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REVIEW ARTICLE

Tunneled pleural catheter in pleural effusion: To Whom? When? How?

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ABSTRACT

Tunneled pleural catheter (TPC) is a standard option for the management of recurrent pleural effusion (PE), both malignant and nonmalignant. Its ease of implantation, simple home management, and safety profile make it attractive for symptomatic patients requiring relief and improved quality of life. In patients with trapped lung, TPC is the best option for symptomatic relief. In cases of expandable lung, TPC is used to relieve symptoms and, in some cases, to achieve a desirable pleurodesis. In addition to TPC, there are other treatment alternatives in symptomatic PE that should be evaluated, and the final treatment decision should be individualized in each case, considering the patient's preferences. We present the evidence on TPC in malignant and nonmalignant PE and outline the indications of the catheter according to the etiology of the effusion, discuss the most appropriate time for its implantation, and describe step by step how to do it.

Keywords: Malignant pleural effusion. Nonmalignant pleural effusion. Pleurodesis. Recurrent pleural effusion. Symptomatic pleural effusion. Tunneled pleural catheter.

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INTRODUCTION

In February 1985, a peritoneal access port was implanted in the chest wall with a permanently attached Tenckhoff catheter inserted into the left pleural space with the patient under local anesthesia. The patient, who had recurrent malignant pleural effusion, was drained at home twice a week to relieve his dyspnea related to fluid accumulation in the pleural cavity. The authors, in a brief note published in 1986, described the advantages, ease of implantation, and management of the device[1]. A decade later, in 1997, the Food and Drug Administration approved the PleurX catheter manufactured by Denver Biomedical, for indwelling use of a pleural catheter. Since its approval, the use of the indwelling pleural catheter, hereafter referred to as a tunneled pleural catheter (TPC), has become standard practice in the management of recurrent pleural effusion. Today, it is an option not only for palliative management of pleural effusion, malignant and nonmalignant, but also for therapeutic management. The exponential increase in the use of TPC in recent years is due to its ease of implantation, simple home management, and adequate safety profile. The main objective of its placement is symptomatic relief of recurrent pleural effusion. Thus, when the lung is expandable and the patient has recurrent and symptomatic pleural effusion, the alternative to TPC is chemical pleurodesis, which can be performed through pleural drainage (slurry) or thoracoscopy (poudrage). Both procedures, unlike TPC, require hospitalization. In the case of trapped lung, TPC will be the best and recommended option over serial thoracentesis.

In clinical practice, there are three possible scenarios for symptomatic patients with recurrent pleural effusion despite adequate treatment and/or awaiting effective targeted therapy:

1. Patient with trapped lung whose only goal is symptomatic relief and improvement in quality of life.

2. Patient with expandable lung whose only main goal is symptomatic relief and improvement in quality of life.

3. Patient with expandable lung, where the aim is both symptomatic relief and pleurodesis.

In the third scenario, chemical pleurodesis (slurry or poudrage) is a good alternative to TPC for patients with good prognosis and functional status. However, treatment decisions must be flexible and individualized, and all treatment decisions must take into account the patient's goals and preferences.

These are the three possible scenarios, but in which types of recurrent pleural effusions is TPC indicated? There are a large number of clinical trials[2-6] demonstrating the benefits of TPC in malignant pleural effusion, which is why its usefulness is not questioned in any of the clinical guidelines for the management of malignant pleural effusion[7-11]. Regarding the use of TPC in nonmalignant pleural effusion (NMPE), the

scientific evidence is less robust and mainly limited to single-center retrospective studies with small sample sizes and a single clinical trial[12]. In addition, the population is more heterogeneous and may require a disease-specific approach, as will be discussed later. The most relevant published clinical guidelines and studies according to the etiology of pleural effusion will be described in the following text.

MALIGNANT PLEURAL EFFUSION AND TUNNELED PLEURAL CATHETER

Malignant pleural effusion is one of the most frequent causes of unilateral exudative effusion, with pleural metastases from lung and breast cancers being the most frequent, followed by lymphoproliferative syndromes, ovarian cancer, and gastric cancer. Pleural mesothelioma is the most frequent primary tumor, often presenting with pleural effusion, which, together with pleural implants, causes typical symptoms such as pain and dyspnea.

