chest zone (UCZ) in 33 patients and from the lower chest zone (LCZ) in 117 patients. UCZ was defined as the upper half of the hemithorax and LCZ was defined as the lower half of the hemithorax.

Results. One-week success rates were obtained in 88 out of 117 patients (75.2 %) in the LCZ group, and in 26 out of 33 patients (78.8 %) in the UCZ group ($p = 0.67$). Recurrence rates at 1-year follow-up were 22 out of 117 (18.8%) in the LCZ group, and 4 out of 33 (12.1%) in the UCZ group ($p = 0.37$). Further analysis of length of hospital stay, duration of pigtail intubation and complication rate in both groups revealed no statistically significant difference between the two procedures (all $p > 0.05$).

Conclusions. The insertion site of ultrasound-guided pigtail catheter does not affect one-week success rate, one-year recurrence rate, complication or hospital stay in patients with PSP. **(Mid Taiwan J Med 2006;11:90-6)**

Key words

chest ultrasound, pigtail catheter, primary spontaneous pneumothorax

INTRODUCTION

Spontaneous pneumothorax is the collection of air or gas in the chest that causes the lung to collapse in the absence of a traumatic injury to the chest or lung. Primary spontaneous pneumothorax (PSP) refers to spontaneous pneumothorax which does not present with clinically apparent underlying lung abnormalities or underlying conditions known to promote pneumothorax (eg, chronic obstructive airway disease, tuberculosis and idiopathic pulmonary fibrosis). The incidence of primary spontaneous pneumothorax is estimated to be approximately 15 cases per 100,000 people per year among men, and 5 cases per 100,000 people per year among

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women [1]. PSP typically occurs in healthy young men of taller than average height [2]. Factors associated with primary spontaneous pneumothorax include cigarette smoking, changes in ambient atmospheric pressure, family history, mitral valve prolapse and Marfan's syndrome [3-7].

Treatment for first episode PSP includes simple observation, bed rest and oxygen supplementation, chest tube drainage, manual aspiration and surgical intervention depending on clinical presentation and severity [8]. Drainage tubes are available in small (< 14 F), medium (16 to 22 F) and large sizes (24 to 36 F). Small caliber chest tubes (pigtail catheters) have been used successfully to treat pneumothoraces since 1986 [9-12]. Liu et al previously reported that pigtail drainage of primary spontaneous pneumothorax appears to be a safe and promising technique, leads to less ambulatory limitation and produces fewer complications than large-bore chest tube thoracotomy [13].

Chest ultrasound has been shown to be valuable for the evaluation of a wide variety of chest diseases, particularly when the pleural cavity is involved [14]. Ultrasound has been reported to be even more accurate than plain radiograph and computed tomopgraphy in detecting pneumothorax [15,16]. It is recommended that tubes or drains be placed in a low position for drainage of pleural fluids and placed in a high position for drainage of air. However, we have successfully treated many PSP patients via pigtail catheters placed in a low position. The purpose of this report was to investigate whether different positions of ultrasound-guided pigtail drainage for treating PSP would influence the treatment results. This is the first study using ultrasound-guided pigtail drainage for treating PSP and is the first study to compare different positions of chest tube drainage in a homogenous group of patients with first episode PSP.

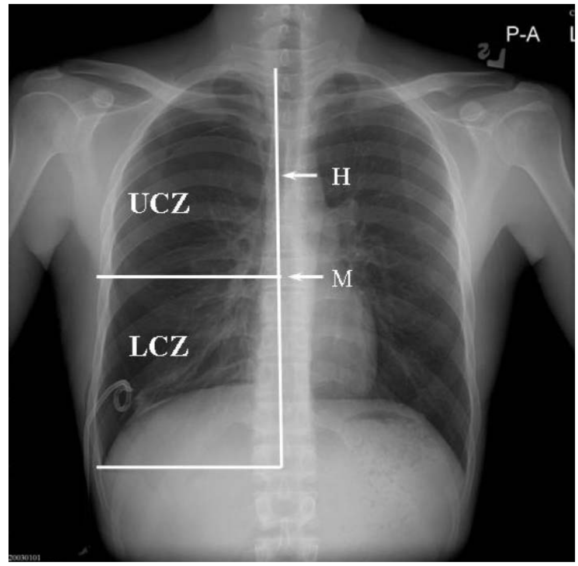

Fig. 1. Chest radiograph shows right side pneumothorax with pigtail tube drainage in the lower chest zone. LCZ was defined as the lower half of the hemithorax. H = height of hemithorax; M = mid-point of height of hemithorax; UCZ = upper chest zone; LCZ = lower chest zone.

