Percutaneous Catheter Drainage of Thoracic Fluid:
The Usefulness and Safety of Bedside Trocar Placement under Ultrasound Guidance[1]

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Purpose: The author wanted to evaluate the usefulness and safety of the trocar technique for US-guided bedside catheter placement into thoracic fluid collections, and this technique has generally been reserved for the larger or superficial fluid collections.

Materials and Methods: 42 drainage procedures were performed in 38 patients at the bedside. The patients were positioned supine or semi-upright. A drainage catheter system with a stylet and cannula assembly was used and all of the catheters were inserted using the trocar technique. The procedures consisted of drainage of empyema ($n=14$), malignant effusion ($n=13$), lung abscess ($n=3$), massive transudate ($n=8$), hemothorax ($n=2$) and chest wall hematoma ($n=2$). The clinical results were classified as successful (complete & partially successful), failure or undetermined. The medical records and images were retrospectively reviewed to evaluate the success rate, the complications and the procedure time.

Results: Technical success was achieved in all of the 42 procedures. With using the trocar technique, all the catheters were placed into even the small collections without significant complications. Drainage was successful in 36 (85.7%) of the 42 procedures. The average volume of thoracic fluid that was aspirated manually at the time of catheter placement was 420 mL (range: 35 to 1470 mL). The procedure time was less than 10 minutes from US-localization to complete catheter placement in all of the procedures.

Conclusion: The trocar technique under US guidance can be an efficient and safe alternative to the Seldinger or guide-wire exchange technique for bedside catheter placement in the critically ill or hemodynamically unstable patients.

Index words : Ultrasound (US), guidance
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With the advent of modern imaging modalities and the advances in interventional techniques, image guided percutaneous catheter drainage (PCD) has become a safe and effective alternative to traditional surgical therapy for collecting intrathoracic fluid, and this is now one of the most commonly performed procedures worldwide. Catheter placement can be performed using two different techniques: the Seldinger technique or the trocar technique (1). Although either the Seldinger or trocar techniques can be used, the former that uses puncture needles, guide wires and dilators has been regarded to be safe for most patients, while the latter has been reserved for the larger or superficial fluid collections due to the risk of incorrectly positioning the catheter and puncturing vital organs (1 - 3). Yet the author thought that the trocar technique can be more efficient as a bedside procedure because it needs fewer pieces of equipments and a short procedure time. So the author performed this study with using the trocar technique, regardless of the size and the location of the fluid collection. A few previous cases have been reported on that concerned trocar placement of catheters for draining thoracic fluid with using CT, fluoroscopy, ultrasonography or any combination of these modalities at radiology departments (4 - 6), but to the best of the author's knowledge, there have been no studies in the English medical literature that have analyzed the efficacy and safety of bedside trocar placement under only ultrasound guidance. This study was performed to evaluate the technical success rate, the procedure time, the procedure-related complications and the clinical efficiency of bedside trocar placement of drainage catheters for collecting thoracic fluid.

Materials and Methods

Patient Population

Between August 2003 and May 2005, 42 ultrasound-guided percutaneous drainage procedures were performed at the bedside of 38 patients in Seoul Medical Center (Table 1). The author performed these procedures on the hemodynamically unstable patients in the ICU, but the author also performed these procedures on patients who were too severely debilitated to be transported to the radiology unit, or on patients who should be isolated. The patients were 28 men and 10 women, and they ranged in age from 19 to 94 years. The absolute contraindications were limited to bleeding diasthesis (platelet count < 50,000/mm^3 and a partial thromboplastin time > 15 sec) and the inability to visualize the collection from the puncture site under ultrasound guidance.

The nature of the percutaneous drainage procedures is summarized in Table 1. The procedures were PCD of pleural fluid collections ($n=37$), lung abscesses ($n=3$) and chest wall hematomas ($n=2$). Multiple cases of transudate were drained when their volume reach a size that compromised the cardiac or respiratory function. Second drainage procedures were performed for two recurred malignant effusions, and for a recurrent massive pleural effusion in one patient with chronic renal failure. In one patient with empyema, the catheter spontaneously removed itself and a second drainage procedure was also required.

