Outcome of Ultrasound-Guided Small-Bore Catheter Drainage in Exudative Pleural Effusions

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Objective: *To evaluate the outcome and safety of ultrasound-guided percutaneous catheter drainage of exudative pleural effusion.*
Material and Method: *The present study was a retrospective analysis of 412 pleural effusions from 373 patients that underwent ultrasound-guided small-bore catheter drainage in exudative pleural effusions between 2004 and 2009.*
Results: *The two most common causes for drainage were parapneumonic effusion or empyema (52.2%) and malignant effusion (30.3%), while the remains were trauma, iatrogenic, and others. Overall clinical success rate was 76.5%. The success rate was lower among malignant pleural effusion (p = 0.003). Causes of effusion were the only independent predictors related to success. Only five (1.2%) patients developed complication during the procedure. Seventy-five of 412 effusions (15.8%) developed complication during the period of drainage; the majority were drain blockage (9%) and accidental dislodgment (4.1%)*
Conclusion: *Ultrasound-guided small-bore catheter drainage was a safe and efficient procedure for exudative pleural effusions.*

Keywords: *Pleural effusion, Small-bore catheter, Outcome, Chest drain*

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Malignancy and infection are two common causes of exudative pleural effusions. Chest tube drainage is recommended to improve the symptoms and prevent complications. Large-bore catheters have been used for a long time. However, the overall complication rate was up to 30%[1,2], and technical complications such as diaphragmatic perforation, lung laceration, liver laceration, and esophageal perforation can occur[3-5].

Imaging-guided small-bore catheter insertion has become popular. The evidence to date showed that it is a safer and more effective alternative to conventional intercostal drainage using large-bore catheters[6-11]. However, there are few studies reporting a relatively large series[6,10].

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The purpose of the present study was to evaluate the outcome and safety of ultrasound-guided percutaneous catheter drainage of exudative pleural effusion in a large number of patients.

Material and Method

Patients

The Ethics Committee of the Faculty of Medicine, Prince of Songkla University, approved the retrospective study. The electronic medical records of all patients, except those referred from other hospitals, whom underwent ultrasound-guided small-bore catheter drainage of exudative pleural effusion at the Department of Radiology, Songklanagarind Hospital, between January 1, 2004 and December 31, 2009 were reviewed. Data collected included demographic information, size and number of catheters, ultrasonographic appearance of pleural effusions, prior large-bore chest tube insertion, duration of catheter insertion, complication, and clinical success.

Light's criteria[12] were used to classify the type of effusion as exudate. The definition of

complicated parapneumonic effusion or empyema was based on the indications for drainage of the American College of Chest Physicians (ACCP)[13].

For ultrasonographic appearance, loculations were defined as fixed pockets in the pleural space. Internal septations were defined as stranding fibrin or floating septa within the pleural effusions.

Procedure

In Songklanagarind Hospital, most patients underwent ultrasound-guided small-bore catheter drainage of pleural effusion by experienced interventional radiologists or residents who performed the procedure under the supervision of attending interventional radiologists. All patients had radiologically proven pleural diseases, and real-time ultrasound was used to locate the puncture site and guide the catheter insertion for all drainages. Ultrasonography was usually used for catheter insertion guidance, except for difficult cases, the drains were inserted under computed tomography guidance. Under local anesthesia and under imaging control, an 18-gauge sheathed needle was inserted into the effusion. A small amount of pleural fluid was aspirated for laboratory analysis. Then catheter was inserted by using the Seldinger technique[14]. If there were loculations not drained by the first catheter, more catheters were inserted immediately or during the follow-up period. Eventually, the catheters were connected to a 1-way valve drainage bag with or without low-flow suction, and most of the catheters were fixed to the skin using sticking plaster. During the period of drainage, regular flushing was not routinely performed in our institute. However, when catheter blockage was suspected, about 10 ml of normal saline solution was used to flush the catheter until patency was restored.

