

# Efficacy of ultrasound-guided thoracentesis catheter drainage for pleural effusion

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**Abstract.** The factors influencing the efficacy of ultrasound-guided thoracentesis catheter drainage were investigated in the present study. A retrospective analysis of clinical data from 435 patients who presented with a pleural effusion was performed. Patients were divided into a control group and an intervention group. Thirty-seven patients in the control group were given standard care using pleural puncture to draw the excess fluid. The 398 patients in the intervention group were treated using ultrasound-guided thoracentesis catheter drainage. The rate of successful drainage of a pleural effusion was significantly higher ( $P < 0.05$ ), while the rate of complication was lower, in the ultrasound-guided thoracentesis cases compared to standard care treatment. In conclusion, ultrasound-guided thoracentesis catheter drainage is an efficient, safe and minimally invasive procedure to alleviate pleural effusion. The efficacy of the procedure is related to the separation of pleural effusion, drainage tube type and tube diameter.

## Introduction

Pleural effusion is a relatively common complication that can result from many medical conditions such as congestive heart failure, pneumonia, cancer, liver cirrhosis and kidney disease (1-5). In clinic, the etiology is determined by specimens obtained from a series of thoracentesis (6,7), and therapy uses appropriate treatment after diagnosis and puncture drainage therapy (8,9). Over the years, the use of ultrasound-guided catheterization in the diagnosis and treatment of pleural effusion has increased, tending to replace the traditional puncture method (10-12).

From January 2013 to May 2014, 435 cases with different causes of pleural effusion were collected to treat with pleural

puncture drawing fluid and ultrasound-guided thoracentesis catheter drainage and analyzed.

## Patients and methods

**Patients.** In total, 435 patients with pleural effusion from January 2013 to May 2014 were included in the present study. The control group (group A) included 37 cases of pleural effusion that were treated using standard care pleural puncture to draw fluid. The intervention group (group B) included 398 cases of ultrasound-guided thoracentesis catheter drainage; 230 males and 205 females, with an average age of 60 years (range, 16-93 years). In the intervention group B, there were 140 separated pleural effusion cases (Fig. 1A) and 258 non-separated pleural effusion cases (Fig. 1B).

After approval of the Ethics Committee of Huashan Hospital of Fudan University and informed consent of patients or relatives were obtained, the cases were randomly divided into the control and intervention groups.

## Methods

**Instruments.** V730 GE ultrasonic diagnostic apparatus, thoracentesis package, disposable central venous catheter package (containing 16 G drainage tube; Shanghai Puyi Medical Instruments Co., Ltd., Shanghai, China), and SKATER drainage tube (Fig. 2) (including 6 and 8 F; Anjie Tai Medical Technology Co., Ltd.).

**Pleural puncture drawing fluid.** For ultrasound preoperative localization or percussion localization, the site was disinfected prior to conventional puncture site and draped locally. After lidocaine was used as the local anesthetic, thoracic puncture needle was slowly inserted into the skin from the puncture site along the rib edge. When there was a break, the syringe pump was used to pump pleural effusion (the first time  $< 600$  ml and  $\leq 1,000$  ml each time thereafter).

**Pleural puncture catheter drainage.** Ultrasonic localization and conventional disinfection drape was used. After lidocaine was used as the local anesthetic, thoracic puncture needle was inserted into pleural effusion under ultrasound guidance. A guide wire was used with the puncture needle to insert the drainage tube (central venous catheter or SKATER drainage tube) (Fig. 2), and the guide wire was then removed. The drainage bag was connected and the tube fixed on the body surface. Pleural effusion was drawn out periodically.

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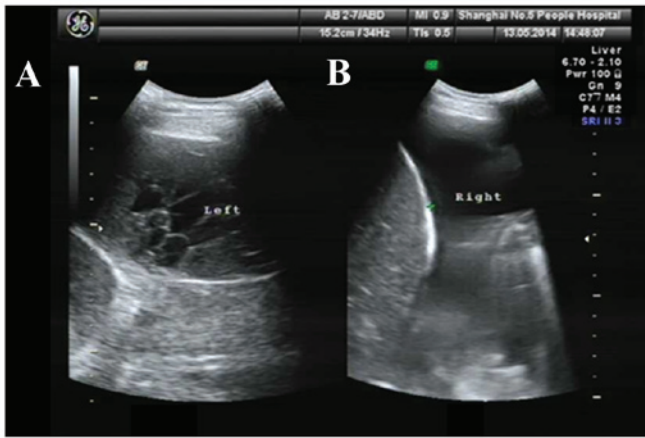


Figure 1. Ultrasound scan showing distinct pleural effusion types. (A) Separate and (B) non-separated pleural effusion.