Drainage Procedure

The patients were positioned supine or semi-upright on the bed. The collections were localized with using ultrasonography only. A 8.5 French drainage catheter system with a stylet-cannula assembly (FleximaTM, Boston Scientific) was used, and all of the catheters were inserted using the trocar technique.

Once the collection site was localized with ultrasonography, the distance between the skin and the fluid collection was measured and the probe was removed. The skin was then anesthetized, and the initial fluid was aspirated with using same syringe for confirming the proper location. After a small incision was made, the catheter system was introduced into the fluid collection to the minimum depth where the fluid was expected to be. The inner stylet was then removed from the cannula and the fluid was aspirated to confirm the proper location of the catheter system. The outer catheter itself was then advanced over the stiffened cannula into the fluid. Once the catheter had been placed into the fluid collection, the fluid was manually aspirated until mild resistance was encountered. In the case of lung abscess drainage, a catheter was passed to the proper site using real time ultrasonographic guidance with a sterile glove-covered probe.

Catheter patency was maintained by flushing the catheter with a small amount of saline. The amount of drainage was easily determined by marking the fluid level on the collection chamber of the drainage apparatus. Daily chest radiographs assessed the size of the residual fluid, and the need for additional manipulations or alternative therapy was determined. Transcatheter instillation of urokinase was also performed in the cases of loculated or septated pleural effusions. For the patients whom we experienced failure to drain their malignant effusion, pleurodesis was not performed because of their short life expectancy. The catheters were removed when the drainage had diminished to less than 10 mL/day and radiographic resolution of the collection had occurred.

Evaluation of technical and clinical results

The author retrospectively evaluated the technical and clinical success rates, and the procedure-related complications. Technical success was defined as proper positioning of the catheter in the target space with proper drainage. The clinical success rates were evaluated according to the published quality assurance guidelines (7) and according to a modified version of the criteria suggested by Civardi et al. (8). Successful treatment of infected collections was defined by the complete resolution of infection that required no further operative intervention, and successful drainage of a noninfected fluid collection was defined as the complete evacuation of fluid with resolution of the pulmonary symptoms. For malignant effusion, when the patient died or was discharged with a well-functioning catheter, the result was classified as a 'partial response'. However, when the patient obtained no benefit from the procedure, the result was defined as a 'failure'. Finally, when the patient died or was discharged before the clinical response could be evaluated, or if the catheter spontaneously removed itself shortly after insertion, the response was defined as 'undetermined'

Results

Technical success was achieved in all 42 procedures. Under ultrasound guidance, the catheters were easily placed into even the small collections (less than 100 mL) with using the trocar technique. In one case of empyema, buckling of the cannula and the stylet assembly occurred during the direct puncture through the thickened pleura, but a new catheter system was then successfully introduced. We had one case of pneumothorax, but there were no significant complications in our cases such as bleeding from the intercostal arteries or inadvertent organ puncture.

Drainage was successful in 36 (85.7%) of 42 procedures (Table 1). The clinical response was 'complete' in 33 cases, 'partial' in 3, 'failure' in 5 and 'undetermined' in 1 (Table 2). Ineffective pleural drainage was the cause of all the failures. Of the 5 patients in whom the PCD failed, these included three patients with empyemas and two patients with malignant effusions. In one case classified as 'undetermined', a well functioning catheter spontaneously removed itself 2 days after insertion. The average volume of the manually aspirated thoracic fluid at the time of catheter placement was 420 mL (range: 35 to 1470 mL). The procedure time was less than 10 minutes from the time of ultrasound-guided localization to the time of complete catheter placement for all of the procedures. The duration of drainage ranged from 1 day to 44 days (mean duration: 5 days).

