Tunneled Pleural Catheters
An Update for 2013

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KEYWORDS

• Pleural effusions • Tunneled pleural catheter • Lung cancer

KEY POINTS

- Tunneled pleural catheters (TPCs) are a safe, effective, and well-tolerated option for palliation in patients with malignant pleural effusion (MPEs) on an outpatient basis.
- TPCs are incorporated into international guidelines for the management of MPEs and appear to be the most cost-effective option according to current data.

Pleural effusions are commonly encountered in clinical practice, although the exact prevalence is unknown and is likely dependent on the population studied. When small or slowly accumulating, they may go unrecognized unless the patient undergoes chest imaging for some other clinical reason. Pleural effusions have been broadly grouped categorically into transudative and exudative effusions according to the criteria of Light and colleagues.[1] In brief, this classification is based on the integrity of the filtration barrier that is considered normal in transudative effusions and impaired in the case of exudates. As such, transudative effusions are usually of low protein content, whereas exudates contain a relatively high amount of protein. Most malignant and paramalignant effusions are exudative in nature, and the primary indication for the use of tunneled catheters is malignancy.

SYMPTOMS AND MANAGEMENT OPTIONS

In health, there exists a fine balance between the secretion and resorption of pleural fluid; however, in malignancy this homeostasis can become disrupted. As there is a large reserve in the ability to clear pleural fluid under normal conditions, there is usually both an increase in fluid production and an inability to maintain adequate removal when effusions develop. Accumulation of fluid in the pleural space can lead to a myriad of symptoms including shortness of breath, cough, chest discomfort, and fatigue. It should be noted that many patients have several reasons for dyspnea, as well as for other pulmonary symptoms, during the course of their disease, and other causes of symptoms must be considered and addressed before definitive management of the pleural effusion. When effusion is the primary cause, symptoms are often relieved by removal of fluid from the pleural space, even in the context of a nonexpanding lung. In the particular case of "trapped lung," it is thought that the removal of fluid inhibits the stimulation of receptors in the hemithorax, in turn resulting in improvement in symptoms.

The impact on quality of life related to pleural effusions may be significant. Eighty-seven percent of new patients with lung cancer present with dyspnea, and 60% of patients with cancer grade their dyspnea as moderate to severe.[2,3] Dyspnea is the most common symptom associated with malignant pleural effusions (MPEs), and the majority of patients with MPEs are symptomatic. Once a patient is diagnosed with an MPE the life expectancy is typically 3 to 6 months, varying with the type of cancer. The general rule of thumb for MPE is recurrence.[4] Effusions related to breast

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cancer, small-cell lung cancer, hematologic malignancies, and other solid-organ tumor primaries will often respond to systemic therapies; therefore, definitive intervention beyond this approach may not be necessary. In this setting it is appropriate to proceed with simple drainage for symptomatic relief, pending response to the patient's systemic therapy. If, however, the pleural collection is refractory to systemic therapy, definitive management may be considered.

Talc pleurodesis and tunneled pleural catheters (TPCs) are the 2 most viable options for definitively dealing with MPEs. The decision to proceed with a TPC rather than pleurodesis depends on the patient's preference, whether the lung fully expands (necessary for pleurodesis), the patient's support systems, and other considerations. Definitive therapy should be considered once the patient becomes symptomatic to prevent trapped lung and loculation. Unfortunately, after drainage 30% of symptomatic patients with MPE do not achieve reexpansion of the lung adequate enough to allow an attempt at pleurodesis.[5] Of interest, small asymptomatic MPEs do not generally progress to the point of requiring intervention. In a 1-year study of 34 consecutive patients with known MPE from a large regional cancer center, 14 were asymptomatic.[6] These 14 patients were followed for their life span (median survival 128 days). Follow-up chest imaging was available in 13 of the 14 patients up to a median time of 98 days from first clinic visit. None of the follow-up images revealed an increase in the size of the effusions. No patient over the course of the study required pleural intervention for the index effusion. Of the patients studied, only 1 needed any subsequent intervention in the contralateral pleural space.