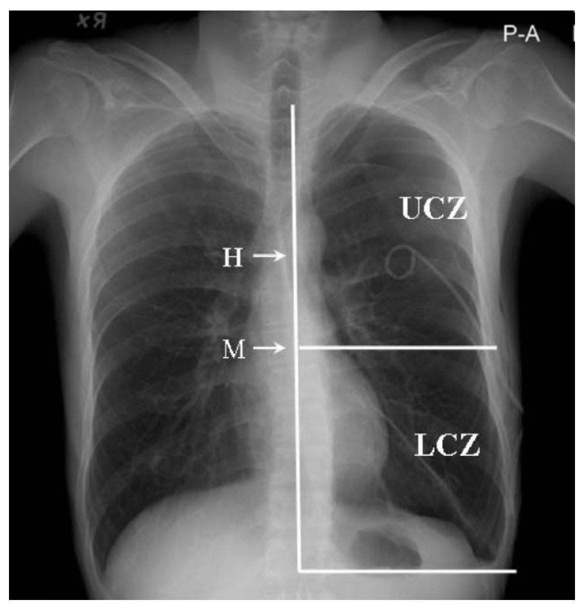

Fig. 2. Chest radiograph shows left side pneumothorax with pigtail tube drainage in the upper chest zone. UCZ was defined as the upper half of the hemithorax. UCZ = upper chest zone; LCZ = lower chest zone.

MATERIALS AND METHODS

Patient selection

Patients with a documented first episode of primary spontaneous pneumothorax were considered eligible for inclusion [17] if they were symptomatic (chest pain, dyspnea) [18] and if the size of the pneumothorax was greater than 20% as estimated by Light's formula (estimated percent of pneumothorax = $(1 - L^3/H^3) \times 100$, where H =

Table 1. Clinical characteristics of pigtail drainage of primary spontaneous pneumothorax from the upper chest zone (n = 33) and lower chest zone (n = 117)

	Upper chest zone	Lower chest zone	*p*
Age	25.88 ± 9.3	24.58 ± 10.1	0.31
Sex, M/F	23 / 10	99 / 18	0.41
Right/Left sided PTX	18 /15	49 /68	0.52
BMI (kg/m^2)	18.7 ± 4.3	19.2 ± 2.1	0.67
Smokers, n (%)	29 (87.9)	106 (90.6)	0.43
Chest pain, n (%)	29 (87.9)	102 (87.2)	0.56
Dyspnea, n (%)	5 (15.2)	22 (18.8)	0.65
Size of PTX (%)	49.3 ± 26.2	51.8 ± 24.5	0.47

M/F = male/female; BMI = body mass index; PTX = pneumothorax. Age, BMI and size of PTX were expressed as mean ± standard deviation. The size of PTX was calculated using Light Index.

diameter of the hemithorax, and L = diameter of the collapsed lung) [19]. Exclusion criteria were the presence of underlying lung disease, a history of previous pneumothorax, and tension pneumothorax. After informed consent was obtained, and after confirmation of absence of exclusion criteria was made, 150 consecutive patients presenting with PSP at the China Medical University Hospital (a tertiary care academic hospital in Taichung, Taiwan) from January 1997 to December 2003 were included.

Definition of upper chest zone and lower chest zone

Using the base of the diaphragm as a reference point, we measured the height of the hemithorax (H) and then divided it into two zones by the mid-point (M) of the height of the hemithorax. The mid-point of the height of the hemithorax was the boundary between the upper and lower chest zones. Lower chest zone (LCZ) was defined as the lower half of the hemithorax (Fig. 1). Upper chest zone (UCZ) was defined as the upper half of the hemithorax (Fig. 2).

