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ORIGINAL ARTICLE

Investigation of The Efficacy and Safety of An Ultrasonography-guided Percutaneous Pigtail Drainage Catheter

Ultrasonografi Kılavuzluğunda Perkütan Pigtail Drenaj Kateterinin Etkinliği ve Güvenliğinin Araştırılması

[1]İsmail DİLEK, [2]Erbil ARIK, [3]Görkem ATASOY, [3]Emre Utkan BÜYÜKCERAN, [3]Salih KÜR, [1]Halil ÖZER

[1]Selcuk University, Faculty of Medical, Department of Radiology, Konya, Türkiye
[2]Marmara University, School of Medicine, Department of Radiology, İstanbul, Türkiye
[3]Iğdır Dr. Nevruz Erez State Hospital, Iğdır, Türkiye

Correspondence

İsmail DİLEK
Selcuk University, Faculty of Medical, Department of Radiology, Konya, Türkiye

E-Mail: drismaildilek@gmail.com

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ABSTRACT

Background/Aims: This study aimed to evaluate the effectiveness, reliability, and complications of percutaneous pigtail catheter drainage guided by ultrasound (USG) in the treatment of pleural effusion.
Materials and Methods: This retrospective study analyzed patients aged 18 years and older treated with percutaneous pigtail catheter placement under USG guidance between January 1st, 2019, and January 1st, 2023. Clinical, laboratory, and radiological characteristics of the patients, etiological causes of pleural fluid, biochemical properties of the pleural fluid, and success rates of percutaneous pigtail catheter drainage were analyzed.
Results: A total of 77 patients were included in the study. 59.7% of the patients were male. Exudative effusion was detected in 61% of the patients, with a mean age of 52.8±17.7 years in this group. Most effusions in both exudative and transudative groups were on the right side, observed in 55.3% and 56.6% of cases, respectively. Bilateral pleural effusion was present in 2.12% of the exudative group and 23.3% of the transudative group. The mean pleural fluid depth was 58 mm in the exudative group and 54 mm in the transudative group. The mean drainage duration was 6.5 days in the exudative group and 4.5 days in the transudative group. Comorbidities such as hypertension (76.6%), diabetes mellitus (53.3%), and coronary artery disease (36.6%) were more prevalent in the transudative group. Metastasis (32%) and lung cancer (26%) were the most common causes of exudative effusions, while heart failure (46.6%) and liver failure (30%) were the predominant causes of transudative effusions. The success rate of percutaneous pigtail catheter drainage was 90.5% in exudative effusions and 93% in transudative effusions.
Conclusion: Our study concludes that percutaneous pigtail catheter drainage guided by USG is an effective and reliable method with high success rates and low complication rates for the treatment of both exudative and transudative pleural effusions.

