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Case Study

Seldinger or trochar for pleural effusion drainage; A case-control study

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ABSTRACT

The purpose of the present study was to compare the complications of pleural effusion drainage using one-step and two-step catheters. The current study is cross-sectional-analytical. The population in this study were patients suffering from pleural effusion with any type of etiology who were candidates for drainage. Each patient was evaluated for the occurrence of complications, including early pneumothorax, delayed pneumothorax, infection, leakage, and intrapleural bleeding. Also, blockage or displacement of the catheter, volume of pleural effusion, and size of catheter used in both methods were recorded separately in each patient. In the present study, 90 patients were included in the study based on the inclusion and exclusion criteria. Of these, 45 patients were randomly assigned to the one-step group and 45 patients to the two-step group. The median age and interquartile range (IQR) of the patients in this study were 57.5 and 20.5 years respectively (age range 34 to 81 years). Also, 61.1% of the patient population in this study were men. There was no statistically significant difference in the incidence of early pneumothorax, delayed pneumothorax, infection, leakage, and intrapleural bleeding between the two study groups. The incidence of intrapleural bleeding and delayed pneumothorax was higher in the one-step group than in the two-step group (respectively, 13.3% vs. 4.4% and 11.1% vs. 4.4%), but this difference was not statistically significant.One-step and two-step catheterization techniques are both safe methods in medium-sized pleural effusions without serious complications.

Keywords: Pleural effusion, Catheter, Pleura, Drainage, Complications

Introduction

In the normal pleural space, there is a steady state in which the amount of fluid formation (inflow) and absorption (outflow) is approximately equal. To cause pleural effusion, this balance must be disturbed [1].To cause pleural effusion, the amount of input should be increased or the amount of output should be decreased. Insertion of a thoracostomy tube (Fr ≥ 16 diameters) or thoracostomy catheter (Fr ≤ 14 diameter) through the chest wall into the pleural cavity is a common procedure for evacuation of air (eg, pneumothorax), simple fluid (effusion), pus (empyema), or blood (hemothorax) or injection of drugs into the pleural space (such as pleurodesis, fibrolysis). It is important to understand which tube to use in different situations and how to correctly insert the tube or catheter. This article that one type or one size of tube or catheter is suitable for everyone is outdated.

Placement of thoracostomy tube (Fr ≥ 16 diameter) or thoracostomy catheter (Fr ≤ 14 diameter) may be indicated in different conditions. Different types of tubes (diameter, shape) are selected based on the type of indication [2-7].

One of the common conditions for placing a thoracostomy tube or catheter is Pneumothorax, which is the most common reason for placing a thoracostomy tube or catheter in the adult and pediatric population. This indication is also true in the newborn population. Hemothorax, pleural effusion, which is another major diagnosis, may require placement of a thoracostomy tube or catheter. and pleurodesis, which is placing a thoracostomy tube or placing a catheter to administer sclerosing agents to the pleural space to treat resistant effusions [8, 9].

For patients with pleural adhesions, prior pleurodesis, or prior lung surgery, guidance by ultrasound or non-contrast CT is preferred over blind placement of a thoracostomy tube or catheter, which can be associated with complications[10].

Conventional thoracostomy tubes are relatively rigid and transparent tubes. Larger diameter tubes (Fr ≥ 16) require a surgical procedure and incision for insertion.

Conventional tubes with a smaller diameter (Fr ≤ 14) and more rigid and more flexible catheters can be implanted through the Seldinger technique by placing them on a wire [11].A tube with a smaller diameter causes less pain than a tube with a larger diameter. However, smaller-diameter tubes can become clogged with blood or purulent drainage and become more easily blocked due to bending or kinking. Also, while smaller tubes can often be inserted without imaging guidance, imaging should be used during insertion for patients with leucular fluid collections. The size of thoracostomy tubes and catheters is determined based on the patient's weight and its indication (i.e. the nature of the fluid to be drained)[12].