The presence of malignant pleural effusion indicates advanced disease and a worse prognosis. Despite this, new targeted oncological therapies tend to increase the survival of our patients, and this obliges us to offer them appropriate and individualized therapeutic and symptom control alternatives. Patients with long survival will require definitive interventions, while for patients with reduced life expectancy, the aim is to minimize interventions and maximize time at home, and this is where TPC has a clear indication. Multiple clinical trials have shown that TPC improves symptoms and quality of life[2-6]. In addition, it significantly reduces hospitalization time and pleural drainage procedures compared with talc pleurodesis procedures (Table 1). Additionally, spontaneous pleurodesis is achieved in a notable percentage of cases, although with a wide variability (11–51%) according to the literature. However, in TPC, the success of spontaneous pleurodesis may increase depending on the intensity and frequency of fluid drainage. This is demonstrated by two randomized clinical trials[3,5] that compared two drainage regimens, concluding that aggressive drainage, when evacuated daily for 60 days, was associated with higher rates of pleurodesis than symptom-guided drainage (37–47% vs. 11–24%), and improved quality of life, with no difference in dyspnea control, which was equal in both groups. There were no differences in pleural infection, other adverse events, hospitalization, or mortality rates. Aggressive daily drainage also achieved pleurodesis faster than symptomatic drainage (54 vs. 90 days, respectively). At the same time, in those patients selected for their age, functional status, and better prognosis, TPC and pleurodesis can be combined. A prospective study of 22 patients[13] showed that instillation of talc suspension through the TPC was possible and resulted in pleurodesis in 92% of patients with few complications. Subsequently, in 2018, Bhatnagar et al.[6] published the first single-blind clinical trial comparing two groups of patients with malignant pleural effusion, expandable lung, and TPC. One group was instilled with talc through the TPC, and the other group was instilled with saline. The study concluded that the TPC and talc group had a higher pleurodesis rate than the saline group, although in this study the pleurodesis success rate was 43% at 35 days. Table 2 shows the percentages of pleurodesis

Table 1. Clinical trials tunneled pleural catheter in malignant pleural effusion

Study (year of publication)	Design	Main findings	Secondary findings
TIME 2 (2012)	Randomized, unblinded. TPC (n = 52) versus pleural catheter with pleurodesis (n = 54).	TPC group: Improvement of dyspnea in the TPC group at 6 months (p = 0.01). Shorter initial hospitalization (p < 0.001). Less need for further interventions (p = 0.03).	No significant differences in dyspnea in both groups in the first 42 days. No differences in quality of life.
ASAP (2016)	Randomized: TPC daily drainage (n = 73) versus TPC symptom drainage (n = 76).	Higher self-pleurodesis in daily drainage (47 vs. 24%, p = 0.003). Shorter autopleurodesis time in daily drainage (54 vs. 90 days).	No difference in the percentage of side effects and quality of life.
AMPLE (2017)	Multicenter ramdomized (1:1). TPC (n = 74) versus talc pleurodesis (n = 72).	Fewer days of hospitalization in the TPC group vs. pleurodesis (p = 0.003). Fewer additional pleural interventions in the TPC group.	No difference in dyspnea or quality of life.
AMPLE 2 (2018)	Multicenter randomized (1:1). **T**PC daily drainage versus TPC symptom drainage (n = 44).	Daily drainage TPC: No difference in shortness of breath scores. Self-pleurodesis is higher at 3 (37.2 vs. 11.4%, p = 0.0049) and 6 months (44.2 vs. 15.9%, p = 0.004). Better quality of life.	No differences in percentage of adverse effects, pain, length of stay, and mortality.
IPC-PLUS (2018)	Randomized multicenter (only in trapped lung after 10 days of TPC placement): 4 g talc slurry (n = 69) versus placebo (n = 70). Follow-up 70 days.	Talc group: Pleurodesis 43% versus 23% (p = 0.008). Improvement in quality of life and symptom control.	No differences in percentage of adverse effects, amount of effusion, complexity, days of hospitalization, and mortality.

TPC: tunneled pleural catheter.

by procedure performed in malignant pleural effusion according to the published scientific evidence.

There are two brief thoughts on pleural effusions secondary to patients with neoplasms of hematological origin and pleural mesothelioma. In the first case, despite reasonable concerns about infection and bleeding in this population, scientific evidence suggests that TPCs are safe and effective in patients with hematological diseases. Two retrospective studies[14,15] on the use of TPC in hematological malignancies show that the rates of complications and pleurodesis with TPC are similar to those in solid organ tumors, with adequate palliation of symptoms. In a review on the subject, Vakil et al.[16] concluded that pleural effusions in patients with hematological malignancies can be safely treated with TPC. Sterile techniques and standardized algorithms for placement and removal are crucial in centers that place these catheters. The safety of these catheters in hematological

Table 2. Pleural interventions in malignant pleural effusion and pleurodesis

Pleural interventions	Pleurodesis (%)
Talc *poudrage*	78–82
Talc *slurry*	68–71
TPC + talc	43–92
TPC + daily drainage	37–44
TPC + symptom drainage	15–23

malignancies justifies a paradigm shift in the treatment of pleural disease in hematological patients.