Empyema drainage

Thirteen patients underwent 14 catheter insertions for empyemas. Of these, 10 catheters were successfully inserted and they completely drained the empyemas. One

Table 1. The Nature of the Percutaneous Drainage Procedures We Performed (the Numbers in Parentheses are the Numbers of Patients)

Cause of Procedure	Number of Cases
Infected pleural fluid collection	
Tuberculous empyema (10)	10
Nontuberculous empyema (3)	4
Noninfected pleural fluid	
Massive Transudate (7)	8
Malignant effusion (11)	13
Hemothorax (2)	2
Parenchymal infection	
Lung abscess (3)	3
Chest wall collection	
Traumatic hematoma (2)	2
Total (38)	42

Table 2. Clinical Response in the US Guided Drainage Procedures (the Numbers in Parentheses are the Numbers of Cases)

Drainage	Successful		Failed	Undetermined
	complete	partial		
Pleural collection (37)				
Empyema	10	0	3	1
Transudate	8	0	0	0
Malignant effusion	8	3	2	0
Hemothorax	2	0	0	0
Parenchymal infection (3)				
Lung abscess	3	0	0	0
Chest wall collection (2)				
Traumatic hematoma	2	0	0	0
Total (42)	33 (78.6%)	3 (7.1%)	5 (11.9%)	1 (2.4%)

patient had two catheter insertions placed because the first catheter spontaneously removed itself 2 days after insertion, and this case was classified as 'undetermined'. In the 3 cases of empyema that were classified as 'failure', the failures occurred in the late fibrinopurulent stages, and two of the three cases had a chest tube inserted as an additional drainage procedure.

Therapeutic drainage of noninfected pleural fluid

All 9 patients achieved successful therapeutic drainage of their non-infected pleural collections. The etiologies included chronic renal failure, peritoneal dialysis fluid ascending through the diaphragmatic pore, chest trauma and uremic hemothorax. The amount of fluid that was removed ranged from 700 mL to 2100 mL (average: 1300 mL). One patient in this group had the procedure done two times because of recurring transudate that was due to chronic renal failure.

Lung abscess and chest wall hematomas

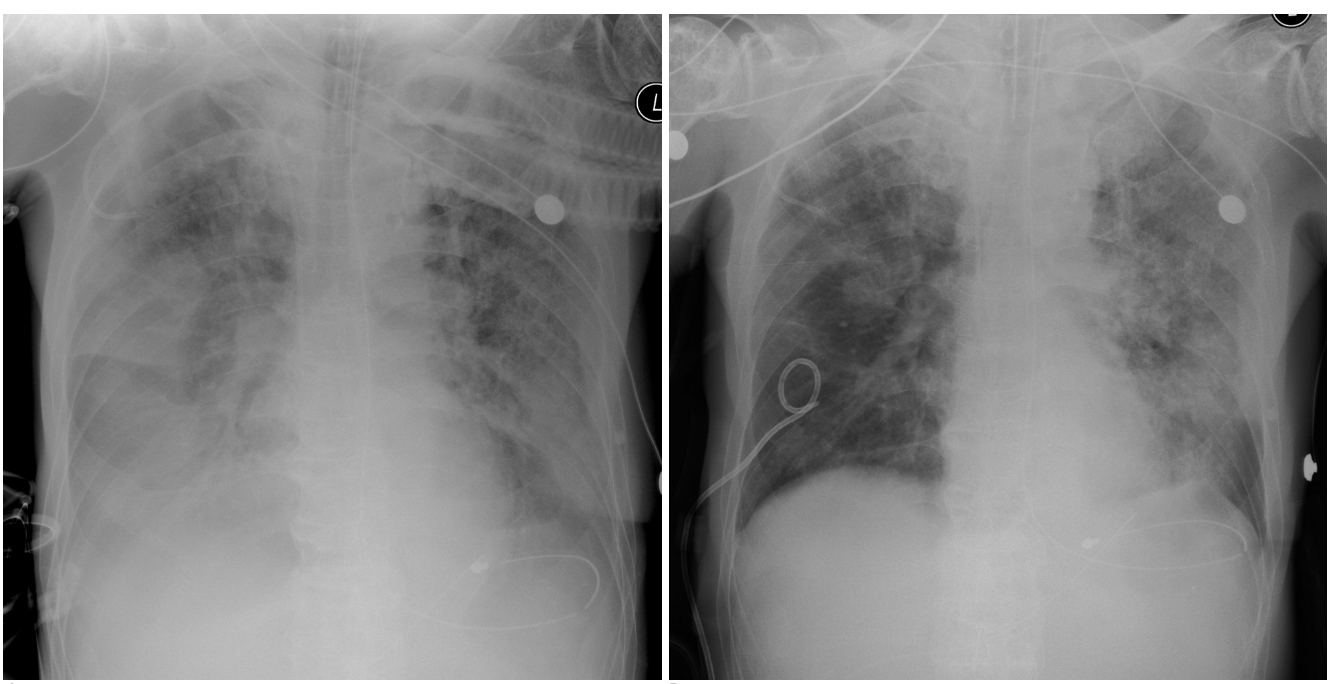
All 3 patients achieved successful therapeutic drainage of their lung abscess under real time ultrasonographic guidance. The clinical response was 'complete' in all cases and there were no major complications such as pneumothorax, bronchopleural fistula and hemorrhage. 2 patients with chest wall hematomas underwent successful catheter drainage. The etiologies were traffic accident trauma in one patient and heparin-induced hemorrhage in the other patient who was suffering with chronic renal failure.