PATIENT SELECTION

A major advantage of the TPC as an option for treatment of MPE is the liberal patient selection. Performance status and operative risk have little impact on patient selection. Given that this patient population is at risk for multiple conditions leading to dyspnea (ie, lymphangitic carcinomatosis, anemia, radiation fibrosis, pulmonary embolus, pericardial disease, emphysema), often a therapeutic thoracentesis is performed before TPC insertion. Thoracentesis allows the provider to determine response to drainage, confirm whether the lung is able to reexpand, and assess how rapidly the effusion reaccumulates, if ever. If the lung is unable to reexpand sufficiently, few therapeutic options exists other than TPC. Decortication is infrequently performed for malignant lung entrapment, and an inability of the lung to adhere to the chest wall precludes successful pleurodesis. Conversely, there is no need for a TPC if the fluid does not reaccumulate following a large-volume thoracentesis or if symptoms are not improved by the procedure.

Patients with very short life expectancies (days to weeks) or those who are debilitated may be better served with other treatment options such as intermittent thoracentesis or nontunneled small-bore chest tubes. In these patients, the cost of intermittent drainage supplies and protection from pleural infection from a tunneled catheter may not confer any significant benefit. On the other hand, a TPC attached to a leg bag for continuous drainage is an inexpensive and well-tolerated method to achieve pleural drainage during the end stage of life. Other contraindications to TPC placement include coagulopathy, extensive malignant skin involvement (eg, inflammatory breast cancer), infection over the site of insertion, and multiloculated or septated effusions that would not drain even with a pleural catheter in place.

THE TUNNELED PLEURAL CATHETER SYSTEM

The TPC system is composed of a silicone catheter allowing ambulatory pleural drainage, on an intermittent basis, into plastic vacuum bottles. The catheter is composed of silicone with fenestrations at its distal margin (ie, the portion within the thoracic cavity) and a one-way valve on the proximal, external end for drainage purposes. A polyester cuff midway along the catheter acts as barrier to infection and promotes granulation tissue to secure the catheter in place. A special adapter is required to open the one-way valve at the proximal end of the catheter before drainage. This adapter is located on individual drainage lines and also on vacuum bottles specifically designed for this purpose. When the TPC is not being drained, a cap is placed over the one-way valve as an extra measure to ensure the valve remains clean and secure.

CATHETER PLACEMENT

Cather placement does not require inpatient admission and may be performed anywhere there is patient monitoring and a sterile environment; this may be in the intensive care unit, ambulatory procedure center, or operating room. Although topical anesthesia is standard, the type and dosages of other medications (such as intravenous analgesics or sedatives) varies.

There is no single ideal insertion site for all patients. Determinants of tube position include patient anatomy, location of the effusion by transthoracic ultrasonography, and patient comfort. Catheters should avoid breast tissue, excessive skin folds, undergarments, skin infection, and cutaneous tumor. It is preferable to avoid prior radiation fields, as the skin and soft tissues may be less amenable to tunneling of the catheter. Furthermore, lateral catheters may disrupt sleep for those who lie on their side. If the effusion is not loculated, positioning of the catheter just above the hemidiaphragm is optimal for drainage.

During placement, patients may be positioned semirecumbent with their ipsilateral arm over their head, or alternatively in the seated position with their arms crossed over a tray table, similar to during a thoracentesis. Patients may also be positioned in the lateral decubitus position with the affected side up. The best position depends on the clinical situation, operator preference, and patient factors already described.

In addition to physical examination, radiographic imaging may identify the most appropriate entry site. Ultrasonography can be particularly helpful in the setting of more complex fluid collections, metastatic involvement of the pleura, or the presence of adhesions. To avoid complications such as bleeding, it is best to avoid having the catheter traverse a metastatic deposit or breech an adhesion. In addition, ultrasonography allows the operator to confirm that he or she is indeed intrapleural and not in a subdiaphragmatic fluid collection.