In the case of pleural effusions due to pleural mesothelioma, the same treatment alternatives as in malignant pleural effusions are considered, taking into account that, in the specific case of pleural mesotheliomas, a high percentage of patients present with a trapped lung at diagnosis, making TPC the most appropriate option. A possible complication is the growth of metastases in the catheter tract. In a single-center retrospective study of pleural mesotheliomas with TPC implantation for symptomatic pleural effusion, prospective follow-up was performed for a minimum of 6 months. Thoracic computed tomography (CT) scans following TPC insertion were reviewed to assess for evidence of path metastases. A total of 90 patients were included and path metastases were identified in 23 of 90 patients (26%). Not all metastases were diagnosed clinically or in the radiology report but were diagnosed on review of the CT scan for the study. The median time from insertion to metastasis was 408 days. TPC insertion at the time of thoracoscopy did not increase the likelihood of metastasis, and the incidence of metastasis was not different between mesothelioma subtypes ($p = 0.09$). Patient-reported dyspnea scores improved after TPC insertion in 80% of patients, reducing the number of pleural procedures[17]. For this reason, the authors recommend the use of TPC in mesothelioma, but being aware of the possibility of path metastases. Symptoms are mild to moderate pain and are usually controlled with oral analgesics. Radiotherapy is also effective and does not damage the catheter or its function.

Returning to recurrent and symptomatic malignant pleural effusion, after an initial thoracentesis and pleural manometry to assess the characteristics of the underlying lung[18] and the symptomatic improvement after evacuation of the fluid, the patient should be offered therapeutic alternative(s). The one selected, according to the patient's preferences, including TPC, should not be delayed. In the latest published guidelines, the BTS recommends that definitive pleural interventions should not be postponed after systemic anticancer treatment[11]. In the same vein, a recently published systematic review on the safety and efficacy of tunneled pleural drainage related to the timing of anticancer therapy concludes that the efficacy and safety of TPC in malignant pleural effusion do not appear to vary depending on the timing of catheter insertion. The data most likely support early implantation of TPC[19]. This review has led to an editorial agreeing with the authors on early catheter insertion and debating the need for fluid evacuation even in nonsymptomatic patients, arguing that effusion is a protein-rich fluid with pro-oncogenic properties and suppression of anti-tumor immune activity[20].

NONMALIGNANT PLEURAL EFFUSION AND TPC

Pleural effusion secondary to heart failure

Heart failure is the most common cause of pleural effusion. In a prospective, multicenter study of 3,295 patients with congestive heart failure[21], the presence of pleural effusion was 46% (58% bilateral) and the 1-year mortality of these patients was 32%, although the presence of effusion was not a predictor of mortality. In symptomatic cases, treatment involves increasing diuresis by intensifying oral or intravenous diuretic therapy, if necessary. In routine clinical practice, in cases refractory to intensive diuretic treatment or in patients with impaired renal function that precludes increasing diuretic doses, therapeutic thoracentesis is the second step. The frequency of therapeutic thoracentesis needed to relieve dyspnea in our patients may force us to think about alternative options, such as pleurodesis or TPC.

In 2017, the Food and Drug Administration approved TPC for the management of pleural effusions secondary to heart failure that do not respond to diuretic treatment or have undesirable effects from diuretic treatment, despite limited scientific evidence. Other NMPEs treated with TPC in these publications include effusion secondary to liver failure, inflammatory pleuritis, renal failure, empyema, postsurgical lung transplant effusion, and chylothorax, among others.

In a meta-analysis[22] selecting 13 studies with a total of 325 patients with NMPE (more than 50% secondary to heart failure), TPC led to symptomatic improvement of dyspnea, decreased hospitalizations, and reduced need for repeat invasive procedures in all cases. Pleurodesis in effusions secondary to heart failure was 42% versus 62% in the non-cardiac etiology group.

Recently, Walker et al.[12] published the first and only clinical trial comparing the use of TPC in patients with symptomatic pleural effusion secondary to heart failure, renal and hepatic failure versus thoracentesis: 68 patients (46 with heart failure, 16 with hepatic hydrothorax [HH], 6 with renal failure) were randomized to TPC (n = 33) and thoracentesis (n = 35). There was no significant difference between both groups in dyspnea improvement at 12-week follow-up. Thoracentesis was associated with few complications and TPC reduced the number of invasive procedures required. The authors conclude that patients' circumstances and preferences should be considered in the selection of the intervention.