Malignant pleural effusion

Eleven patients underwent 13 catheter drainage procedures for malignant effusions. Two patients had second catheter insertions done because of recurrent effusions after the first successful drainages. We regarded these second drainage procedures in these 2 patients as success. Of these 13 catheter placement, 11 catheters successfully drained the effusions (84.6%) (Fig. 1). Failures occurred in 2 patients due to the lack of symptomatic improvement without adequate drainage.

Discussion

Percutaneous drainage is a well-established therapeutic technique and it is one of the most commonly performed procedures worldwide (1). Although fluoroscopy, ultrasonography, CT or any combination of these techniques can be used to accurately guide the placement of a drainage catheter, ultrasonography has



A B

Fig. 1. A 77-year-old male with malignant effusion in the right pleural cavity.
A. The chest radiograph demonstrated a massive pleural effusion of the right pleural cavity. CT scans showed tumor infiltration and collapse of the right lower lobe (not shown).
B. A drainage catheter was inserted. A chest radiograph taken after drainage showed no residual pleural fluid collection.

gained popularity for guiding pleural and thoracic fluid drainage for several reasons, including the technique's good manageability, portability and real-time capabilities, and the absence of ionizing radiation (2, 3). Furthermore, ultrasonography has its greatest value in guiding drainage procedures at the bedside of critically ill patients (3). These portable drainage procedures include cholecystostomy, nephrostomy and drainage of various body fluid collections (1). Thoracic fluid drainage can also be performed at the bedside via portable ultrasonographic guidance for the critically ill, hemodynamically unstable patients, and this includes patients in the intensive care unit (ICU) (2, 3, 9).

Catheter placement can be performed using two different techniques: the Seldinger technique or the trocar technique (1). In the Seldinger technique, which is also called the guide wire exchange technique, a puncture needle is inserted into the fluid and a guide-wire is advanced into the fluid through the needle. The needle is then removed and the guide-wire serves as both anchor and guide as progressively larger dilators are passed over the guide-wire to prepare the tissue for the passage of a catheter and cannula assembly (or simply a catheter). A catheter is then passed over the guide-wire and the guide-wire is removed, allowing the distal loops of the catheter to form that secure it in the fluid collection. The trocar technique uses a catheter mounted over a stiffened cannula, which has a sharp inner stylet, and they are both inserted into the collected fluid as a unit. The stylet is removed to allow fluid aspiration and to confirm the location of the catheter tip, and then the cannula is removed, allowing the distal loop of the catheter to form and so secure the catheter in the collected fluid.