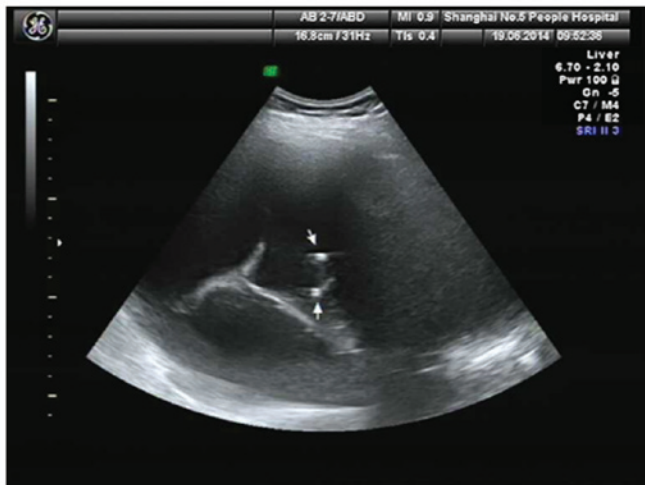


Figure 2. Ultrasound scan showing SKATER drainage tube in pleural effusion.

**Pleural effusion control criteria.** Complete remission (CR): Pleural effusion disappearing maintained at least 4 weeks. Partial remission (PR): Pleural effusion reduction was more than 50% and maintained 4 weeks. Stable remission (SR): Pleural effusion reduction was <50% without a decrease or increased trend. Progressive disease (PD): No reduction or a decrease or increased trend of pleural effusion. Overall effectiveness was calculated as, CR + PR.

**Statistical analysis.** SPSS 19.0 statistical software (Chicago, IL, USA) was used for statistical analysis. Measurement data were analyzed using a Student's t-test. Counting data are expressed as a  $\chi^2$  test. P<0.05 was considered to indicate a statistically significant difference.

**Results**

As shown in Table I, 37 patients in group A were treated with pleural puncture and fluid was drawn a total of 57 times and the disposable puncture success rate was 84% (48/57). CR was seen in 4 cases, and PR in 15 cases (overall effectiveness: CR + PR = 19 cases total). Furthermore, there were

Table I. Effectiveness and complication rates for standard care (group A) vs. ultrasound-guided thoracentesis (group B).

Groups	N	Overall effectiveness <sup>a</sup>	Complications	
			Pneumothorax	Pleural reaction
A	37	19	2	2
B	398	309	4	1
P-value		0.001	0.038	0.020

<sup>a</sup>Overall effectiveness (OR) = CR + PR + SR. CR, complete remission; PR, partial remission; SR, stable remission.

11 stable patients, and progression was observed in 7 patients. Complications were observed in 4 cases (2 cases of pneumothorax and 2 cases of pleural reaction).

In group B, 398 patients were treated with ultrasound-guided thoracentesis catheter drainage (419 total procedures) with a 100% success rate. CR was observed in 135 cases, PR in 174 cases, stable in 56 cases and progression in 33 cases (Table I). There were 5 complications reported (4 cases of pneumothorax and 1 case of pleural reaction); the drainage tube fell off in 8 cases and was obstructed in 11 cases.

In 258 cases of non-separated pleural effusion, central venous catheter was identified in 103 cases, 117 used 6F-SKATER drainage tube and 38 the 8F-SKATER (Table II). In 140 cases of separated pleural effusion, 18 were with central venous catheter, 50 using 6F-SKATER drainage tube, and 77 with 8F-SKATER.

**Discussion**

Numerous factors cause excess body fluid to collect in the pleural cavity to produce pleural effusion (13-17): An increase in the venous pressure of pleural capillaries, an increase of pleural permeability, and a decrease of colloid osmotic pressure of the pleural capillaries, lymphatic drainage barrier and damage.

Pleural effusion can be divided into transudate and exudate (18-21). The former mainly treats primary disease without repeated drainage, but draining of the pleural cavity is needed when the etiology is unknown, and drainage treatment should be done regardless of tuberculosis, tumor or purulence of exudate.

When excessive pleural effusion leads to dyspnea, both transudate and exudate need to be drained to improve breathing (22). Traditional puncture drainage operation requires is repeated, bringing suffering to patients many times, and increases the reaction of hemothorax, pneumothorax and pleura and the risk of infection (23). Traditional puncture drainage operation require repeated conduction and increases the chance of hemothorax, pneumothorax and risk of infection.