The entry site is marked with a pen or by other indelible means. After preprocedural planning, the skin is cleansed with chlorhexidine over an extended surface that allows for a sterile margin around the catheter entry and exit sites, as well as along the entirety of the tunnel. Broad sterile drapes are applied, and additional drapes beyond those provided in the preprepared catheter kits are often necessary to ensure sterility throughout the procedure (**Box 1**). The operator dons personal protective wear including a hat, mask with face shield, sterile gown, and gloves. Lidocaine is used to inoculate the skin and soft tissues to the level of the parietal pleura and along the length of the tunnel site. Quantities as high as 40 mL of 1% lidocaine have been used routinely without complication. Of note, an entry site in the middle of the rib space as opposed to just above the rib is often selected to avoid kinking of the catheter on the rib. Bending of the catheter on the rib can lead to difficulties with drainage.

The track having been identified during the initial anesthesia, a guide needle with overlying sheath is then advanced while aspirating. Once a flash of pleural fluid is seen, the sheath is advanced into the pleural space and the needle removed (**Fig. 1**). A guide wire is passed through the sheath and into the pleural space, then the sheath is removed (**Fig. 2**). Two 1-cm incisions are made at the entry and exit sites, respectively (**Fig. 3**). The incision size should allow the catheter to fit tightly beneath the skin, minimizing the risk of dislocation of the catheter. The catheter is tunneled from the exit site toward the pleural entry site (ie, the site of the guide wire) (**Fig. 4**). The polyester cuff sits just beneath the skin at the exit site to allow for its access at the time of catheter removal. Thereafter, the entry site is dilated, the dilator and guide wire removed, and a peel-away sheath left in place. The catheter is rapidly advanced through the sheath to minimize the flow of air into the pleural space. Once the entire catheter has been advanced through the sheath, a thumb is placed over the silicone tubing and the sheath peeled apart and removed (**Fig. 5**). The exit site is closed and the catheter secured in place with suture material.

Box 1
List of supplies recommended for TPC insertion in addition to the supplied kit

Required Supplies in Addition to TPC Insertion Kit:

- Antiseptic (chlorhexidine, povidone-iodine)
- Personal protective equipment
- Sterile drapes
- Vacuum bottles or wall suction
- Ultrasound

Fig. 1. A guide wire is advanced into the pleural space.

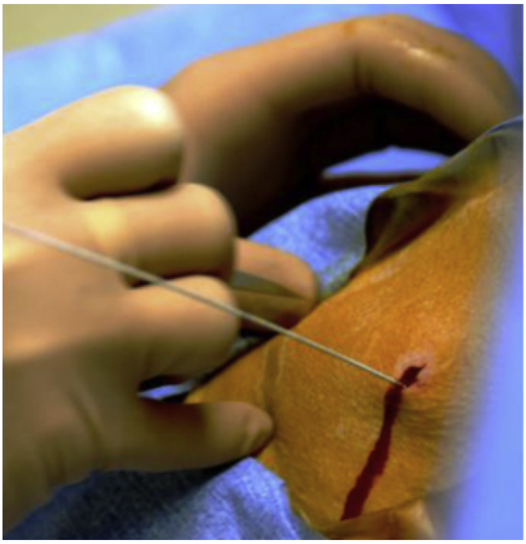

Fig. 2. Catheter is tunneled beneath the skin.

Fig. 4. A dilator is advanced over the guide wire into the pleural space.

