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REVIEW

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Indwelling pleural catheters for the treatment of malignant pleural effusions; where are we now?

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ABSTRACT

Introduction: Malignant pleural effusions (MPE) affect many patients with advanced malignant disease and lead to significant symptomatic burden. Management is primarily focused on controlling symptoms. IPCs are considered an alternative treatment strategy to chemical pleurodesis and in randomized clinical trials, are shown to have comparable outcomes with regards to symptom management such as dyspnea score and quality of life, and are associated with shorter length of hospital stay. Additional studies have examined the optimal drainage strategy for IPCs and the combination of IPC and pleurodesis. The most common complication is infection, and management differs based on the specific infection type. For many patients, IPCs are likely a cost-effective option for management of MPE compared to alternative approaches.

Areas covered: This review article details the role of the indwelling pleural catheter (IPC) for symptom control, strategies for management, removal, complications, cost-effectiveness, and future directions.

Expert opinion: There are various management options for MPE, each with their own advantages and disadvantages. Management should be personalized, with full knowledge of the patient's life expectancy, pleural space physiology, risks and benefits of each approach, and most importantly patient preferences.

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Indwelling pleural catheter; malignant pleural effusion; pleurodesis; Thoracoscopy; Pleural effusion

1. Introduction

Malignant pleural effusions (MPE) are common affecting 200,000 individuals in the United States annually [1]. MPE is associated with significant symptomatic burden, primarily presenting as dyspnea and chest discomfort. In the US alone, MPEs result in up to 125,000 hospital admissions and $5 billion in healthcare costs annually [2]. While most cancers can metastasize to the pleural space, the most common primary malignancies leading to MPE are lung, breast, and hematologic malignancies [2]. While advancements in cancer therapeutics have led to an improved life expectancy, the global prevalence of cancer is rising, leading to an expected rise in the prevalence of MPE [3].

Except for primary pleural malignancies, a diagnosis of MPE represents advanced malignant disease. Survival varies based on the histologic type of the primary malignancy as well as patient-specific factors. In one study, survival ranged from one month to eight years with a median survival of 5 months [4]. Given the short life expectancy and often terminal diagnosis that accompanies an MPE, management is primarily palliative in nature, focusing on symptom control to maximize quality of life.

After initial histologic diagnosis of an MPE is made, recurrence is common. Fifty-five percent of patients will require another pleural procedure, with 58% of those occurring within two weeks, considered to be 'rapid reaccumulation' [5]. Most (80%) of patients with MPE present with moderate to large effusions, and 77% are symptomatic, most commonly with dyspnea (57%) [6,7]. For patients with recurrent and symptomatic MPE, management options include serial thoracenteses, pleurodesis, indwelling pleural catheter (IPC) placement, decortication by video-assisted thoracoscopic surgery or open thoracotomy, or a combination of these procedures. Pleurodesis may be performed chemically through a chest tube (most commonly with talc) or via thoracoscopy by either chemical or mechanical means. For patients with a longer life expectancy, a definitive treatment option may offer fewer hospitalization days, fewer exposure to invasive procedures, and more consistent symptom management compared to serial thoracenteses.

Prior to the popularization of the IPC, pleurodesis was the mainstay for definitive treatment for recurrent symptomatic MPEs and a grade A recommendation by the 2010 British Thoracic Disease Guidelines [8]. Because pleurodesis requires apposition of the visceral and parietal pleura, it cannot be performed in those with non-expandable lung – which occurs in roughly 20% of patients – and thus another modality, such as IPC is used [9]. One of the earliest predecessors to the indwelling pleural catheter was a Tenckhoff catheter placed by Robinson et al in 1994, allowing nine patients with MPE the ability to drain at home, avoiding further hospitalizations and interventions [10]. Other early advances in safe, repeated drainage of the pleural space included placing a pleural port and pleural catheter placement [11,12].