A pleural puncture tube can be drained repeatedly in one operation, reducing the risk of complications. In particular, the application of central venous catheters in pleural effusion has proven to be an effective, safe and economical method (24,25). The first and crucial step of thoracentesis is choosing a puncture point.

Table II. Influence of drainage tube on pleural effusion treatment success.

Case	16 G central venous catheter		6 F-SKATER drainage tube		8 F-SKATER drainage tube		P-value
	N	OR <sup>b</sup>	N	OR	N	OR	
Non-separation	103	89	117	100	38	34	0.822
Separation	13	5	50	26	77	55	0.018 (0.037 <sup>a</sup> )
P-value	0.000		0.000		0.034		

<sup>a</sup>Comparison of the therapeutic effect of 6 F and 8 F SKATER drainage tube in the separation of pleural effusion. <sup>b</sup>Overall effectiveness (OR) = CR + PR + SR. CR, complete remission; PR, partial remission; SR, stable remission.

There are three clinical methods for choosing a puncture point to treat pleural effusion: Blind puncture, ultrasonic locating of puncture and ultrasound-guided puncture (26,27). Blind puncture is used by clinicians to locate the puncture according to imaging data, experience and percussion; ultrasound puncture locates the puncture point via ultrasound, then clinicians continue to puncture the locating point back on the ward, and ultrasound-guided puncture is performed under real-time monitoring.

Ultrasound location often has associated problems, such as failure to puncture the exact ultrasound localization, or the pleural effusion drainage is not satisfactory (28). To ensure the safety of the puncture, clinicians mainly choose the effusion surface of largest area as a puncture point. However, after drainage, with the reduction of pleural effusion, lung recruitment or diaphragm elevation, the drainage tube area has no effusion, and the closeness to the pleura causes poor drainage and drainage is incomplete. The ultrasound-guided catheterization cannot only avoid the above factors, but can also guide and correct the placement of the drainage tube. Compared to the traditional thoracentesis, it has a lower incidence of pneumothorax and pleural reaction.

Pleural effusion caused by congestive heart failure and hypoalbuminemia is mostly transudate, which is low in protein content, with a few cells and good fluidity (29,30). While the exudate of tuberculous pleurisy and the malignant pleural effusion produced by malignancy invasion in pleura are high in protein content, with many cells, tending to form fibrous bands, separation and even honeycomb. The existence of separation reduces the fluidity of pleural effusion. Fibrous bands block the drainage, and interfere or limit the diffusion of drug injected in the thoracic cavity. Early drainage of separated pleural effusion is important, especially for tuberculous pleural effusion, to reduce adhesions between pleural and lung tissue or decrease pleural thickening (31,32). To achieve early recovery of lung function, the key is a clean drainage of pleural effusion on the basis of reasonable and standard anti-tuberculosis therapy.

Currently, thoracentesis catheter drainage is mainly via central venous catheter (24,25). It has the traits of flexibility and good tissue compatibility but is easily blocked. Some researchers believe that small-diameter drainage tubes (diameter,  $\leq 14$  F) have no effect on drainage (33), but the present study shows this is not always true. For a non-separated pleural effusion drainage tube, diameter has no effect on the drainage

efficacy, while for a separated pleural effusion drainage tube, diameter does affect drainage efficacy. Two kinds of drainage tubes were used: a central venous catheter and the SKATER drainage tube (34). The side aperture of central venous catheter is less than its diameter, and the drainage effect depends on the size of side holes. Central venous catheters of different diameter have small side holes, which are easily blocked by fibrous bands within separated pleural effusion, thus lowering efficacy. The SKATER drainage tube has an elongated side hole, whose diameter is greater than the drainage pipe, so its efficacy depends on the diameter of the drainage tube. Therefore, for a small-diameter drainage tube, in fibrous bands or separation within pleural effusion, the efficacy is related to the diameter. For a separated or potentially separated effusion like tuberculous pleural effusion, a drainage tube with a big side hole like SKATER should be used while a lower cost central venous catheter can be used for non-separated pleural effusions.

In conclusion, ultrasound-guided thoracentesis catheter drainage is an efficient, safe, minimally invasive procedure with a high rate of success. Its efficacy is related to the separation of pleural effusion, drainage tube type and tube diameter. The choice of the drainage tube should be based on the nature of pleural effusion, separation of pleural effusion and cost.

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