Keywords: Pigtail catheter, Pleural drainage, Pleural effusion, Ultrasonography

ÖZ

Amaç: Bu çalışmada plevral efüzyon tedavisinde USG kılavuzluğunda perkütan pigtail drenaj kateterinin etkinliği, güvenilirliği ve komplikasyonlarının değerlendirilmesi amaçlanmıştır.
Materyal ve Metod: Bu çalışma 01.01.2019 ile 01.01.2023 tarihleri arasında USG kılavuzluğunda perkütan pigtail drenaj kateteri yerleştirilerek tedavi edilen 18 yaş ve üzeri hastalar analiz edilerek retrospektif olarak yapılmıştır. Hastaların klinik,laboratuar ve radyolojik özellikleri, plevral sıvının etyolojik nedenleri, plevral sıvının biyokimyasal özellikleri, perkütan pigtail drenaj kateter tedavisinin başarı yüzdesi analiz edilmiştir.
Bulgular: Çalışmada 77 hasta analiz edildi. Hastaların %59.7'si erkekti. Hastaların %61'inde eksüdatif efüzyon tespit edildi ve eksüdatif efüzyonu olan hastaların yaş ortalaması 52.8±17.7 idi. Hem eksüdatif hem de transüdatif grupta efüzyonların çoğu sağ tarafta olup eksüdatif grupta %55.3, transüdatif grupta %56.6 hastada efüzyonlar sağ tarafta izlenmiştir. Eksüdatif grupta %2.12, transüdatif grupta %23.3 hastada bilateral plevral efüzyon izlendi. Ortalama plevral sıvı derinlikleri eksüdatif grupta 58 mm, transüdatif grupta 54 mm olarak hesaplandı. Ortalama drenaj süresi eksüdatif grupta 6,5 gün, transüdatif grupta 4,5 gün idi. Komorbid hastalıklardan hipertansiyon (%76.6), diabetes mellitus (%53.3) ve koroner arter hastalığı (%36.6) transüdatif grupta daha fazla görüldü. Eksüdatif efüzyonların en sık nedeni metastaz (%32) ve akciğer kanseri (%26), transüdatif efüzyonların en sık nedeni kalp (%46.6) ve karaciğer (%30) yetersizliği idi. Perkütan pigtail drenaj kateterinin başarı yüzdesi eksüdatif efüzyonalarda %90.5, transüdatif efüzyonlarda %93 olarak saptandı.
Sonuç: Çalışmamızda hem eksüdatif hem de transüdatif plevral efüzyonların tedavisinde, USG kılavuzluğunda yerleştirilen pigtail kateter drenajının yüksek başarı ve düşük komplikasyon oranları ile etkin ve güvenilir bir yöntem olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Plevral drenaj, Plevral efüzyon, Pigtail kateter, Ultrasonografi

Introduction

Pleural effusion arises from an imbalance between the secretion and absorption of pleural fluid, attributed to various etiologies such as congestive heart failure (CHF), malignancy, liver and kidney failure, and pneumonia (1-4). Recent studies have suggested that using smaller caliber pigtail drainage catheters under ultrasonography (USG) guidance is effective, reliable, and better tolerated by patients compared to larger chest tubes in treating pleural effusion or pneumothorax (5-7). Smaller catheters are less invasive, easier to place, and associated with lower complication rates. Ultrasound-guided placement is particularly suitable. This study aimed to evaluate the efficacy, reliability,

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Complaints: geneltip@selcuk.edu.tr

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and complications of percutaneous pigtail drainage catheters in the management of pleural effusion.

Materials and Methods

This retrospective study utilized data from patients who underwent percutaneous pleural effusion drainage catheter placement under USG guidance at the Radiology Department of Iğdır Dr. Nevruz Erez State Hospital between January 2019 and January 2023. Informed consent was obtained from all patients or their families in cases where patients were unable to provide consent. The study was approved by the Iğdır University Non-Interventional Clinical Research Ethics Committee on 28/02/2024 (approval number: 3), and there are no conflicts of interest among the authors.

Patients included in the study were those aged 18 and above with pleural effusion who were treated with a USG-guided percutaneous pigtail drainage catheter. Patients who had undergone pleural drainage catheter placement under USG guidance but for whom clinical, laboratory, and USG parameters were unavailable, and those who underwent surgical chest tube placement as initial treatment, were excluded. Demographic data, diagnoses, clinical, laboratory, and USG parameters of included patients were recorded. Cytological, biochemical, and microbiological properties of pleural fluid were documented. Light's criteria (8) were used to distinguish exudative from transudative effusions.

Routine procedures performed in our clinic for patients undergoing pleural effusion drainage were as follows:

The Pre-procedural evaluation: The guide proposed by Colice et al. (9) was used for draining parapneumonic effusions and empyemas. Patients with decompensated heart, liver, and kidney failure with massive transudative pleural effusion, despite adequate medical treatment, underwent pleural effusion drainage via percutaneous pigtail drainage catheter. For traumatic hemothorax patients, the indications for drainage catheter placement were guided by Adrales (10). Using USG examination, the depth of intrapleural fluid measurement and the craniocaudal extent of effusion between both pleural layers were routinely recorded. Pre-procedural evaluation of patients' laboratory findings indicated that procedures were performed on patients with platelet counts >50.000 and INR <1.5. Procedures were conducted under local anesthesia with 5-10 mL of 2% lidocaine for intensive care unit patients and difficult-to-transfer patients, and in all other patients, in the interventional radiology unit.