Another therapeutic option, as mentioned above, is pleurodesis with talc[23]. There is a published study comparing talc pleurodesis and TPC in patients with symptomatic pleural effusion secondary to heart failure who had previously undergone two thoracenteses for dyspnea[24]. Forty patients underwent talc thoracoscopy and 40 patients underwent TPC. Both treatments were successful in terms of palliation and improvement of dyspnea. However, the cohort of TPC patients had a significantly shorter mean

hospital stay, a reduced incidence of morbidity, and a reduced readmission rate. In addition, no TPC failure was identified and only one patient had a catheter-associated infection.

TPC is thus shown to be a good alternative for these patients. However, despite standard clinical practice supported by several studies, the latest European guidelines on the diagnosis and treatment of acute and chronic heart failure[25] make no mention of the management of symptomatic pleural effusion in these patients, nor do they mention the indication for repeated thoracentesis, let alone the use of tunneled pleural drainage and/or chemical pleurodesis. Therefore, clinical trials with a consistent number of patients would be needed to support the conclusions of the only clinical trial on the subject. In the meantime, for symptomatic patients with pleural effusion secondary to heart failure who do not improve despite intensified medical treatment and who do improve with repeated thoracentesis, chemical pleurodesis, TPC, or both could be considered. The choice of the most appropriate therapeutic option until the scientific evidence is more robust, as in the management of malignant pleural effusion, will depend on the patient's condition and preferences.

Pleural effusion secondary to liver failure or hepatic hydrothorax

HH is a rare complication in patients with cirrhosis. However, when it occurs, it implies an advanced stage of the disease, leading to a worse prognosis and thus increased mortality, which is around 50% per year. Additionally, the presence of recurrent HH is an indication of liver transplantation. The diagnosis is one of exclusion, and the treatment does not differ from the medical treatment of ascites, which may not be present. In addition to medical treatment, in large ascites, paracentesis is indicated for symptomatic relief of pleural effusion. Despite this, one-third of patients with pleural effusion do not respond to medical treatment and/or paracentesis, and the symptomatology makes it necessary to evaluate other therapeutic options, including surgical treatment to close diaphragmatic defects, transjugular intrahepatic portosystemic shunt (TIPS), thoracoscopy with pleurodesis, repeated thoracentesis, TPC, and liver transplantation, the latter being the only definitive option that improves mortality in these patients. Therefore, the recommendation is that the management of HH should be multidisciplinary and conducted by hepatologists, pulmonologists, and surgeons, and that the choice of one or another therapeutic option will be individualized considering factors such as the response to previous treatments, the severity of symptoms, and the viability of the treatment.

A recent systematic review and meta-analysis[26] on the efficacy of TPC in HH, reviewing 10 studies with a total of 269 patients, confirmed the achievement of spontaneous pleurodesis in 47%, with a mean time of 104 days. The overall complication rate associated with TPC placement was 30.36%, with an incidence of pleural cavity infection of 12.4% and a mortality rate of 3.35% due to catheter

complications. Despite the complications, the study suggests that TPC placement is a relatively safe therapeutic option for refractory hepatic hydrothorax. The authors highlight the need for further research and clinical trials to better understand the efficacy of TPC in HH and to determine whether it provides survival benefits.

In another recent study published on pleural interventions in the management of HH[27], the authors propose an algorithm where the use of TPC would be indicated in patients with refractory HH who are not candidates for transplantation and who have failed other treatments such as thoracentesis or TIPS and require a palliative approach. Also, for patients with incomplete or uncertain hepatological treatment plans, TPC can provide long-term management of pleural effusion. In patients who are candidates for transplantation, especially those with a long transplant waiting list, the decision to be made is highly debated. The authors recommend serial thoracentesis but are aware of the role that other options could have as a bridge to transplantation: TPC versus pleurodesis versus surgical correction of diaphragmatic defects.