Once the catheter is secured, the pleural space is drained. The drainage line is connected to the one-way valve at the end of the TPC and pleural drainage is initiated into a wall suction apparatus or vacuum bottle. Pleural fluid is removed as tolerated until a maximum volume is achieved or the patient develops symptoms such as cough, pain, or dyspnea. The drainage system is then disconnected and the plastic valve cap provided is clicked onto the valve. The incisions are sutured and a dressing applied. A foam drain sponge may be placed over both incisions with the catheter through the central opening and curled over the sponge. The sponge and catheter may then be covered by 2 to 4 layers of gauze and a self-adhesive water-resistant dressing (**Fig. 6**). A chest radiograph is typically performed following catheter insertion to ensure adequate placement and lack of complications. Once the radiograph is reviewed by the physician, the patient may be discharged home.

ROUTINE CATHETER DRAINAGE

Supplies for drainage are ordered in bulk for ongoing drainage. Typically the packages include

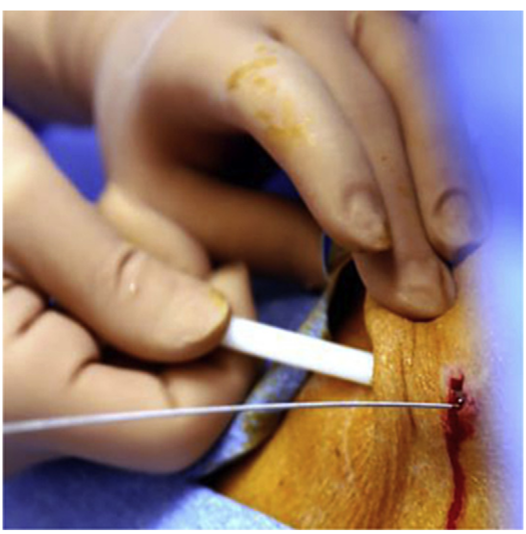

Fig. 3. Catheter is tunneled beneath the skin.

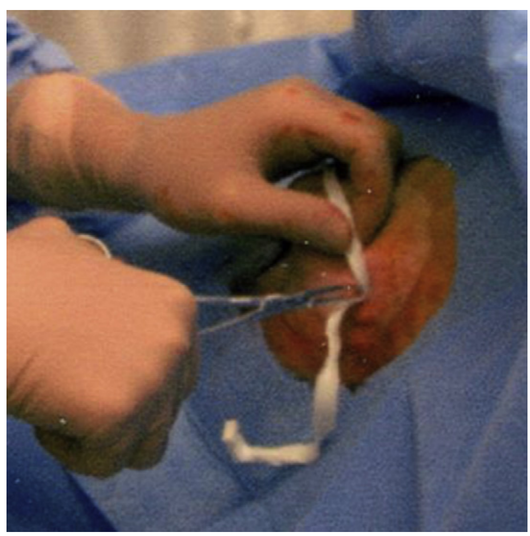

Fig. 5. The peel-away sheath, which allows the catheter to be introduced, is removed after catheter insertion.

Fig. 6. The catheter is coiled upon itself to allow for dressing application.

gloves, sterile supplies, dressings, and drainage bottles (500 mL and 1 L). At present, the standard of care is to drain the catheter intermittently, either on alternate days or 3 times weekly. On rare occasions when patients are producing large volumes of fluid on a daily basis, the frequency of drainage is increased to daily, or a leg bag is connected to the catheter to decrease costs and the need for frequent drainage procedures. In a current multicenter study, patients are being randomized to daily versus intermittent drainage to test the hypothesis that daily drainage improves symptom management and results in more rapid eradication of the pleural space. As suggested earlier, the amount of fluid that can be drained varies significantly between patients. Removal of volumes as high as 1 L has been shown to be safe, and does not require volume repletion with colloids or crystalloids. In select cases where patients have bilateral catheters, more attention to volume shifts may be necessary. Drainage is discontinued when the flow stops, indicating an evacuated space, or when the patient becomes symptomatic. Some patients complain of chest tightness and others of refractory cough when they reach their symptomatic limit, although symptoms depend on the individual. Persistence of drainage beyond the onset of symptoms may result in protracted discomfort on the part of the patient, and is not advised.