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Article highlights

- Malignant pleural effusions are becoming increasingly prevalent and management is primarily directed at palliating the patient's symptoms.
- The indwelling pleural catheter has emerged as an alternative to chemical pleurodesis for control of MPE associated symptoms, with several trials noting similar symptomatic benefits, including dyspnea score, as well as quality of life between the two therapies.
- Compared to those with pleurodesis, patients with indwelling pleural catheters have fewer hospitalization days.
- Indwelling pleural catheter management can be individualized to meet each patient's needs through customization of drainage frequency and combination therapies.
- Although complications occur, many are manageable without hospitalization or removal of the indwelling pleural catheter.
- Indwelling pleural catheters are cost-effective treatment strategies for malignant pleural effusion management, especially in patients with limited life expectancy and high rates of fluid recurrence.

Following these initial successes, the IPC was developed. A fenestrated, smaller bore (15.5 French) silicone catheter, the IPC contains a valve on the distal end to prevent drainage unless the proper access equipment is connected. When drainage is desired, patients can easily connect the vacuum-sealed chamber to their catheter, allowing for control of their symptoms at home. The FDA approved the first catheter for use in 1997 [13]. Since that time, additional catheters have been introduced to the market.

This review is focused on IPC, and below we will discuss the role of the IPC in symptom control, provide specifics in managing catheters and their complications, discuss cost effectiveness, and postulate what the future of pleural effusion management with IPCs holds. A comprehensive search was conducted in major biomedical databases including MEDLINE, Embase, and the Cochrane Central Register of Controlled Trials, using a combination of keywords such as 'indwelling pleural catheter,' 'pleural effusion,' 'malignant,' 'cost effectiveness,' and 'management.' Studies involving adult human subjects and articles published in English were included. Both randomized controlled trials and observational studies (retrospective and prospective cohorts, case series, and case reports) were considered for inclusion, depending on the scope. After the initial search, titles and abstracts are screened for relevance, followed by full-text review of potentially eligible articles which were included and referenced in the manuscript text.

2. Role of IPC in symptom control

The role of the IPC as a definitive management strategy for recurrent symptomatic MPE is established in prospective and retrospective studies. Early studies of IPC in MPE demonstrated significant improvement in dyspnea scores [14,15]. These studies established IPCs as an important alternative management strategy. Subsequent studies focused on the role of IPCs in patient-centric outcomes such as dyspnea, quality of life (QOL), and hospital length of stay, replacing spontaneous pleurodesis as the main outcomes. The two landmark trials that cemented its role in symptom management in comparison to talc pleurodesis are the TIME2 and AMPLE trials.

The TIME2 trial was a multicenter randomized controlled trial (RCT) conducted in the United Kingdom that included 106 patients with proven or highly suspected MPE who were randomized to either IPC or chest tube with talc pleurodesis (TP). At 42 days following IPC placement, patients had improved on average 37.00 mm on the validated visual analog scale (VAS) of dyspnea, a clinically significant difference [16,17]. Additionally, 86% of patients had a statistically significant improvement in their dyspnea score. However, when compared to TP, there was no significant difference at 42 days or 3 months. In this study, QOL was measured by the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-30). As with dyspnea, there was improvement at 42 days in those who received an IPC, but no significant difference when compared to TP [16].

Similarly, the AMPLE trial was a multicenter, multinational RCT that included 146 patients with histologically proven or suspected MPE. Following IPC placement, dyspnea measured by VAS was improved at day one and was sustained for 12 months, but was no different when compared to TP [18]. The AMPLE trial studied QOL as a secondary outcome as well, using a VAS for QOL as well as a modified EuroQol 5 Dimensions (EQ5D). Quality of life increased after IPC placement by both tools, and was maintained throughout the period, similar to TP [18].

For many patients, a key component to QOL is time spent at home. IPC placement is mainly performed as an outpatient procedure while pleurodesis often necessitates inpatient stay. In both the TIME2 and AMPLE trials, the IPC group had fewer initial procedure-related hospitalization days and less time readmitted to the hospital in the 12 months following the procedure [16,18]. In the AMPLE trial, repeat pleural procedures were more common in the TP group. Both trials demonstrated a higher number of adverse events in the IPC group. Older RCTs, such as the study by Putnam et al, NVALT-14, and CALGB-30102 comparing IPC and TP have shown similar findings to the TIME2 and AMPLE trials (see Table 1) [19–21].