Pigtail insertion procedures

Chest ultrasound was performed before chest tube insertion to reconfirm the absence of the "gliding sign", characteristic of pneumothorax [20]. Ultrasound was also used to determine whether there were any visceral organs (liver, spleen or heart) near the puncture sites. All of the procedures took place while patients were in a seated position. After skin disinfection, field preparation and local anesthesia with 2% lidocaine, a small-caliber soft polyurethane chest tube (12 French; SCATER, PBN MEDICALS, Denmark) was introduced through the anterior midclavicular second interspace, or at the posterior axillary line from the sixth to eighth interspace. The drain was connected to a Heimlich valve and a plastic bag. A chest X-ray was taken immediately after the procedure and repeated when air leakage had ceased. The pigtail tube was removed and the patient was discharged if lung expansion was complete. If air leakage persisted for more than 7 days, a second chest X-ray was taken and further intervention (eg, thoracoscopy, thoracotomy) was considered if the lung had not expanded.

Study end-points

Primary end-points were 1-week success rate and 1-year recurrence rate for both treatment groups. One-week success was defined as complete lung expansion followed by chest tube removal within 7 days after insertion of the first tube. One-year recurrence was defined as the presence of recurrent pneumothorax at 1-year follow-up. Secondary end-points were complications, length of hospitalization and duration of pigtail intubation. Complications of the procedure included subcutaneous hematoma and hemothorax.

Statistical analysis

Demographic and descriptive data are presented as means ± SD and were compared by the two-tailed Student *t* test. Categorical variables

Table 2. Comparison of success rate, recurrence rate, duration of pigtail intubation and complications of pigtail drainage between upper chest zone (n = 33) and lower chest zone (n = 117)

	Upper chest zone	Lower chest zone	*p*
One-week success rate, n (%)	26 (78.8)	88 (75.2)	0.67
One-year recurrence rate, n (%)	4 (12.1)	22 (18.8)	0.37
Duration of pigtail intubation	4.1 ± 1.8	4.2 ± 2.1	0.64
Length of hospital stay	6.8 ± 2.8	6.1 ± 2.1	0.34
Complications, n (%)	1 (3)	3 (2.6)	0.44

Length of hospital stay and duration of pigtail intubation were expressed as mean ± standard deviation (days).

were compared by the chi-square test (SAS stastical software version 6.12 for Windows). The level of significance was fixed at $p < 0.05$.

RESULTS

In the study group, 117 patients underwent lower chest zone (LCZ) and 33 patients underwent upper chest zone (UCZ) pigtail drainage to treat primary spontaneous pneumothorax. Patient characteristics for each group are listed in Table 1. There were no differences between the groups in gender, age, pneumothorax size, smoking status, body mass index, affected side or symptoms.

Study end-point analysis results are shown in Table 2. There was no significant difference between the two groups in one-week success rate, one-year recurrence rate, length of hospital stay or complication rate. Patients in whom pigtail catheter drainage failed subsequently underwent large-bore chest tubes or VATS with pleurodesis. Recurrence rates at one-year follow-up were 22 out of 117 (18.8%) in the LCZ group and 4 out of 33 (12.1%) in the UCZ group (p = 0.37). Recurrences were treated by thoracoscopy with endo-stapling. Complications included subcutaneous hematoma and hemothorax. The complication rates were 2.6% (n = 3) in the LCZ group (subcautenous hematoma (n = 2) and hemothorax (n = 1)), and 3% in the UCZ group (subcutaneous hematoma (n = 1)).

DISCUSSION

We previously compared traditional chest tube thoracostomy with pigtail tube drainage to treat spontaneous pneumothorax. No statistical significance was found in the mean hospital stay, evacuation rate, and total cost between pigtail tube drainage and traditional chest tube thoracostomy in treating PSP [13]. In the present study, we classified patients according to the position of pigtail insertion, and compared the outcomes between the two groups. We also compared duration of pigtail intubation, complications, and hospital stay between the UCZ and LCZ groups.