ONGOING CARE OF THE PATIENT WITH A TPC

Patients with indwelling tunneled catheters benefit from continuity of care and accessibility to a team experienced in not only insertion but also the long-term management of these devices. This goal often is achieved in the context of multidisciplinary teams with one or more chest physicians, oncology and palliative care providers, skilled nursing personnel, mid-level practitioners, and family members or friends. The patient and others specially trained in the management of tunneled catheters perform the chronic management of the catheter. Ideally patients and their families receive training on the method of catheter drainage, application of dressings, sterile technique, and indications for reaching health care providers if problems arise. When the patient is not in a facility or home nursing is not arranged, initial education may include videos, reading materials, and observation of drainage by members of the health care team.

A routine follow-up visit is generally scheduled for all patients 2 weeks after insertion. At this time, a radiograph is performed and symptoms, concerns and complications are addressed. The incisions are inspected and sutures are removed if not done by the home care team. Patients are then seen on an as-needed basis if problems or new symptoms arise, or if catheter removal is indicated.

DISCONTINUATION OF THE TPC

The effusions stops accumulating, or pleurodesis occurs, in approximately 50% of patients who have a TPC placed for malignancy. The rate of spontaneous pleurodesis is higher in patients whose lungs fully reexpand following catheter insertion, suggesting the importance of maintaining pleural apposition and minimizing residual fluid in the pleural space. In these cases, the catheter can be removed because it is no longer serving its purpose, and to avoid infection from having a foreign body in place.

The authors' criterion for catheter removal is drainage of less than 50 mL on 3 consecutive attempts in the absence of increasing symptoms or an accumulating effusion on radiography. Catheter removal does not require hospitalization or intravenous medications. Typically the skin surrounding the exit site is cleansed, and approximately 5 mL of 1% lidocaine is infiltrated around the tissue cuff with a 25-gauge needle. The catheter is then withdrawn by applying a steady and firm traction on the catheter with a circular motion. Occasionally small forceps may be required to free the cuff from the subcutaneous tissues. Steri-strips and a dry dressing are applied to the exit site. On occasion, a significant amount of pleural fluid drains from the site following removal of the TPC, likely from loculated fluid pockets near the insertion site. The authors have managed this by applying an ileostomy system over the incision to contain the fluid, which can usually be removed within 48 hours as drainage stops.

COMPLICATIONS

TPC placement and maintenance is safe and free of complications in the vast majority of patients. Complications include infections, clogging of the catheter, or other rare events. Empyema can occur in 1% to 5% of patients, usually late in the course of treatment.[7,8] Empyema has been successfully treated using a combination of intravenous antibiotics and continuous pleural drainage through the TPC. In certain circumstances, additional small-bore chest tubes or thrombolytics for loculated infections may be necessary. The TPC can be removed once the infection has resolved, as the pleural space usually achieves symphysis secondary to inflammation from the infection. Cellulitis has been reported in up to 7% of patients,[8] but has been lower in the authors' experience (1.4%). Cellulitis is usually an early event and responds to oral antibiotics without the need for catheter removal.

Patients often notice fibrin deposits partially occluding the tube. These deposits will often clear spontaneously during drainage, and rarely occlude the TPC itself. However, they may block the drainage line. In rare cases, the tube may need to be flushed with sterile saline and then aspirated to dislodge the fibrin. Before flushing the tube, it may be prudent to attempt a second drainage with a new bottle, as failure to drain may be attributable to loss of suction in the first bottle.

Significant bleeding necessitating catheter removal is rare, although fluid drained is often bloody in appearance. The hematocrit of the fluid can be measured, but is rarely found to be elevated and should not be considered the sole cause for anemia in most patients. In addition, a recent article by Fysh and colleagues[9] described fracture of the catheters on removal. Fortunately, none of the patients described had any significant negative effects related to the portion of the catheter remaining in situ.