TP (slurry or poudrage) failure rates increase over time, from 10%–28% at one month, to ~30% at three months, and 28%–50% at six months [22–24]. The TIME2 trial showed a difference in dyspnea at 6 months that favored IPC. The AMPLE study reported a slight, nonsignificant trend toward favoring IPC over TP for dyspnea at 12 months. These factors may make IPC placement a more attractive option for patients with a longer life expectancy. Ultimately, any MPE study of this time frame is limited by attrition due to death; in the AMPLE study, only approximately one third of original patients were alive at 12 months.

Given the limited survival in patients with MPE, a more suitable approach to understanding how IPC placement impacts symptoms and QOL may be the quality-adjusted life years measurement. Ost et al studied quality-adjusted life days using the Short Form Six Dimension (SF-6D) in patients with MPE who received IPCs. Following IPC placement, although dyspnea improved, there were only moderate improvements in utility. Patients who were most dyspneic

Table 1. Randomized controlled trials evaluating IPC placement vs chemical pleurodesis.

Trial	Comparator Group	IPC Drainage Strategy	Primary Outcome	Notable Secondary Outcomes
Putnam et al. [20]	Doxycycline Pleurodesis (DP) via Chest Tube	Every other day or as required for relief	Fewer initial hospital days in IPC group vs DP group (1.0 vs 6.5, $p < 0.001$)	At 30, 60, and 90 days, similar improvements in Guyatt CRQ, Borg score at rest and with exercise – except for dyspnea at 30 days (Borg, exercise) for which IPC was favored ($p = 0.05$).
CALGB-30102 Demmy et al. [21]	Talc Slurry Pleurodesis via Chest Tube	Daily drainage	No significant difference in composite outcome: 1) patient alive, 2) no effusion recurrence 3) lung expansion ≥90% 4) intervention complete by 2 weeks	IPC group: improved activity without dyspnea and survival with effusion control at 30 days, both driven by subgroup of patients with incomplete lung expansion
TIME2 Davies et al. [16]	Talc Slurry Pleurodesis via Chest Tube	3x weekly or as required for relief	No significant difference in dyspnea (VAS score) at 42 days	IPC group: improved dyspnea at 6 months ($p = .01$); fewer hospital days initially at one year (both $p < 0.001$). No difference in mortality, QOL, or adverse events
AMPLE Thomas et al. [18]	Talc Slurry Pleurodesis via Chest Tube	Guided by symptoms	Fewer hospital days in IPC group over 12 months or until death (median 10 days vs 12 days, $p = 0.03$)	IPC group: needed fewer repeat pleural interventions ($p = 0.001$). No difference in dyspnea, QOL, mortality.
NVALT-14 Boshuizen et al. [19]	Talc Pleurodesis via Chest Tube	Guided by symptoms	No statistically significant difference in improvement in dyspnea (MBS)	No statistically significant difference in hospital days, re-interventions, or number of adverse events.

and those who received chemotherapy following IPC placement had the greatest increases in utility, suggesting that dyspnea may only be one component of overall QOL for patients with MPE, and studies should focus on more comprehensive approaches [25].

While potential benefits of IPCs in symptom control, hospitalization time, and QOL were noted above, several studies have highlighted drawbacks. A consideration for patients with an IPC is the time spent draining at home. A multicenter survey of 105 patients published by Mitchell et al highlighted other relevant and less frequently studied aspects of living with an IPC. Two weeks following IPC placement, 36% reported discomfort with home drainage and 63% reported that the catheter reminded them of their disease. However, avoiding hospitalization was an important benefit to IPC for 95% of patients [26]. Shared decision-making including education on post-IPC placement care and potential drawbacks will help patients and providers determine the best course of action for their specific situation.