The size of the pigtail catheters used ranged from 8 to 14 French, depending on the fluid viscosity. A larger bore (12-14 F) was preferred by the operator in cases of empyema and complex septated effusion, whereas a smaller bore chest drain (8-10 F) was used in anechoic, non-septated effusion.

Clinical success was defined as improvement in the effusion clinically or by radiographic findings, and there were no further interventions including large-bore chest tube insertion or surgery.

Complications, including hemothorax, pneumothorax, organ perforation, kink, or obstruction of catheters, disconnection or dislodgment of catheters and infected insertion sites were recorded.

Statistical analysis

Continuous variables were reported as mean ± SD and compared across outcome groups using t-test. Categorical variables were reported as number and percent and compared using Chi-squared test or Fisher's exact test as appropriate.

Multivariate logistic regression analysis was used to identify variables that were independently associated with success. The type of effusion and other variables yielding a p-value <0.2 in univariate analysis were included in the initial model, which was refined by stepwise removal of non-significant variables, guided by the change in log-likelihood of successive models. Variables were retained in the final model if their contribution to the fit of the model was significant at $p<0.05$.

The times to remove the catheters were compared across categories of potential predictor variables including success status using Kaplan-Meier analysis and log-rank test. Statistical significance was set at $p<0.05$.

All analyses were conducted using Stata for Mac, version 12.1 (StataCorp, College Station, Texas).

Results

Patient characteristics

Four hundred twelve effusions from 373 patients were analyzed. Of the 373 patients, 32 had bilateral pleural effusions. For the 412 effusions, 438 catheters were used. Twenty-four effusions required two catheters and one effusion required three catheters. Most (203/412, 49.3%) drains were size 10F (range, 8F-14F). Ninety-four effusions (22.8%) had undergone previous conventional large-bore chest tube drainage and failed to respond. The mean ± SD age of the study population was 54±19 years. Catheters remained in place for one to 69 days (median 10 days). The two most common causes for drainage were parapneumonic effusion or empyema (52.2%) and malignant effusion (30.3%) (Table 1).

Table 1. Causes of exudative pleural effusion

Cause	No. of patients (%)
Parapneumonic effusion	215 (52.2)
Malignant effusion	125 (30.3)
Trauma	13 (3.2)
Iatrogenic	9 (2.2)
Others	50 (12.1)

The ultrasonographic appearance of 185 cases (44.9%) had no loculation and 260 cases (63.1%) had no internal septation. Of 412 effusions, 20 cases had no documented ultrasonographic appearances and included seven cases of loculation and 13 cases of internal septation.

Effectiveness

The overall clinical success rate of small-bore chest drain was 76.5%. Clinical success rates broken down by demographic and clinical variables are summarized in Table 2. The success rate was lower among malignant pleural effusion (68%) and higher among effusions resulting from trauma (92.3%) compared to other diagnoses. There was a statistically significant difference between these groups ($p = 0.003$). Effusions with internal septation had a slightly lower success rate (71.2%). However, there was no statistically significant difference ($p = 0.13$).

Three variables were included in the initial multivariate model, causes of effusion, internal septation, and number of catheters. After model refinement, only malignancy had a lower success rate (odds ratio 0.611, 95% CI, 0.373-1.001) (Table 3).

Complications

Five patients (1.2%) developed complications during the procedure; three developed pneumothorax and one developed hemothorax. One patient who had leukemia and a low platelet count developed hemothorax and died. No hollow organ perforation occurred.

Seventy-five patients (15.8%) developed complications during the period of drainage. The majority of complications were drain blockage (37/412, 9.0%) and accidental dislodgment (17/412, 4.1%). Other complications included disconnection of tubing (0.5%), kink of catheter (0.7%), skin infection (0.7%) and others (1.5%) such as pain, retained suture material, and superimposed infection.