The procedure under USG guidance: After determining the appropriate insertion site under USG guidance, catheters were placed using the modified Seldinger technique. Pigtail catheters (GEOTEK Medical, Ankara, Turkey), with a diameter of 8-14 French (F) and a length of 25 cm, were used. After securing the catheters to the skin, they were connected to drainage bags and left for free drainage. The drainage procedure was considered successful if imaging and/or clinical symptoms related to pleural disease improved without requiring additional intervention. Cases without improvement in imaging and/or clinical and laboratory symptoms, necessitating large-bore chest tube/surgical intervention for drainage, were considered unsuccessful.

Statistical evaluation: Statistical analysis was performed using the SPSS package program. Categorical data were presented as numbers (%), and continuous numerical data as mean ± standard deviation. Independent t-tests were used for continuous numerical data and chi-square tests for categorical data. Correlation and variance analyses were applied to demonstrate relationships between numerical data. P <0.005 was considered statistically significant.

Results

Seventy-seven patients with pleural effusion were included in the study. Of these, 46 (59.7%) were male and 31 (40.3%) were female. Forty-seven patients (61%) had exudative effusions, and thirty patients (39%) had transudative effusions. The mean age was 52.8 ± 17.7 years for patients with exudative effusion and 66.2 ± 16.5 years for those with transudative effusion. In both groups, there were more male patients (exudative: 29, 61.7%; transudative: 17, 56.6%). Most effusions requiring drainage were on the right side in both groups (p=0.002), with 26 (55.3%) in the exudative group and 17 (56.6%) in the transudative group. Bilateral pleural effusions were observed in one patient (2.12%) in the exudative group and seven patients (23.3%) in the transudative group. The mean depths of pleural fluid were 58 mm in the exudative group and 54 mm in the transudative group. Post-catheterization drainage times varied from one to 17 days. The average drainage time was 6.5 days for patients with exudative effusion and 4.5 days for those with transudative effusion (p>0.005). The

median drainage time for the entire study group was 5.5 days (Table 1).

Table 1. Demographic data of the patients undergoing pleural drainage catheter placement under USG guidance, characteristics of effusion, pleural fluid depths, and drainage times

	Exudate (n=47) n (61%)	Transudate (n=30) n (39%)	*p*-value
Gender			
Male	29 (61.7)	17 (56.6)	>0.005
Female	18 (38.3)	13 (43.4)	>0.005
Hemithorax			
Right	26 (55.3)	17 (56.6)	**0.002**
Left	20 (42.5)	6 (20)	>0.005
Bilateral	1 (2.12)	7 (23.3)	>0.005
Pleural fluid depth (mm)	58	54	>0.005
Drainage duration (days)	6.5	4.5	>0.005

When comparing the comorbid disease histories of patients, hypertension (p<0.001), diabetes mellitus (p=0.001), and coronary artery disease (p=0.003) were more prevalent in patients with transudative effusion, whereas the smoking history was similar in both groups (n=8, 17% and n=6, 20%, respectively). Hypertension was found in 23 patients (76.6%) in the transudative group, diabetes mellitus in 16 patients (53.3%), and coronary artery disease in 11 patients (36.6%). In patients with exudative effusion, hypertension was found in 17 patients (36.1%), diabetes mellitus in 11 patients (23.4%), and coronary artery disease in six patients (12.7%) (Table 2).