Pleural effusion secondary to end-stage chronic renal failure

Pleural effusion in patients with chronic renal failure on hemodialysis has a prevalence of 20%[28], with some cases resulting in symptomatic effusions that do not resolve with hemodialysis. The etiology is multifactorial, the most frequent causes being hyperhydration and heart failure, which sometimes go hand in hand; other less frequent etiologies that should be evaluated are uremic pleuritis, empyema, and hemothorax. After an etiological diagnosis and effective medical treatment in symptomatic recurrent effusions (which in most cases will be secondary to hyperhydration vs. heart failure), an alternative is TPC. There is only a single published study of a cohort of patients with chronic kidney disease on hemodialysis with symptomatic pleural effusion in which a TPC was implanted as a palliative symptomatic measure[29]. A total of nine catheters were placed in eight patients with symptomatic pleural effusion secondary to end-stage renal disease. Dyspnea improved significantly 2 weeks after insertion. There was no occurrence of empyema or other major complications. Serum albumin did not decrease after catheter insertion. Spontaneous pleurodesis occurred in three patients (37.5%) after a median of 77 days. The authors conclude that TPC insertion in symptomatic pleural effusion secondary to end-stage renal disease appears to be safe and effective. In another retrospective study of TPC in patients with benign pleural effusions with a total of 37 patients[30], 59% of which in patients with chronic renal failure with other comorbidities, a considerable reduction of admissions for dyspnea in the year following drain insertion compared with the previous year was confirmed, no catheter-related complications were documented and spontaneous pleurodesis was 83.8%. The authors conclude that the results of the study support the placement of a TPC in recurrent NMPEs refractory to etiological treatment as an effective and plausible alternative. Finally, in

the only clinical trial comparing TPC versus therapeutic thoracentesis[12], 8% were effusions secondary to chronic renal failure and the conclusions, already mentioned, were that there was no significant difference in the improvement of dyspnea in the 12 weeks of follow-up in both groups, and TPC reduced the number of invasive procedures required. The authors conclude that patients' circumstances and preferences should be considered in the selection of the intervention.

Chylothorax

Chylothorax is the accumulation of chyle in the pleural cavity due to damage to the thoracic duct or its tributaries, with leakage of chyle from the lymphatic system into the pleural space. The most frequent causes are malignant (lymphoma or invasion of other tumors), postsurgical, traumatic, and idiopathic. The treatment of choice will be the treatment of the cause. In selected patients with recurrent effusions despite medical treatment and not suitable for surgical treatment or percutaneous radiological interventions, TPC may be an alternative. DePew et al.[31] published a retrospective study of benign recurrent chylothorax controlled with TPC. Eleven patients were treated with placement of 14 TPC: three postsurgical (two esophageal and one lung), four idiopathic, two yellow nail syndromes, one lymphangioleiomyomatosis, and one chylous ascites. All procedures were well tolerated with no immediate complications. Only two patients had transient drainage occlusions successfully treated with intracatheter fibrinolytics. No nutritional, hemodynamic, or immunological adverse effects related to fluid drainage were observed. Pleurodesis was achieved in 9 of 14 treated hemithoraces (64%) with a mean time of 176 days. The authors conclude that the use of TPC should be considered early as pleurodesis can be achieved frequently and safely in this patient population.

In the case of chylothorax secondary to malignant disease, the management of chylothorax does not vary from the management of malignant pleural effusion. In a published study on chylothorax of malignant origin[32], 10 patients with chylothorax and TPC were compared with 9 patients who underwent other palliative interventions. The authors found that the risk of requiring a second pleural intervention after the index procedure during the first 500 days was lower in the TPC group compared with the other pleural interventions and, although albumin levels decreased, this decrease was no worse than in the control group and levels recovered after removal of the drain. The authors conclude that placement of a TPC can be considered as a first-line palliative treatment for patients with symptomatic recurrent chylothorax who respond poorly to systemic cancer therapy.

Postlung transplant pleural effusion

Postsurgical pleural effusion in both thoracic and abdominal pathology is frequent and the evolution is generally favorable with conservative management and/or occasional thoracentesis. However, in a small percentage of

patients, especially in thoracic surgery, this effusion can be recurrent and persistent over time. In the specific case of lung transplant, this effusion can become chronic and be responsible for respiratory failure and cause pulmonary trapping. Decortication has considerable morbidity, and prolonged use of tube thoracotomy is impractical. There are several publications of single-center studies with TPC placement for the management of pleural effusions in lung transplant[33] and other solid organ transplants[34] with good results. Recently, in a multicenter study with a total of 61 lung transplant patients, TPC was shown to be safe and effective[35]. TPC was implanted at a median of 59 days post-transplant with a dwell time of 43 days. A total of eight complications (11%) were reported. Infection occurred in five patients (7%) (four empyema and one catheter tract infection). The TPCs did not present any serious complications. Spontaneous pleurodesis occurred in 63 cases (89%). No patient required subsequent surgical decortication. The authors conclude that TPC in lung transplant patients was associated with a higher rate of infectious complications than in other lung transplant patients. The rate of pleurodesis is high and therefore TPC could be considered for the treatment of recurrent pleural effusion in lung transplant recipients.