Discussion

Imaging-guided percutaneous transthoracic drainage of pleural effusion using a small-bore catheter

Table 2. Characteristics of patients in success and failure groups of small-bore catheter drainage

Patient characteristics	Failure (n = 97), n (%)	Success (n = 315), n (%)	*p*-value
Age (years)	53.6±18.6	54.8±18.7	0.58
Gender, male	54 (20.6)	208 (79.4)	0.06
Causes of effusion			0.003*
Parapneumonic effusion	48 (22.3)	167 (77.7)	
Malignant effusion	40 (32.0)	85 (68.0)	
Trauma	1 (7.7)	12 (92.3)	
Iatrogenic	2 (22.2)	7 (77.8)	
Others	6 (22.0)	44 (88.0)	
Loculation			0.31
None	46 (24.9)	139 (75.1)	
Loculation	48 (21.8)	172 (78.2)	
Unknown	3 (42.9)	4 (57.1)	
Internal septation			0.13
None	53 (20.4)	207 (79.6)	
Septation	40 (28.8)	99 (71.2)	
Unknown	4 (30.8)	9 (69.2)	
Catheter size			0.8
8	36 (22.2)	126 (77.8)	
10	52 (25.6)	151 (74.4)	
12	8 (20.0)	32 (80.0)	
14	1 (14.3)	6 (85.7)	
Number of catheters			0.41
1	94 (24.3)	293 (75.7)	
2	3 (12.5)	21 (87.5)	
3		1 (100)	

* Statistical significance, $p<0.05$

Table 3. Univariate and multivariate logistic regression analysis

Variable	Univariate		Multivariate	
	Odds ratio (95% CI)	*p*-value*	Odds ratio (95% CI)	*p*-value*
Causes of effusion				
Parapneumonic effusion	1	0.006	1	0.006
Malignant	0.611 (0.373-1.001)		0.611 (0.373-1.001)	
Other	2.012 (0.933-4.340)		2.012 (0.933-4.340)	
Internal septation				
No septation	1	0.062		
Septation	0.634 (0.394-1.019)			
Number of catheters				
1	1	0.133		
≥1	2.353 (0.689-8.036)			

* *p*-value from likelihood ratio test

has become popular. Ultrasound is the technique of choice to guide catheter insertion. Its advantages include absence of radiation, real-time ability, and portability[15]. The present study evaluated the outcome and safety of ultrasound-guided small-bore catheter drainage in exudative pleural effusions.

In the present study, the overall clinical success rate was 76.5%, similar to the previous studies[10]. Patients with empyema had success rate of 77.7%, similar to the findings of others[7,8,11] who reported success rates of between 72.2 and 92.5%. By contrast, two studies[6,9] reported high failure rates among patients with empyema between 74.2 and 80%. This may be explained by the use of only a single catheter in the later two studies. However, the present study was somewhat limited because of no evaluation of the effect of fibrinolysis.

The success rate in malignant cause of 68% was not only lower than the other conditions in the present study, but also lower than the success rates of 75.5 to 93.8% reported with malignant cause in other studies[6,10]. Malignant cause was also associated with a lower probability of success after adjustment for other variables. In the present study, most of the cancer patients were end-stage diseases and poor performance status. Therefore, the goal of ultrasound-guided small-bore catheter drainage for these patients was palliative treatment.

Ultrasound patterns were associated with the success rates in other studies[10,16,17]. As in the present study, a septated pattern was found to be associated with a lower success rate. Bore size was not found to be associated with success rate in the present study. In this institute, a larger bore catheter (12-14 F) was preferred in cases of empyema and complex septated effusion, whereas a smaller bore chest drain (8-10 F) was used in anechoic, non-septated effusion. This may be the reason why there was no statistical difference among the bore sizes. Because of this reason, the previous study also had the same results[10].

The process of inserting a small-bore catheter is a relatively safe procedure. Only 1.2% of patients in the present study developed pneumothorax or hemothorax. This was in contrast to the 7% of patients who developed major complications, including hemothorax, perforation of intra-abdominal or intrathoracic organs and diaphragmatic laceration, reported with large-bore chest tube insertions[3-5,18].