3. Drainage frequency

One method that has been studied to expedite spontaneous pleurodesis is drainage frequency. Depending on the degree of lung expansion and volume of fluid present, drainage of the pleural fluid can create pleural apposition. Maintaining pleural apposition combined with inflammation from the catheter or underlying malignancy is thought to lead to pleurodesis [27]. This has been examined in two RCTs, AMPLE2 and ASAP. In the ASAP trial, patients were randomized to daily or every other day drainage (standard management). At 12 weeks, complete and partial pleurodesis (indicating some fluid still present on chest X-Ray) were achieved in 30% and 16% of the patients, respectively. This was significantly higher than the standard arm, with 24% and 16% of patients achieving complete and partial pleurodesis, respectively [28]. No difference in performance status was noted between groups. The AMPLE2 trial compared daily drainage to symptom-guided drainage. Both at 60 days and at 6 months, daily drainage was the superior strategy in terms of rate of spontaneous pleurodesis (for daily and symptom-guided: 37.7% and 11.4% at 60 days; 44.2% and 15.9% at 6 months, respectively) [29]. Notably, dyspnea measured by VAS was not significantly different between groups. In both the ASAP and AMPLE2 trials, there was no difference in complications, especially catheter-related infections between the drainage strategies [28,29]. Providers should consider the patient's expected lifespan and goals of treatment when deciding a drainage strategy.

4. IPCs and combination therapies

Another approach currently being evaluated is the combination of an IPC with chemical pleurodesis. The goal of combination therapies is to maximize time at home and minimize the time to pleurodesis following outpatient IPC placement and pleurodesis. In the IPC-Plus study, following IPC placement and daily drainage for 10 days, patients were randomized to 4 grams of talc or placebo instilled in the IPC, assuming they had evidence of expandable lung. The talc arm had increased rates of pleurodesis at 35 days (43% vs 23%) compared to the placebo arm. Patients in the talc arm additionally experienced either equal or significantly improved QOL, dyspnea, and chest pain scores. No differences in adverse events or hospitalization were noted, including rate of catheter blockage [30]. Notably, the IPC plus talc arm had a much lower pleurodesis success rate compared to historical talc pleurodesis rates [21].

In another combination therapy study, the Optimum trial, patients were randomized to outpatient IPC placement followed by outpatient talc pleurodesis via IPC and aggressive drainage on day 4 if non-expandable lung was ruled out. The comparator arm was pleurodesis by talc slurry via chest drain. In the IPC group, roughly half the patients received talc pleurodesis. No change in the primary outcome, global health status measured by EORTC QLQ-C30, was noted. There was a higher pleurodesis failure rate and higher adverse intervention-associated events in the IPC arm [31].

The SWIFT trial was a comparison of standard IPC treatment with a novel silver nitrate coated indwelling pleural catheter (SNCIPC). Silver nitrate on its own is an effective pleurodesis agent and the SNCIPC had shown success in animal models [32]. However, when compared to a standard IPC, the SNCIPC was less effective at inducing pleurodesis. A post-hoc analysis suggested that the SNCIPC may have induced more loculations that led to its inability to produce pleurodesis [32]. These newer methods of treating MPE, along with further studies such as the currently ongoing AMPLE-3 and TACTIC, will add to the ever-expanding array of treatment options available to patients.

5. IPC removal

For many patients, despite limited life expectancy, catheter removal is a common occurrence. Spontaneous pleurodesis, although not always the primary goal, occurs often with IPCs. When cessation of drainage occurs (i.e. less than 50–150 ml removed on three consecutive drainage attempts [14]) and patients are found to have no residual fluid on imaging, spontaneous pleurodesis is deemed to have occurred and the catheter can be removed. The frequency at which pleurodesis occurs and the time to pleurodesis varies. Older observational and retrospective studies noted a rate ranging from 42% to 51%, with one study citing median time of 59 days [14,16]. More recent RCTs examining drainage frequency found longer times to and lower rate of pleurodesis in patients with standard drainage strategies [27]. Predictors of increased rate of spontaneous pleurodesis include cancer type (lymphoma, ovarian cancer) and higher functional status (Eastern Cooperative Oncology Group [ECOG] performance status score < 2) [33]. Following pleural infection, spontaneous pleurodesis often occurs [34]. In addition to pleurodesis, indwelling pleural catheters can be removed due to patient discomfort or pain that is not controllable with analgesics, which is uncommon [35].

Removal of the IPC is typically done in the outpatient setting. Catheter fractures with retained portions of the catheter have been reported [36]. In some cases, during IPC removal, pleural catheters have been reported to fracture, leading to retained parts of the catheter. In a retrospective review by Fysh et al fracture reported in nearly 10% of removals [37]. In four of the six cases, no adverse events including infection were noted [37]. Given the palliative intent of IPCs, shared decision-making whether to undergo invasive procedures for removal of retained catheters is warranted.