Table 2. Comparison of comorbid diseases

	Comorbid Diseases			
	DM (n=27) (35%)	**HT (n=40) (51.9%)**	**CAD (n=17) (22%)**	**Smoking (n=14) (18.2%)**
Exudate (n=47)	11 (40.7)	17 (42.5)	6 (35.2)	8 (57.1)
Transudate (n=30)	16 (59.3)	23 (57.5)	11 64.8)	6 (42.9)
***p*-value**	**0.001**	**<0.001**	**0.003**	>0.005

CAD: Coronary artery disease, DM: Diabetes mellitus, HT: Hypertension,

The most common indications for pleural drainage catheter placement were massive transudative effusions (n=29, 37.6%), malignant pleural effusions (n=27, 35%), and infectious pleural effusions (n=10, 12.9%). The most common causes of exudative effusions were metastasis (n=15, 32%) and lung cancer (n=12, 26%), while the primary causes of transudative effusions were heart (n=14, 46.6%) and liver failure (n=9, 30%) (Table 2). Breast cancer metastasis accounted for 26% (n=4) of metastatic pleural effusions. Non-specific exudative effusion classifications included pulmonary embolism, drug reaction, and trauma patients. Chylothorax was observed in one patient with non-specific transudative effusion.

The success rate of drainage catheters in treating all effusion causes was 91.5%. The success rate was 90.5% in exudative effusions and 93% in transudative effusions. The success rate of drainage catheters was higher when used to treat malignant pleural effusions (93.8%) and massive transudative effusions (93.4%). It was lower when used for hemothorax treatment (77%) and pleural infection/parapneumonic effusion treatment (84%) (Table 3).

Table 3. Etiology of pleural effusion and success rates of percutaneous pigtail catheter placement guided by ultrasound

Diagnosis	Number (n)	Percentage (%)	Success Rate (%)
Exudate	47	61	90.5
Metastatic	15	32	89
Lung cancer	12	26	100
Pleural infection	10	12.9	84
Inflammatory	2	4.2	90.5
Traumatic	1	2.1	77
Non-specific	7	14.8	88.6
Transudate	30	39	93
Heart Failure	14	46.6	94.7
Liver Failure	9	30	93
Kidney Failure	6	20	89
Non-specific	1	3.3	93.2

Complications were detected in 7 out of 77 patients (9%) in our study. One patient (1.3%) with liver failure in the transudative group developed empyema, which was treated by placing a 14 F drainage catheter under ultrasound guidance. Methicillin-resistant S. aureus was identified as the responsible pathogen

in the laboratory evaluation sample. Four patients (5.1%) developed minor complications related to the procedure that did not have clinical significance (catheter occlusion and dislocation). Additionally, two patients (2.6%) experienced pain at the procedure site requiring simple analgesics. Pneumothorax, luminal organ perforation, and procedure-related mortality were not observed.

Discussion

Our study demonstrates that the placement of small-bore catheters under ultrasound guidance for the treatment of pleural effusion has shown high treatment success rates with low complication rates. While some researchers have suggested that small-bore (≤ 14F) drainage catheters may not provide effective drainage, our study has proven it to be an effective and reliable procedure (11-14). The British Thoracic Society currently recommends small-bore (10-14F) drainage catheters for pneumothorax, parapneumonic effusion, and malignant effusion (15).

In our study, the drainage duration ranged from one to 17 days (median 5.5 days) across all study groups. It was found that there is a statistically significant need for longer drainage durations in the exudative effusion group. When compared with similar studies, no significant differences were found in drainage durations; Jayakrishnan et al. reported an average drainage duration of five days in their study. Similarly, they reported that more than three days of drainage were needed in 76.1% of patients with exudative effusion, suggesting a longer duration required for drainage in patients with exudative effusion (16). Jain et al. reported an average drainage duration of seven days in their study (17), while Parulekar et al. reported six days (18).