No significant difference was found between the two groups in treatment outcomes, including success rate, recurrence rate, length of hospital stay, and duration of pigtail intubation. The length of hospital stay was 6.1 ± 2.1 days in the LCZ group and 6.8 ± 2.8 days in the UCZ group (p = 0.34). Our results are in contrast to those reported in other studies, which showed a mean duration of hospitalization of 4 days, (range, 3 to 6) [21,22]. However our duration of pigtail intubation was 4.2 ± 2.1 days in the LCZ group and 4.1 ± 1.8 days in the UCZ group (p = 0.64). The physicians in our hospital are used to observing patients in hospital for 1 to 2 days after pigtail tube extubation; this may explain why hospitalization in our study was longer than in other studies.

Chest ultrasound has been reported to be valuable for the evaluation of a wide variety of chest diseases, particularly when the pleural cavity is involved [14]. It has been shown to be more accurate than plain radiograph and computed tomopgraphy in detecting pneumothorax [15,16]. However, no previous study has proposed ultrasound-guided chest tube insertion to treat pneumothorax. We used the absence of "gliding sign" on ultrasound image to reconfirm the diagnosis of pneumothorax and then performed ultrasonographic scan along the posterior axillary line from the sixth to eighth interspaces to locate the most adequate insertion sites. Furthermore, we used ultrasound to locate the visceral organs before insertion of the catheter to prevent penetration injury by chest tube insertion. There are a few advantages of inserting the chest tube through the lower interspaces at the posterior axillary line: first, the chest wall in the lower thorax is thinner than in the upper thorax; therefore chest tube insertion in the lower thorax may cause less soft tissue injury. Second, there are no great vessels adjacent to the posterior chest wall. The anterior chest wall approach poses a higher risk for penetrating great vessels. Third, chest tube insertion from the back reduces cosmetic problems, especially in women.

One of the criticisms of this study might be that it was a retrospective analysis, and that it does not accurately document the recurrence rate. The one-year recurrence rate was 18.8% in the LCZ group and 12.1% in the UCZ group; both of them were lower than those reported in a previous study [22].

This is the first study using ultrasound-guided chest tube drainage to treat primary spontaneous pneumothorax (PSP); it is also the first study to compare different catheter insertion sites in a homogenous group of patients with first episode PSP.

In conclusion, ultrasound-guided pigtail catheter insertion site dose not affect one-week success rate, one-year recurrence rate, complication rate, or hospital stay in patients with PSP.

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比較超音波導引豬尾導管在上下胸域引流原發性自發性氣胸

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目的　我們發現以超音波導引豬尾導管置放在下胸域可以成功地治療原發性自發性氣胸。這個研究將探討從上胸域引流原發性自發性氣胸是否和從下胸域的引流一樣有效。

方法　從六年來連續150位以豬尾導管作爲初步治療第一次發生原發性自發性氣胸病患的回溯性病歷分析。所有納入的病患在置入豬尾導管前先執行胸部超音波。根據胸部X光片豬尾導管的置放位置，我將把這些病患分成兩組。有33位病患從上胸域引流氣胸而有117位病患從下胸域引流。上胸域的定義爲胸廓中線以上，而下胸域爲胸廓中線以下。

結果　一週的成功率在下胸域組117位中有88位(75.2%)，在上胸域組33位中有26位(78.8%)（$p = 0.67$）。至少追蹤一年的復發率分別在下胸域組117位中有22位(18.8%)以及上胸域組33位中有4位(12.1%)（$p = 0.37$）。而對於住院時間、豬尾導管以及併發症的進一步的分析，在兩組間顯示沒有統計學上明顯的差異(全部$p > 0.05$)。

結論　原發性自發性氣胸病患經超音波導引的豬尾導管置入部位不影響一週的成功率、一年的復發率、併發症和住院時間。（中台灣醫誌 2006;11:90-6）

關鍵詞

胸部超音波，原發性自發性氣胸，豬尾導管

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