Percutaneous thoracostomy tubes or catheters are a viable alternative to surgical thoracostomy tubes for many indications. In a large case-series study, percutaneous thoracostomy catheters (i.e., pigtail type) were highly effective for serous and chylous pleural effusions, but less effective for blood and air and least effective for infection (empyema) [1, 3].Percutaneous pigtail catheters also appear to be more effective in infants and younger children. There is concern that small-diameter thoracostomy tubes or catheters may be more occluded because of blockage with blood or purulent debris, or because of flexibility due to kinking. If this happens, a larger tube should be inserted. However, in a study that evaluated changing larger thoracostomy tubes to 8.5 French thoracostomy catheters, the catheters were effective and no obstruction occurred [12]. The term thoracostomy catheter is used to refer to smaller diameter tubes or non-transparent and flexible specialized tubes (such as pigtails). Smaller diameter thoracostomy catheters and thoracostomy tubes can be placed using the Seldinger technique with a guidewire [4]. However, today, one-step catheters have been developed, which can be placed faster and easier than Seldinger catheters (two-step). However, compared to two-step catheters, it has the potential for less accuracy and more risks. However, learning one-step skills can be faster and can be used in patients who need rapid drainage. This is the first study in Iran that compares the one-step and two-step techniques for placing a thoracostomy catheter into the pleural effusion drainage port.

Materials and Methods

The current study is cross-sectional-analytical. The research population in this study were patients with pleural effusion with any type of etiology, candidates for drainage with diagnostic confirmation at Imam Ba'ath Army Hospital in Tehran province. This cross-sectional study was conducted after the approval of the Research Ethics Committee of the Army University of Medical Sciences. In this study, referring patients from June 1402 to June 1402 with the confirmation of pleural effusion diagnosis in lung CT scan or pleural ultrasound in Baath Hospital, Tehran, and based on the entry and exit criteria and with informed consent, were included in the study. Data collection in this study was based on a checklist including the patient's age, gender, underlying disease, hospitalization department, volume of effusion fluid, size of the catheter used, and the type of catheter used (one step or two steps). In each patient, after catheter insertion, in case of shortness of breath or case of exacerbation, CXR was taken and checked for the presence of pneumothorax. After that, each patient was classified according to the incidence of catheter-related infection during treatment, leakage from the catheter (leak), withdrawal of the catheter, or closure of the catheter (kink). It should be noted that since the volume of pleural effusion fluid and performing thoracic surgeries such as heart surgery can lead to hemothorax and pneumothorax and are confusing in conducting the study, hence in this study patients with medium pleural effusion volume and without thoracic surgery before or after catheter insertion were included in the study.

In this study, descriptive indices such as mean, standard deviation, quartiles, frequency, and percentage were used according to the nature of the variables. For inferential analysis, at first, the hypothesis of normality of the variables was examined (using the Shapiro-Wilk test). To analyze independent groups, the T-test was used in the case of normal distribution, and the Mann-Whitney test was used in the case of non-normal distribution. Also, to examine two independent groups in nominal variables, Chi-square or Fisher's exact test has been used. In all cases, the two-sided P value was less than 0.05, the criterion for statistical judgment. SPSS version 26 software was used to perform statistical tests.

Results and Discussion

In the present study, 90 patients were included in the study based on the inclusion and exclusion criteria. Of these, 45 patients were randomly assigned to the one-step group and 45 patients to the two-step group. The median age and interquartile range (IQR) of the patients in this study were 57.5 and 20.5 years respectively (age range 34 to 81 years). Also, 61.1% of the patient population in this study were men (median, interquartile range), where the age of the patients in the one-step catheter group was (0.55, 18.5) years, and in the two-step catheter group (0.61, 23.0) years. There was no statistically significant difference in terms of age between the two study groups (P = 0.085). In the One Step and Two Step groups, 57.8 and 64.4 percent of the patient population were men, respectively. There was no statistically significant difference in terms of gender between the two study groups (P = 0.517). The etiology of pleural effusion in the One Step and Two Step groups was malignancy in 44.4% of cases, pneumonia in 48.9%, and other causes such as heart, kidney, or rheumatoid diseases in 6.7% of cases. The etiology of pleural effusion in the two-step group was malignancy in 66.7% of cases, pneumonia in 28.9%, and other causes in 4.4% of cases. There was no significant difference between the two study groups in terms of pleural effusion etiology (P = 0.124). (median, interquartile range) the volume of pleural effusion in both one-step and two-step groups was