Our rate of drain blockage during drainage of 9% was consistent with the 7.5 to 12.9% reported elsewhere[6,9], whereas our rate of 4.1% of accidental dislodgment was somewhat lower than the 5.4% to 21% reported in other studies[6,19]. However, the retrospective data in the present study may had resulted in an underestimation of the actual complication rates.

As the present study was a retrospective analysis, information on all potential confounders may not be completed. It was possible that minor complications were unrecorded so that our reported complication rate might be underestimated.

In conclusion, ultrasound-guided percutaneous small-bore catheter drainage is a safe and effective method for management of pleural effusion. Malignant pleural effusion was the independent predictor of poor outcome of chest drain using small-bore catheters.

What is already known on this topic?

The evidence to date showed that imaging-guided small-bore catheter insertion is a safer and

more effective alternative to conventional intercostal drainage using large-bore catheters. However, there are few studies reporting a relatively large series.

What is this study adds?

The present study confirms that ultrasound-guided percutaneous catheter drainage of exudative pleural effusion is a safe and effective procedure, via the analysis of the large number of patients and in Thai population.

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Potential conflicts of interest

None.

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ผลลัพธ์ของการใส่สายระบายขนาดเล็กนำทางด้วยคลื่นเสียงความถี่สูงสะท้อนภาวะสารน้ำข้นในช่องเยื่อหุ้มปอด

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วัตถุประสงค์: เพื่อประเมินผลลัพธ์และความปลอดภัยของการใส่สายระบายขนาดเล็กนำทางด้วยคลื่นเสียงความถี่สูงสะท้อนภาวะสารน้ำข้นในช่องเยื่อหุ้มปอด

วัสดุและวิธีการ: เป็นการศึกษาย้อนหลังของผู้ป่วยที่มีสารน้ำในช่องเยื่อหุ้มปอดจำนวน 412 ข้าง จากผู้ป่วย 373 ราย ที่ได้รับการใส่สายระบายขนาดเล็กนำทางด้วยคลื่นเสียงความถี่สูง ตั้งแต่ พ.ศ. 2547 ถึง พ.ศ. 2552

ผลการศึกษา: สาเหตุ 2 อันดับแรกในการใส่สายระบาย คือ สารน้ำในช่องเยื่อหุ้มปอดที่เกิดตามหลังการติดเชื้อในปอด คิดเป็นร้อยละ 52.2 และสารน้ำที่เกิดจากการแพร่กระจายของมะเร็ง คิดเป็นร้อยละ 30.3 ส่วนสาเหตุที่เหลือ ได้แก่ จากอุบัติเหตุ ผลแทรกซ้อนจากการรักษา และอื่น ๆ อัตราความสำเร็จทางคลินิกโดยรวมคิดเป็นร้อยละ 76.5 โดยพบอัตราความสำเร็จต่ำในกลุ่มสารน้ำที่เกิดจากการแพร่กระจายของมะเร็ง ($p = 0.003$) โรคที่เป็นสาเหตุของสารน้ำในช่องเยื่อหุ้มปอดเป็นตัวแปรอิสระเดียวที่มีผลต่อตัวทำนายความสำเร็จ มีผู้ป่วยเพียง 5 ราย คิดเป็นร้อยละ 1.2 ที่เกิดผลแทรกซ้อนระหว่างทำหัตถการ การใส่สายระบายสารน้ำจำนวน 75 ข้าง คิดเป็นร้อยละ 15.8 เกิดผลแทรกซ้อนระหว่างคาสายระบาย โดยผลแทรกซ้อนส่วนใหญ่คือสายระบายอุดตัน คิดเป็นร้อยละ 9 และสายระบายหลุด คิดเป็นร้อยละ 4.1

สรุป: การใส่สายระบายขนาดเล็กนำทางด้วยคลื่นเสียงความถี่สูงมีความปลอดภัยและมีประสิทธิภาพสำหรับสารน้ำข้นในช่องเยื่อหุ้มปอด