Pleural infections

The treatment of pleural infection is unquestionable and involves antibiotic treatment and action on the pleural effusion. This action may be conservative, evacuating or requiring thoracic drainage, and intrapleural and/or surgical treatment. However, in chronic infectious effusions with thickening of the visceral pleura and the presence of trapped lung, thoracic drainage with lavage until resolution and/or surgical treatment for cleaning and decortication may be indicated. This procedure is associated with significant morbidity and therefore requires appropriate patient selection. Majid et al.[36] reported a study of a cohort of 11 patients with pleural space infection and trapped lung treated with TPC. After placement, hospital discharge and catheter removal occurred after a median of 5 and 36 days, respectively. Three patients had residual loculated effusion that resolved with instillation of intrapleural fibrinolytic therapy. One patient eventually required thoracotomy with an open window due to ongoing pleural infection attributed to poor compliance with TPC care and drainage instructions. The authors conclude that TPCs represent an alternative option for drainage of an infected pleural space in nonsurgical candidates with a nonexpandable lung. Its use, as an adjunct to traditional treatment, can facilitate early hospital discharge and outpatient treatment in patients with limited life expectancy.

How TPC insertion is performed?

TPC insertion is a simple, outpatient procedure. It is performed with the patient awake and under local anesthesia. In special cases, it can be performed under superficial sedation. The patient is placed in lateral decubitus with the arm elevated at head level (Fig. 1A) so that the intercostal spaces are

more open. The pleural chamber is located with thoracic ultrasound, generally in the mid-axillary line and in a space above the diaphragmatic curvature. The entry zone for the catheter into the pleural cavity is marked, and 5 cm lower (or forward in the anterior axillary line), the entry zone for the subcutaneous tract is marked. In the case of a massive pleural effusion with diaphragmatic flattening, the entrance of the drainage into the pleural cavity is marked 2–3 spaces above the diaphragm, as this will normalize its position once the liquid has been extracted. Once the two marks have been made, the area is disinfected, and sterile drapes are placed over the entire field (Fig. 1C). It is important to perform the procedure in total and careful asepsis (gowns, caps, mask, sterile gloves, and sterile field). The necessary instruments are placed on a table together with the tunneled pleural catheter kit (Fig. 1B). Steps to follow:

1. Local anesthesia, with 5% mepivacaine, in the marks: in the lowermost mark, we will infiltrate only the skin, making a small bruise (Fig. 1D). It is not necessary to instill anesthesia in the route through which we will tunnel towards the second mark, as there are no nerve endings in the fat and therefore it will not hurt. At the upper mark, where the catheter will enter the pleural cavity, we anesthetize the skin well and perpendicularly infiltrate the pleura. Finally, we confirm that we are in the pleural cavity, recovering liquid (Fig. 1E).

2. We make an incision of approximately 1 cm at the upper mark or point of entry into the pleural cavity (for greater ease of work). And a minimal incision of about 4 mm (minimum space necessary for the polyester plug of the catheter to enter) at the lower mark, which corresponds to the entry point of the catheter into the tunneled tract.

3. We prepare the stitches. A central stitch in the largest upper incision, to bring the edges closer together once the catheter has been introduced into the pleural cavity, and a small stitch next to the smallest incision to hold the drainage in place, until the granuloma forms around the polyester button of the catheter.

4. We place the catheter in the tunneling device (Fig. 2A) and, with the catheter rolled up in our hand for better control, we introduce the tunneling device through the small incision directed towards the larger incision (Fig. 2B) and we first tunnel with the tunneling device until it comes out completely through the larger orifice, and then we drag the catheter through the subcutaneous tunnel (Fig. 2C) until we introduce the small polyester plug (red arrow) through the small incision, made to measure, until we can no longer see it, and we place it a few millimeters from the entrance (Fig. 2D). And it is there where the subcutaneous granuloma will form, which will act as a catheter attachment and a barrier to germs.

5. We cut the catheter to separate it from the tunneller and we take the opportunity to cut the catheter a little longer, depending on the size of the patient's thorax, in order