(1100, 300) ml. There was no statistically significant difference in the volume of pleural effusion between the two study groups (P = 0.740). (Median, interquartile range) The size of the catheter used in two groups, one step and two step, was [12, 2] French. The size range of the catheter used in both groups was 10 to 12 French. Also, there was no statistically significant difference in terms of the size of the catheter used between the two study groups (P = 0.909). The rate of primary pneumothorax after catheterization in the one-step and two-step groups was 6.7% and 2.2%, respectively. This difference was not statistically significant (P = 0.616). The incidence rate of delayed pneumothorax in one-step and two-step groups was 11.1% and 4.4% respectively. This difference was not statistically significant (P = 0.434). The rate of infection in the one-step and two-step groups was 2.2% and 4.4% respectively. This difference was not statistically significant (P = 0.557). The incidence of leakage in the one-step and two-step groups was 2.2% and 8.9%, respectively. This difference was not statistically significant (P = 0.361). The incidence of intrapleural bleeding in the one-step and two-step groups was 13.3% and 4.4%, respectively. This difference was not statistically significant (P = 0.266). The rate of catheter blockage in the one-step and two-step groups was 4.4% and 8.9%, respectively. This difference was not statistically significant (P = 0.677). The incidence of catheter displacement in the one-step and two-step groups was 4.4% and 8.9%, respectively. This difference was not statistically significant (P = 0.677). In the one-step group, 2.2% of patients were placed with Fr 10 catheters, 26.6% with Fr 12 catheters, and 6.6% with Fr 14 catheters. In the two-step group, 13.3% of patients had Fr 12 catheters and 11.1% of patients had Fr 14 catheters. In addition, there is no significant relationship between the size of the catheter used and early pneumothorax (P = 0.404, r = 0.089), delayed pneumothorax (P = 0.717, r = 0.039), infection (r = 0.831 P = r = 0.023), leakage (P = 0.181, r = 0.142) and intrapleural bleeding (P = 0.238, r = -0.126) were absent.

In this study, one-step and two-step techniques using small diameter catheters (Fr ≤ 14) for pleural fluid drainage and primary treatment of pleural effusion were investigated and compared to evaluate possible complications. In the one-step technique, a pre-placed catheter is used in a trocar. In this technique, the catheter and trocar enter directly into the pleural space in one step. Meanwhile, in the two-step technique, which is also known as the Seldinger technique, a guide wire catheter is placed in the pleural space in several steps.

The use of larger diameter tubes (Fr ≥ 16) is well known in the presence of blood or purulent secretions, while smaller tubes are effective in serious cases [13]. In particular, Park *et al.* [14] reported that there was a significant difference in effusion drainage only when the tube diameter was smaller than Fr 8, indicating that large tubules and small tubules with diameters greater than Fr 8 are significantly equivalent in serous effusion drainage.

Based on the available clinical evidence, in our department in this study, the type of tube was selected according to the characteristics of pleural effusion. In addition, if the patient had no signs of empyema (fever, chest pain, white blood cell changes, hydropneumothorax on CT) or bleeding, and the effusion was serious on exploration, a smaller diameter drain was placed. The diameter of the drains used in this study was 10 to 14 French in both methods.

However, like many diagnostic and therapeutic centers, the work experience of our center also started with the two-step Seldinger technique, but the development of new methods, especially in the last decade, has increased the number of available drainage tools . As a result, in the present study, the one-step drainage system compared to the two-step drainage system was investigated to see if this type of chest tube has comparable safety and efficiency characteristics.

Often, small-diameter drains are more likely to become blocked [15] and more prone to kinking compared to larger-diameter drains.

In this study, one-step drainage had a higher displacement rate than one-step drainage (8.9% vs. 4.4%, P = 0.677). However, this difference was not statistically significant. Despite displacement, there was never a need to reinsert the chest catheter due to persistent pleural effusion during the same hospitalization. Nevertheless, despite the higher displacement rate, in general, the one-step system allowed complete drainage of the chest cavity.

Unlike other types of tunnel drains, a step catheter is not designed for long-term use. In addition, the existing one-step catheter may have limitations due to its 22-cm length compared to the 30-cm length of the two-step catheter. Due to this issue and because in some situations the thickness of the chest wall may not be negligible, in some patients, various other models of one-step catheters with a length of 40 cm have been used.