6. Complications

Given the large number of repeated, sterile drainages performed by patients and their caregivers, the potential for IPC-related infections can cause distress for patients. According to a meta-analysis of 41 pooled studies (Table 2), the complication rate following IPC placement is 20.3%, the most common of which is infection (5.7%) [38]. The most common types of infection following IPC placement are pleural infection and empyema (combined, 1.9%), cellulitis (0.9%) and wound infection (0.4%). For cellulitis and exit-site infections, a short course of antibiotics can be given as long as the tunnel site is not involved, which may require catheter removal [39].

In general, other than noting frank pus via the pleural catheter, the diagnosis of IPC-related pleural infection can be challenging. Often, pleural fluid studies in patients with MPE will have similar laboratory markers including elevated LDH and decreased glucose and pH that are typically used to diagnose non-IPC related pleural infections. The laboratory markers may be changed from the patient's prior studies, suggesting pleural infection. Positive cultures are not always indicative of infection, as many catheters become colonized, although the true prevalence of colonization is unknown [40]. On the other hand, an infected pleural space may be culture negative as is the case with pleural infections, in general. Additionally, pleural space septations on bedside ultrasound imaging can be present in the setting of MPE which may look like a complicated parapneumonic effusion. As with all pleural infections, providers often must use a combination of imaging, laboratory, and clinical judgment to determine if the pleural space is infected. A pooled analysis of two studies found the most common bacteria isolated from suspected pleural infections with IPCs is *Staphylococcus aureus* (37.9%). The second most common organism was Coagulase-negative Staphylococci (14.5%), a frequent colonizer, although these studies are limited by the poor diagnostic sensitivity of pleural fluid culture in identifying microorganisms [40]. Obtaining pleural fluid via thoracentesis may provide more accurate

Table 2. IPC complications (rates based on meta-analysis) [38].

Complication	Rate	Suggested Management	Additional Notes
All infection types	5.7%	Varies based on infection type	
Cellulitis	0.9%	Antibiotics are appropriate unless tunnel site is infected [39]	Involvement of tunnel site may require catheter removal [34,45]
Pleural Space Infection	1.9%	Antibiotics to cover *Staph aureus*, gram negative, and anaerobic organisms or as directed by culture data [39]	Complete drainage of pleural space is recommended. Catheter removal is only necessary if conservative management fails [34–46]
Symptomatic Loculations	0.8%	Instillation of fibrinolytics [49]	Many have recurrence of loculations despite appropriate treatment
Catheter Blockage	1.5%	Instillation of fibrinolytics [52]	
Catheter Tract Metastases	26% (in MPM)	Radiation and symptom control	Most seen in MPM Prophylactic radiation prior to development of CTM is not recommended
Pain	1.2%	Supportive care	IPC removal due to pain is rare [35]

CTM: Catheter tract metastases, MPM: malignant pleural mesothelioma.

culture data so as to avoid culturing a colonized organism from the IPC [39]. Risk factors for developing pleural infection are poorly understood, but length of time since catheter placement is thought to play a role, emphasizing the importance of sterile technique for home drainage [40,41]. Multiple retrospective studies indicate that patients who are immunosuppressed from chemotherapy do not have increased risk of infection [42–44].

Treatment of the infected pleural space should focus on covering the potential infectious organism(s), including *Staphylococcus*, gram negative, and anaerobic organisms and adjusting as appropriate. The appropriate antibiotic duration has not been evaluated, but therapy should be tailored to clinical improvement [39]. As with normal pleural space infections, complete drainage is key to controlling the infection. This is often done by connecting the patient's IPC to a continuous chest drain, though this has not been directly compared to intermittent drainage. In recent cohorts of patients with IPC-associated pleural space infection, the catheter has been left in place through the duration of treatment with high rates of infection control with antibiotics and drainage alone [34,45]. This management is supported by overall low mortality (2.2%-6%) [46,47]. The AABIP and ATS do not recommend removal of IPC as standard therapy but suggest tailoring to a patient's specific scenario and clinical course [39,48,49]. Sterile saline can also be used to flush the catheter to ensure pleural space drainage [39]. If necessary, intrapleural fibrinolytics have been used in a prospective observational study successfully, avoiding surgery in the majority of patients (36/39) and without any significant pleural bleeding [50]. As discussed above, post-infectious pleurodesis rates are high (62%), especially in patients found to have *S. aureus* [47].