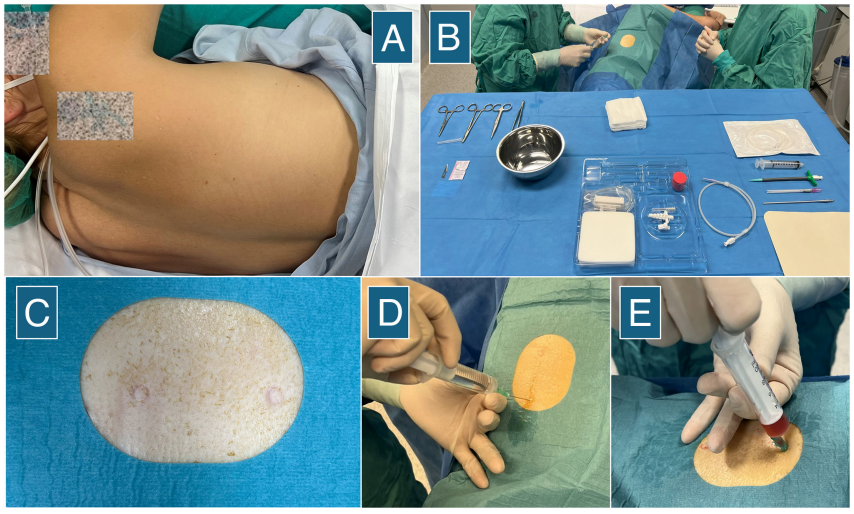

Figure 1. A: position of the patient; **B**: the instruments necessary with the tunneled pleural catheter kit; **C:** the two marks, one for entry into the subcutaneous tissue and one for entry into the pleural cavity; **D:** local anesthesia at the lower mark infiltrates only the skin; **E**: at the upper mark, where the catheter will enter the pleural cavity, the anesthesia reaches perpendicular to the pleura and is finally confirmed by retrieving pleural fluid.

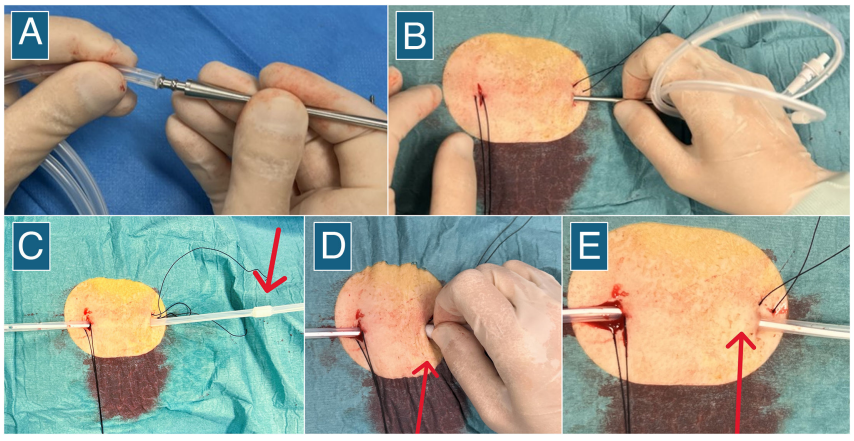

Figure 2. A: the catheter is placed in the tunneling device; **B:** the tunneling device is introduced through the small incision directed towards the larger incision; **C** and **D:** the catheter is dragged through the subcutaneous tunnel until introducing the small polyester plug (red arrow) through the small incision; E: the small polyester plug is introduced until a few millimeters from the entrance.

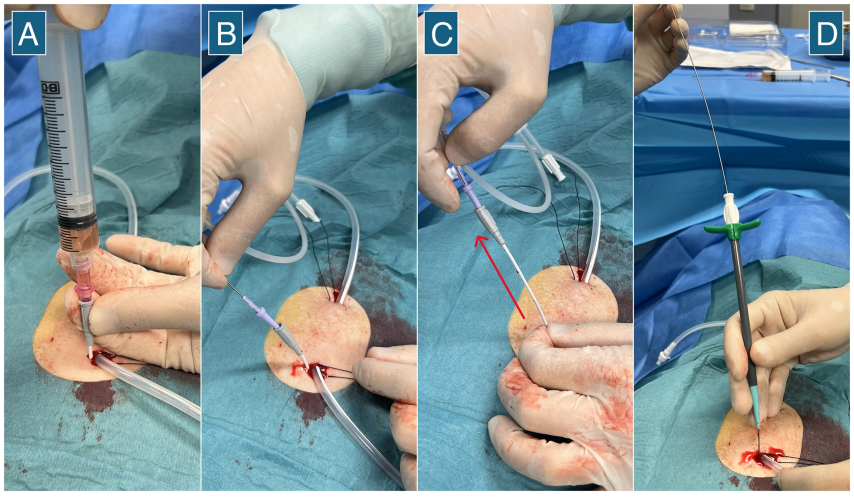

Figure 3. **A:** first, the pleural cavity is located by aspirating with a needle with its catheter in the first incision; **B:** the needle is then removed, and a catheter is left to insert a guidewire; **C:** once the guidewire is inserted, the catheter is removed; **D:** the introducer system is then introduced through the guidewire into the pleural cavity.

to prevent the excessively long catheter from rubbing against the parietal or diaphragmatic pleura, causing pain.