It is important to mention that the rate of catheter displacement can be increased according to the experience of the operator. In a similar study [16], the rate of displacement in the group of patients where the catheter was placed by an experienced specialist was 8.3% and in the case of catheterization by a resident, it was 30%. In the current study, one-step catheterization was performed in all patients by a specialist with radiology experience (8.9%). A study by Davies and colleagues [17] reported a higher replacement rate for less experienced operators. The comparison of these results emphasizes the importance of resident training by experienced professionals.

In addition, the safety characteristics of both drainage methods in this study were satisfactory. In the current study, there was a statistically significant difference between the one-step and two-step groups in terms of complications including early pneumothorax (6.7% vs. 2.2%), delayed pneumothorax (11.1% vs. 4.4%), was no infection (2.2% vs. 4.4%) and leakage (2.2% vs. 8.9%). In addition, two patients in the two-step and two-step groups showed appropriate safety features regarding antiplatelet-anticoagulant treatment. In fact, in this study, this procedure was performed independently of the administration of acetylsalicylic acid, and clopidogrel and within 4 hours after the administration of low molecular weight heparin.

Finally, in the case of the vitamin K antagonist, the oral intake was stopped and then a drain was inserted with an INR less than 1.5. These results are consistent with other studies that reported a very low rate of bleeding following chest drains [18, 19]. However, these studies did not specify whether patients received any antiplatelet-anticoagulant drugs. This study may be considered as an indication for catheter placement with a diameter of Fr ≤ 14 in patients on antiplatelet-anticoagulant therapy, showing that it is safe during the administration of acetylsalicylic acid and clopidogrel. Despite the higher incidence of intrapleural bleeding in the one-step group compared to the two-step group (13.3% vs. 4.4%), this difference was not statistically significant. These results agree with the findings of the study of Congedo and his colleagues [20], although there is a need for a larger study population to confirm this finding.

In this study, there were no complications that required invasive treatments such as thoracoscopic wire removal due to its displacement in the pleural cavity. This complication is unusual but possible with the two-step method and two cases have been reported in studies. In one case, the wire was removed under ultrasound guidance. On the other hand, in the one-step method, due to the absence of a wire, this risk is eliminated and can be considered as an advantage in this technique.

In terms of cost, small-caliber drainage kits cost more. Of course, it should be noted that in most centers, large-caliber drains require surgery, which is performed in the operating room and sometimes with the help of an anesthetist for sedation, while small-caliber drains are performed at the patient's bedside or in the emergency room.

In this study, there were no major complications in the one-step method compared to the two-step method. However, the incidence of minor complications was higher than in similar studies. It is expected that the incidence of these complications will decrease with more treatment in each treatment center. In a similar study, the rate of catheterization to drain pleural effusion is 400 cases per year [21].

According to our knowledge, quantitative studies have compared the results of one-step and two-step methods. A work published in 2016 [22] included 124 patients who underwent trocar catheterization or the Seldinger technique. In this study, catheters between 8 and 12 Fr were used for large transudative effusions, parapneumonic effusions, and empyema. In some cases, this procedure was repeated, especially in patients with neoplastic effusion. A total of 193 procedures were performed with the trocar technique and 38 procedures with the Seldinger technique. This study was done retrospectively and the findings showed that the trocar technique is faster and easier, but the Seldinger technique is a suitable option that can be used in case of failure of the first one.

In the present study, unlike the study of Congedo [20], in which Fr 12 was used in both catheterization methods, Fr sizes 10 to 14 were used, and there was no significant difference between the two study groups. In addition, there was no relationship between the size of the catheter used and complications of catheterization ($P>0.05$).

Considering that malignant pleural effusion alone accounts for more than 150,000 new cases annually in the United States and about 100,000 in Europe[12],its management depends on a large number of different specialists, including pulmonologists, thoracic surgeons, and emergency physicians. And it needs anesthesiologists. Undoubtedly, the simplicity of both described techniques with low complication rates and their similarity to thoracentesis have made this method attractive to many medical professionals.

Conclusion

In this study, the complications of using two types of catheter application techniques were investigated, and it was shown that the complications of these were not significantly different, and if they are chosen with appropriate indications, they can help in the management of the disease.

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