Pain is also a notable complication and one of special concern to patients undergoing a procedure for palliative intent. IPC-associated pain may be related to local pain from the procedure, due to negative pressure of the suction bottle, or less commonly, from intercostal nerve injury [41]. The incidence of pain found in pooled analysis by Wang et al was low, at 1.2% [38]. This number may be falsely low given inconsistent reporting and timing of symptom surveys in various studies. For example, Efthymiou et al reported pain in 35% of patients receiving IPCs. Fortunately, they also reported that pain resolved in less than three days [51]. Severe pain that is unresponsive to analgesics is rare and requires removal of the catheter which occurs in only 0.6% of cases [35].

Another frequently encountered complication is the development of symptoms due to poor drainage secondary to fibrous septations forming in the pleural space, known as symptomatic loculations. In a pooled analysis, the rate of symptomatic loculations was 0.8% [38]. They are most commonly identified approximately two months after IPC placement and may be the result of increased fibrin production from the underlying malignancy and repeated drainage attempts [49]. In a retrospective multicenter study, Thomas et al identified 66 patients with symptomatic loculations who were treated with various fibrinolytics instilled in their IPC (mainly tissue-plasminogen activator). IPC drainage improved in 93% of patients and symptoms were improved in 83% while 3% experienced pleural hemorrhage requiring transfusions [49]. Although most patients only required one dose of fibrinolytics to treat their loculation, 40% eventually had a recurrence.

Similarly, fibrin accumulation can occur within the catheter and lead to catheter blockage. This is reported to occur in 1.5% of patients by a meta-analysis [38]. In a study by Wilshire et al, 37 catheter obstructions were treated with 2–5 mg of alteplase for 1–2 h, relieving the obstruction and restoring drainage in 100% of cases. No complications were noted [52].

Catheter tract metastases (CTM) are rare but are most commonly seen in patients with malignant pleural mesothelioma (MPM) [38]. One cohort of patients with MPM identified CTM in 26% of patients at a median time post-procedure of 408 days [53]. Following disruption of the parietal pleura, malignant spread may occur along the catheter tract, leading to catheter tract metastases. These may cause pain and, in some cases, have ulcerated through the skin [54]. A randomized trial evaluated the efficacy of prophylactic radiation in patients with MPM prior to receiving pleural interventions compared to radiation in response to a procedure-tract metastasis. No difference in the incidence of tract metastases was noted among all pleural procedures, including similar rates in those receiving IPCs [55]. Analgesia or radiotherapy only after developing CTM are usually sufficient strategies for management [56].

Nutrition loss after IPC placement, especially in patients with MPE who are frequently cachectic, is a potential concern. This may be more relevant in patients with chylothoraces given the additional fat content in the pleural fluid. Jiminez et al performed a retrospective review examining the utility of IPC placement for malignant chylothoraces and found patients with and without IPCs experienced comparable decrease in their albumin levels [57].

7. Cost effectiveness

As stated above, MPEs represent a large financial burden to the healthcare system, accounting for greater than $5 billion in related hospital costs each year in the United States [2]. IPCs are increasingly recognized as a cost-effective treatment option for patients suffering from MPE.

By allowing outpatient drainage of fluid, IPCs help reduce the need for recurrent hospital admissions, making them a potentially more cost-effective long-term solution [58]. In contrast, pleurodesis often requires hospital stays, both initially and afterward, and carries the risk of partial or no response. The shift from inpatient to outpatient care reduces the demand for hospital resources and minimizes healthcare expenses related to bed occupancy, nursing care, and procedural costs. One of the first studies assessing cost-effectiveness of IPCs compared to inpatient talc administration showed that there was no significant difference in the mean cost of managing patients with IPCs. Additionally, in patients with limited survival (less than 14 weeks), IPC may be less costly [59]. A subsequent study similarly showed that IPCs were cost-effective when compared with talc pleurodesis and most cost-effective in patients with limited survival. However, if patients

require significant nursing time for catheter drainage, IPC is less likely to be cost-effective [60].