There exist patients who have failed attempts at catheter insertion, develop loculated fluid collections, or develop recurrence after removal of the catheter. If symptomatic loculations occur while the TPC is still in place, administration of thrombolytics may facilitate drainage. Ultrasound-guided placement of a new catheter into large loculations may ameliorate dyspnea and therefore may be considered. Finally, extrapleural extension of the tumor through the insertion site can be seen. This extension occurs in fewer than 3% of cases and is rarely clinically significant, but may respond to local radiation treatment if symptomatic.

EVIDENCE FOR USE OF TPC

TPC placement allows for the safe and effective palliation of MPE in an outpatient setting. Management of symptoms as an outpatient allows patients to maintain control over their lives and minimizes time spent in the hospital. The first and largest study demonstrating the effectiveness of TPCs in the palliation of MPE was published in 2006 by Tremblay and Michaud,[8] who placed 250 catheters in 223 patients. Following successful placement of the TPC, no further ipsilateral procedures were required in 90% of the cases and symptom control was partial or complete in 88.8% of patients. The catheters stayed in place for a median duration of 56 days. Spontaneous pleurodesis occurred at a rate of 42.9% in all patients, and when the population was limited to those whose lungs fully reexpanded following catheter insertion, the rate was in the range of 60%.

A systematic review published in 2010 by Van Meter and colleagues[7] included 19 reports comprising a total of 1370 patients. Symptom improvement was noted in 95.6% of patients and spontaneous pleurodesis in 45.6%, allowing for catheter removal in 47.1% of those patients. Recurrence of the effusion after catheter removal ranged from 5.1% to 7.7%. The reports included in the review were consecutive case series with the exception of one randomized trial. The review concluded that TPCs are safe and that prospective randomized studies comparing the TPC with pleurodesis are needed before recommending TPC as first-line therapy.

One study comparing TPC with talc pleurodesis included 106 patients randomized to receive an outpatient TPC versus hospital admission for placement of a 12F percutaneous chest tube and talc pleurodesis.[10] The primary outcome was dyspnea at 42 days. The study concluded that both methods are highly effective at relieving dyspnea, and no significant difference was identified in the frequency of chest pain or quality of life. A reduction in hospital stay and improved dyspnea were noted as secondary outcomes 6 months postprocedure in the TPC group. There was also a 16% absolute reduction in the proportion of patients requiring further pleural interventions in the TPC group. In light of the limited life span of patients with pleural effusions, TPCs show promise in requiring fewer hospital days, improving dyspnea, and decreasing the need for additional procedures.[11]

As described earlier, lung reexpansion must be considered when determining prospects for pleurodesis. In the case of patients with nonexpanding lungs, TPCs remain one of the sole options for palliation of dyspnea related to recurrent malignant effusions. A survey of patients with nonexpanding lungs demonstrated that nearly 50% were either very or moderately satisfied with their symptomatic relief following insertion of a TPC.[11] Of note, it is suggested to stop drainage at the onset of chest discomfort to avoid pain associated with drainage of a nonexpanding lung, as pain can persist for several hours to days in this scenario.

Hybrid approaches using TPC insertion at the same time as thoracoscopic talc pleurodesis have been proposed.[12] In this study, a TPC was placed under direct thoracoscopic guidance immediately following talc poudrage. A 24F chest tube was inserted into the port site and maintained for 24 hours to ensure resolution of pneumothorax. The TPC was drained 3 times on the first postoperative day, twice daily on days 2 and 3, and then daily until less than 150 mL was drained. The intent of this approach was to reduce the number of days in the hospital after thoracoscopy, as well as to reduce the time that the patient maintains the TPC. This pilot study for rapid pleurodesis included 31 patients. The mean duration of hospital stay was 3.19 (standard deviation [SD] 3.04) days, and the TPC was removed at a mean of 16.65 (SD 30.8) days. Successful pleurodesis occurred in 92% of the patients at 6 months. The rapid pleurodesis approach allows for most patients to be discharged home in 48 hours and have the TPC removed in 2 weeks, thus giving them the benefits of a shorter admission than for conventional thoracoscopic pleurodesis and freedom from prolonged tunneled catheter drainage. Additional studies are required.