In our study, the success rate of drainage catheters was highest when used to treat malignant pleural effusions (93.8%). Cafarotti et al. reported a similar success rate of 93.8% in their retrospective study involving 324 small-bore drainage catheters in malignant effusions (19). Jayakrishnan et al. reported success rates ranging from 90% to 100% in drainage catheter procedures for metastatic and lung malignancies (16). Similarly, our study resulted in high success rates, such as 89% in the metastatic group and 100% in the primary lung cancer group. Currently, pleurodesis is known as the definitive treatment for recurrent symptomatic malignant pleural effusions. However, the use of pleural drainage catheters is increasing due to their potential to produce symptomatic relief in addition to pleurodesis.

In advanced decompensated stages of heart, liver, and kidney failure, massive transudative effusions can sometimes develop. When there is no symptomatic improvement despite appropriate and adequate medical treatment, drainage may be necessary (20,21). In our study, drainage procedures in patients with massive transudative effusions resulted in a high success rate of 93.4%. Specifically, we recorded success rates of 94.7% in patients with heart failure and bilateral transudative pleural effusion, 93% in those with liver failure, and 89% in those with kidney failure. Liang et al. reported that in a broad sample of critically ill patients, pigtail drainage catheters were effective in draining massive transudative pleural effusions, albeit with longer drainage durations and potentially higher infection rates (12%).

In our study, one patient with hepatic hydrothorax developed empyema following drainage. Liang et al. reported success rates ranging from 42% to 80% when using pigtail catheters for empyema treatment in a group of critically ill patients in the ICU (22). Nevertheless, as a conclusion of their study, they recommended the use of pigtail catheters without imaging evidence of loculations due to their ease of procedure, safety, and less invasive nature. Jayakrishnan et al. reported a success rate of 83.3% in pleural infections/parapneumonic effusions (16), whereas we achieved a slightly lower but still high success rate of 84% in our study compared to other groups.

Studies have reported rare but serious complications such as pneumothorax, left ventricular penetration, subclavian artery laceration, and cerebral air embolism secondary to pigtail catheter placement (23,24). In our study, pneumothorax, luminal organ perforation, and procedure-related mortality were not observed. Various studies have reported pneumothorax incidences ranging from 2.8% to 31%. Jayakrishnan et al. reported a pneumothorax incidence of 2.8%, Sabry et al. reported 3.3%, and Morrison et al. reported 19-31% pneumothorax rates (16,25,26). Jain et al. reported a pneumothorax rate of 20% in their study, suggesting that small pneumothoraces may occur due to air entry during the procedure (17).

In our study, a complication rate of 9% (7/77) was observed. However, the majority of these were minor

complications related to the procedure that did not have clinical significance. Catheter obstruction and dislodgement occurred in four patients (5.1%). The obstruction rates of small-bore catheters have been reported between 3.9% and 15% in studies (11,17,27). It has been reported that catheters are particularly prone to obstruction in cases of empyema, and in our study, it was found that two patients (2.6%) who developed catheter obstruction were diagnosed with empyema (28). Pain at the procedure site may vary depending on the catheter size, placement technique, use of analgesics, and patients' pain sensitivity. In our study, simple analgesics were required in two patients (2.6%) due to pain at the procedure site.

In a patient with liver failure in the transudative group who underwent 14 days of drainage, empyema developed, which was drained by percutaneous placement of a 14F drainage catheter under ultrasound guidance. We believe this occurred due to the prolonged drainage duration seen in massive transudative effusions, as indicated in previous studies.

Our study has some limitations. Firstly, being retrospective, documentation of minor complications and possible minimal pneumothoraces may not have been recorded. Secondly, no comparison was made with traditional chest tubes. Thirdly, although early success rates of the procedure were measured, it is unknown whether additional interventions were performed on patients in the long term.

Conclusion

Ultrasound-guided pigtail catheter drainage for pleural effusion has shown high treatment success with low complication rates. When indicated, it should be considered as the initial intervention for draining a pleural effusion.

Data Availability

The data sets generated during or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interest Statement

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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Authors' Contribution Statement

All authors have made substantive contributions to the study, and all authors endorse the data and conclusions.

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