For healthcare providers and insurers, the reduction in hospital readmissions and emergency visits associated with IPCs can lead to substantial cost savings. While the initial cost of IPC insertion is higher than a single thoracentesis, the long-term benefits – fewer hospitalizations, lower procedural rates, and reduced need for inpatient care – make IPCs a more cost-effective choice than serial thoracentesis for managing MPE among patients with longer expected survival.

The IPC drainage strategy utilized may also impact the cost-effectiveness of the procedure given the need for additional healthcare consumables (ex. bottles, dressings, etc.). Using a decision tree model-based analysis, the cost-effectiveness of IPC with the addition of talc was compared to symptom-guided drainage and daily drainage. The standard willingness to pay (WTP) threshold of $100,000 per quality-adjusted life year (QALY) was used. The authors found the combination of IPC and talc was a cost-effective alternative to symptom-guided drainage (incremental cost–effectiveness ratio of $59,729 per QALY). However, symptom-guided drainage was cost-effective for pleurodesis rates > 20% and for life expectancy < 4 months. Daily drainage was not cost effective in any scenario [58]. While the cost-effectiveness of IPCs from the healthcare system perspective is important, it is also equally imperative to consider the financial burden on patients and their families. In a cross-sectional survey of patients with an IPC in place for two months and who had insurance, the median copay for private insurers was $238.45 (every 2–4-weeks, depending on drainage frequency) with more than half the patients reporting additional costs related to the IPC [61].

In conclusion, IPCs represent a cost-effective treatment strategy for MPEs, especially in patients with limited life expectancy and high rates of fluid recurrence. The ability to manage pleural effusions in the outpatient setting, along with reductions in hospital admissions and invasive procedures, make IPCs not only a patient-friendly option but also a financially reasonable option for healthcare systems.

8. Conclusion

MPEs are burdensome to patients, both reducing their quality of life and increasing healthcare costs. IPCs are an important management strategy that provide symptom relief and avoid hospitalizations and repeated procedures. While complications are possible, most can be managed in a noninvasive manner. For many patients, the IPC is a cost-effective method to manage their symptoms. In summary, IPCs provide clinicians and patients an excellent tool to help alleviate symptoms of MPEs. The best way to utilize this tool is still a question being answered.

9. Expert opinion

There are various definitive management options for MPE, each with their own advantages and disadvantages. Selecting the best individualized management strategy is ideally done with full knowledge of the patient's life expectancy, lung elastance, likelihood of pleurodesis success and potential complications, and most importantly patient preferences. Involving the patient's support system in these discussions is essential to fully appreciate each patient's unique situation. The patient's decision to pursue a specific therapy should be based on an informed discussion that takes into account the benefits of each modality, potential complications, and understanding of what care will look like at home.

When a patient elects to undergo IPC placement, choosing a drainage frequency should be done with respect to patient and caregivers' ability to manage drainage at home and the associated costs. Clinicians and their healthcare team should educate patients and their support system of routine care, monitoring drainage output, and how to recognize complications. Frequent follow up and provider availability is key to address any problems that may arise.

The management of MPE is an evolving field with future directions focused on precision medicine, tailored toward improving both patient-relevant outcomes and the efficiency of care. As the understanding of pleural disease advances, new approaches and technologies are emerging to optimize treatment strategies. One of the primary goals for future management is to enhance symptom control and improve quality of life, while minimizing invasiveness and hospital resource use. IPCs and TP are well-established, but ongoing research aims to refine these treatments and develop alternatives that may improve effectiveness, reduce complications, and increase patient comfort.

A key area of investigation that we feel will be a part of pleural disease management in the next five years is personalized or targeted therapy for MPE, leveraging advances in molecular biology and cancer genomics. Research is focusing on identifying biomarkers that can predict response to specific treatment strategies, such as IPC or pleurodesis, for individual patients. This personalized approach could help optimize treatment selection and improve outcomes by tailoring therapy to the individual characteristics of the tumor and pleural space [62]. Ongoing trials are also exploring novel agents that can be delivered intrapleurally to inhibit tumor growth, slow fluid accumulation, or enhance the effectiveness of pleurodesis, including agents that target specific molecular pathways involved in effusion formation [63].