Although either the Seldinger or the trocar technique can be used, the former has been regarded to be safe in most patients; the latter has generally been reserved for the larger or more superficial fluid collections due to the risk of incorrect catheter position and puncture of vital organs (1 - 3). The author performed 42 drainage procedures in 38 patients with thoracic fluid collections. However, all of the catheters were inserted using the trocar technique at the bedside of our study population, regardless of the size and location of the fluid cavity, because we hold that the trocar technique is simpler, more convenient and it can save time without the necessity of using exchange guide wires and dilators. The author also expected that the trocar technique can be the more useful and acceptable method when drainage is performed at the bedside for ICU patients or hemodynamically unstable patients. For the bedside procedures, because of the large amount of life-support equipment, i.e., monitoring devices, ventilators, infusion pumps and IV lines, the space for handling exchange guide wires and dilators is severely limited, and the risk of contamination during catheter placement can be increased with using the Seldinger technique. Besides that, manipulation and placement of the guide wire for a Seldinger insertion can not be observed without fluoroscopic guidance, and problems with catheter exchange may not be detected until an ultrasonogram is obtained.

The author drainage procedures resulted in an overall success rate of 86.7%. Success in our study was measured by complete evacuation of the thoracic fluid, so that the pulmonary symptoms resolved themselves and more invasive procedures could be avoided. For the cases of empyema, the success rate was 71.5%, and the success rate was 92% for the 25 cases of therapeutic drainage of noninfected pleural collection. These results compare favorably with the reported success rates of catheter treatment that have ranged from 72 - 88% for empyema and 62 - 92% for malignant effusion, although these pervious studies were performed using both techniques and various modalities for image guidance in the radiology unit (4 - 6). Ideally, our study should have included another group of similar patients who were treated with the Seldinger technique for comparing the potential advantages or disadvantages of the trocar technique. But this type of randomized trial between the two techniques was not possible because the trocar placement technique had been planned for the relatively more severe patients in our study. So, the author used the data from established quality improvement guidelines to compare results between our study and the other studies in the medical literature (7).

For draining lung abscess, some investigators have reported that the trocar catheter insertion technique through the point of contact of the abscess with the pleural surface can be safely performed under CT guidance because the abscess induces the local pleural symphysis in this region (2). Yet the author was able to place drainage catheters under US guidance into the 3 selected patients suffering with lung abscesses when there were safe windows for accessing the abscesses. In these cases of lung abscess drainage, catheters were successfully placed using real time ultrasonographic guidance with a sterile, glove-covered probe. Drainage of lung abscesses is similar in most aspects to empyema drainage in terms of instruments, technique, results and complications (10). However, an important caveat is not to transgress the normal lung to gain access to the abscess. The path should traverse the contaminated pleura and so enter the abscess where it comes closest to the pleura (10).

The procedure time was less than 10 minutes from fluid localization to complete catheter placement for all of the procedures in our series. Kang et al (11) performed bedside percuteneous drainages of various body fluids with the Seldinger technique under ultrasound guidance; they reported the procedure time to be less than 1 hour in all cases. Rapid catheter placement is one of the benefits of the trocar technique, and this feature is useful for the un-cooperative and/or unconscious patients.