6. In the first incision and with the needle and syringe from the PleureX kit, we locate the pleural cavity (Fig. 3A), taking care not to puncture the catheter already tunneled and which comes out through the same incision, and we introduce the guide through the needle catheter into the pleural cavity, directing it posteriorly and downwards (Fig. 3B). We remove the needle catheter (Fig. 3C) and keep only the guidewire through which we introduce the 16 F dilator together with the introducer sheath following the path of the guidewire perpendicularly towards the pleural cavity (Fig. 3D). When the distal end of the dilator and the sheath have been introduced into the pleural cavity, slide the sheath over the dilator, without inserting it completely, and remove the dilator. We then introduce the fenestrated end of the catheter through the sheath following the natural shape of the loop, without forcing it, to avoid pinching it (Fig. 4A). When all the fenestrations of the drainage are in the pleural cavity, we break the sheath and remove it while introducing the drainage with the index finger (Fig. 4B) until it is finally completely inserted (Fig. 4C).

7. We check with the drainage system, provided with the PleureX kit, the proper functioning of the inserted catheter (Fig. 4D).

8. We finish by closing the largest incision with the stitch already prepared. We hold

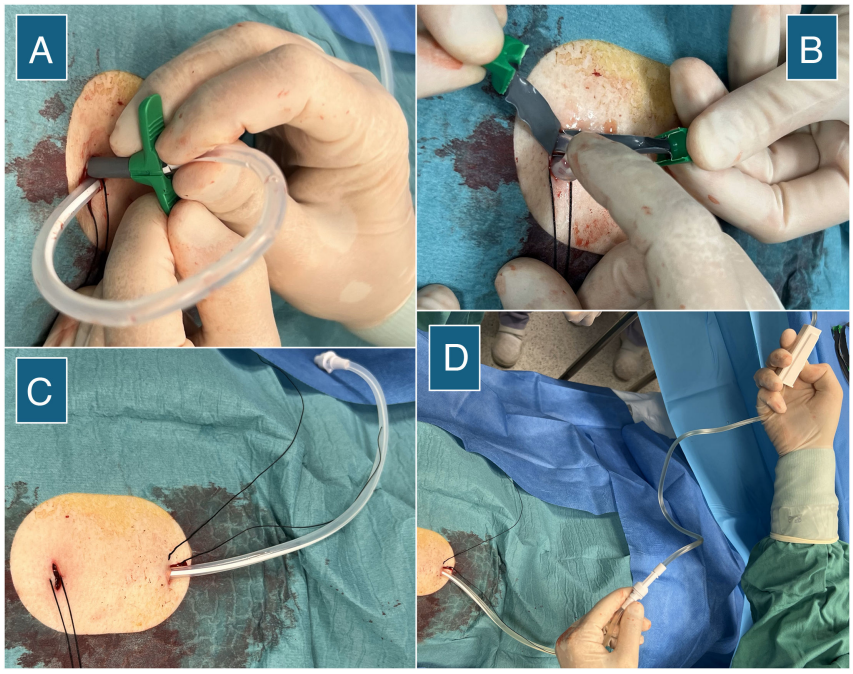

Figure 4. **A:** once the dilator and sheath are inserted into the pleural cavity, the dilator is removed and the fenestrated end of the catheter is inserted through the sheath; **B:** when the entire drain is in the pleural cavity, the sheath is broken and removed while the drain is fixed with the index finger until it is finally completely inserted; **C:** the drain has its distal end located in the pleural cavity, the polyester ring next to the proximal incision and the rest of the drainage system with the unidirectional valve remains free; **D:** the system is then tested for proper operation.

the drainage with the second stitch, without strangling the catheter, until the granuloma forms, in about 10–12 days. It is then that we will remove both stitches.

9. We finish by explaining the drainage system (bottles) to the patient and, above all, to the relative or main caregiver, and how to evacuate the liquid at home.

TPC, together with other pleural procedures (thoracic drainage and pleurodesis, thoracoscopy and pleurodesis, TPC and pleurodesis), form part of the range of treatment alternatives for symptomatic recurrent pleural effusion, both malignant and nonmalignant. The future goal to provide better care for our patients lies in changing the treatment paradigm from generic to specialized and individualized care by offering appropriate procedures in each specific case. The final choice will depend on the patient.

ETHICAL DISCLOSURES

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article. Furthermore, they have acknowledged and followed the recommendations as per the SAGER guidelines depending on the type and nature of the study.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript, nor for the creation of images, graphics, tables, or their corresponding captions.

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