TPCS IN MESOTHELIOMA

Pleural effusions are common in malignant mesothelioma (MM), and methods to relieve the associated respiratory symptoms are important in this incurable disease. The most common procedure for palliation of symptomatic effusions in this setting has traditionally been talc pleurodesis. Recently, TPC insertion has also been described. A single-center retrospective review included 26 patients treated with 31 TPCs.[13] Complete or partial symptom control was obtained in 93.5% of patients and spontaneous pleurodesis occurred in 38.7%. Seeding of the catheter tract was not reported as a complication, although it does remain a concern in MM. If this was to occur, it could be managed effectively with local radiation therapy to the site.

TPCS IN CHYLOTHORAX

Chylothorax in patients with cancer is difficult to manage, and primary treatment is focused on the underlying malignancy. Unfortunately, in patients with poor or no response chylothorax may become debilitating by causing significant dyspnea. There is a paucity of data regarding the use of TPCs in this setting. The largest review compared 19 patients with malignant chylothorax: 10 treated with a TPC and 9 by other palliative measures.[14] All patients with a TPC had symptom relief and 60% of the patients achieved pleurodesis. Ongoing drainage did cause a decrease in serum albumin, but was not significantly different to that in patients undergoing other palliative procedures.

TPCS AND BENIGN DISEASE

Although there are case reports and case series documenting the usage of TPC in the palliation of end-stage benign diseases such as heart failure and hepatic hydrothorax, there are insufficient data to be able to comment on their efficacy and long-term safety at present.

COST-EFFECTIVENESS OF TPC FOR MPE

Because of the ongoing expense of the drainage system and the need for home care, cost is considered a potential barrier to the placement of TPCs; this holds particularly true for patients unable to self-drain and who have no available friends or family to assist. In this scenario, the cost burden includes supplies but also visiting care providers. However, Olden and Holloway[15] showed that the overall cost-effectiveness of TPCs was equivalent to that of pleurodesis via a talc slurry. The cost and effectiveness of the modalities were reported as follows: talc $8170.80 and 0.281 quality-adjusted life years (QALYs); TPC $9011.60 and 0.276 QALYs. In patients with a limited life expectancy (ie, $\leq$6 weeks), TPC placement was found to be more cost-effective. The greatest limitations of this analysis are that the investigators used a simple model and considered talc pleurodesis via slurry as the only alternative to TPC. Many centers perform pleurodesis via thoracoscopy rather than slurry, and this was not analyzed. With respect to the simple nature of the model, it did not consider the ongoing costs of care and, in particular, the impact when the palliative attempts fail. The model assumed that patients did not receive modalities that accrued cost or affected quality of life beyond the initial modality. An abstract presented by the authors at the American Thoracic Society (ATS) international conference in 2011 compared the cost benefit of talc pleurodesis by video-assisted thoracoscopic surgery (VATS), medical thoracoscopy (MT), and talc slurry (TS) with that of TPCs.[16] TPCs were the most cost-effective at $1958/quality-adjusted life month (QALM) and dominated the other 3 options: $19,149 per QALM for VATS, $9844/QALM for MT, and $8737/QALM for TS. Sensitivity analyses failed to identify factors associated with significant changes in cost-effectiveness. This model did consider potential failures and was iterative in nature. A subsequent study by Puri and colleagues[17] also suggested that TPCs are the preferred treatment for patients with MPE and limited survival. As such, the available cost-benefit data would suggest that tunneled catheters do provide a cost-effective means to palliate symptomatic patients with malignant effusions, particularly so when life expectancy is short and protracted draining periods are unlikely.

SUMMARY

TPCs are a safe, effective, and well-tolerated option for palliation in patients with MPEs on an outpatient basis. TPCs are incorporated into international guidelines for the management of MPEs and appear to be the most cost-effective option according to current data.

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