The reported complication rate of image-guided thoracic drainage procedure is low, i.e., less than 2 percent (12, 13). But the possible complications include bleeding due to injury to the intercostal vessels, and pneumothorax (2, 6). The most significant, although fortunately rare, complication is cardiopulmonary arrest during catheter placement and also transient bacteremia (6, 14). In our cases, there were only two complications in the 42 procedures (4.8%). In one case, pnuemothorax occurred after empyema drainage, and this was probably secondary to external air entering into the pleural cavity through the side holes outside the pleural cavity. Also, one episode of buckling of the stylet/cannula assembly occurred during direct insertion into the pleural cavity; this was due to the patient's markedly thickened pleura. However, a new catheter was then employed and successfully inserted. All of the catheters were placed using the trocar technique and only ultrasonography was used as a guide to plan a safe transthoracic route for catheter placement, but with determining the precise location of the collection and the correct catheter axis, and also with measuring the depth to the fluid, most of the catheters were easily, safely placed even into the small collections. So the author concluded that almost all complications could be avoided by doing meticulous imaging and planning, and by having the catheter approach over the top of a rib, and in cases of small collections, by using real time ultrasonographic guidance.

Some investigators (4) have suggested that the trocar method is superior to the Seldinger technique for several reasons in selected cases. First, the use of exchange guide wires and dilators when performing the Seldinger technique may allow introduction of air and induce a resultant pneumothorax. Second, they found it difficult to advance a catheter intercostally through the thickened pleura without buckling the guide wire or the catheter. Third, the Seldinger technique has an additional difficulty that is caused by the lack of fluoroscopic assistance when performing bedside insertions. We also found that trocar placement can be the more effective technique for draining thoracic fluid than for draining intra-abdominal fluid or any other body fluid collection because the thoracic rib cage can play a role as a buttress for the chest wall; thus, the chest wall can't be pushed inward by directly inserting the catheter into the thoracic fluid.

In summary, drainage catheters were safely placed into collections of thoracic fluid with the trocar technique with using just ultrasound guidance. Yet there was no significant difference in the success rate between our cases and the other image guided procedures using the Seldinger technique in the radiology unit. Furthermore, we found the trocar technique to be more efficient, and especially at the bedside, due to the short procedure times and the overall need for fewer pieces of equipment to complete the drainage. So, the author think the trocar technique can be a simple and convenient alternative to the Seldinger technique, and especially for performing bedside catheter placement in the critically ill and unstable patients.

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경피적 흉부도관 배액: 병실에서 시행된 초음파 유도하 트로카(trocar)도관 배액술의 유용성과 안전성[1]

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이 헌

목적: 흉수 배액을 위하여 병실에서 시행된 초음파 유도하 트로카(trocar) 도관 삽입술의 유용성과 안전성을 평가하고자 한다.
대상과 방법: 38명의 환자에게 42 예의 경피적 도관 배액술을 시행하였다. 대상은 농흉 14예, 악성흉막삼출 13예, 폐농양 3예, 대량의 재발성 늑막삼출 8예, 혈흉 2예 그리고 흉벽혈종 2예였다. 환자는 자신의 침대에서 앙와위 또는 반좌위 상태로 시술을 받았으며 초음파 유도하에 트로카 방식으로 도관이 삽입되었다. 치료효과는 성공(완전 또는 부분적), 실패, 미결로 분류하였으며 성공률과 합병증 발생 여부, 시술시간을 조사하였다.
결과: 모든 예에서 성공적으로 도관이 삽입되었으며 소량의 흉수에도 초음파 유도하에 어려움 없이 삽입될 수 있었다. 42예 중 36예(85.7%)에서 성공적으로 배액이 되었으며 삽입 직후 평균 420 mL(35 - 1470 mL)의 흉수가 배액되었다. 시술시간은 천자위치 결정부터 도관 삽입 후 배액이 시작될 때까지 10분 이내였으며 혈흉이나 주변 기관의 부주의한 손상 등의 주요한 합병증은 없었다.
결론: 초음파 유도하의 트로카 도관 삽입술은 셀딩거(Seldinger) 삽입술만큼 안전하고 효과적이다. 따라서 트로카 도관 삽입술은 병실에서 흉수 배액이 필요할 경우 셀딩거 삽입술의 간단하고 편리한 대안이 될 수 있다.