Minimally invasive techniques are another promising direction in MPE management. Advances in imaging and interventional techniques may lead to more precise and less invasive ways to manage pleural fluid accumulation. For example, image-guided pleural interventions and robot-assisted thoracoscopic procedures are being explored to improve the accuracy of pleural biopsies, drainage, and pleurodesis while reducing patient recovery times. In addition, bioengineering innovations may result in the development of next-generation IPCs with features such as drug-eluting properties to help reduce infection risks or catheters that facilitate spontaneous pleurodesis over time.

Several clinical trials are currently investigating innovative approaches to MPE management. The PROSPECT study is a multicenter study that is exploring complications related to pleural procedures as well as identifying characteristics (and thus predictors) of patients who will benefit the most

after a pleural intervention [64]. AMPLE-3 compares long-term outcomes between patients treated with IPCs and surgical pleurodesis, focusing on quality of life, complication rates, and healthcare utilization [65]. Another study currently underway compares the use of IPCs versus IPCs plus doxycycline looking at IPC time in situ to treat symptomatic pleural effusion [66]. Research into catheter-associated complications is also being investigated, such as the study from MD Anderson Cancer Center in the U.S., assessing the use of alteplase through an IPC for management of non-draining MPEs [67]. Future directions in research will include assessing the burden of drainage on patient and families as it relates to their health-related and overall quality of life, comparison of home pleurodesis through IPC vs in-hospital pleurodesis, among other interesting research questions to be addressed.

The future of MPE management lies in personalization, minimally invasive approaches, and the incorporation of new technologies and agents. With ongoing clinical research, it is likely that management strategies will continue to evolve in the next five years, focusing not only on prolonging survival but enhancing the quality of life for patients with this challenging condition. As these innovations come to fruition, they have the potential to revolutionize the standard of care for MPE, making treatment more effective, patient-friendly, and cost-efficient.

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References

Papers of special note have been highlighted as either of interest (•) or of considerable interest (••) to readers

1. Mummadi SR, Stoller JK, Lopez R, et al. Epidemiology of adult pleural disease in the United States. Chest. 2021;160(4):1534–1551. doi: 10.1016/j.chest.2021.05.026
2. Taghizadeh N, Fortin M, Tremblay A. US hospitalizations for malignant pleural effusions: data from the 2012 National Inpatient Sample. Chest. 2017;151(4):845–854. doi: 10.1016/j.chest.2016.11.010
3. Piggott LM, Hayes C, Greene J, et al. Malignant pleural disease. Breathe. 2024;19(4):230145. doi: 10.1183/20734735.0145-2023
4. Zamboni MM, da Silva CT, Baretta R, et al. Important prognostic factors for survival in patients with malignant pleural effusion. BMC Pulm Med. 2015;15:29. doi: 10.1186/s12890-015-0025-z
5. Ost DE, Niu J, Zhao H, et al. Quality gaps and comparative effectiveness of management strategies for recurrent malignant pleural effusions. Chest. 2018;153(2):438–452. doi: 10.1016/j.chest.2017.08.026
6. Chernow B, Sahn SA. Carcinomatous involvement of the pleura: an analysis of 96 patients. Am J Med. 1977;63(5):695–702. doi: 10.1016/0002-9343(77)90154-1
7. Desai NR, Lee HJ. Diagnosis and management of malignant pleural effusions: state of the art in 2017. J Thorac Dis. 2017;9(Suppl 10):S1111–S1122. doi: 10.21037/jtd.2017.07.79
8. Roberts ME, Neville E, Berrisford RG, et al. Management of a malignant pleural effusion: British Thoracic Society pleural disease guideline 2010. Thorax. 2010;65(Suppl 2):ii32–ii40. doi: 10.1136/thx.2010.136994
9. Trovisco R, Freitas C, Serino M, et al. Predictors of lung entrapment in malignant pleural effusion. Pulmonology. 2024;30(6):555–562. doi: 10.1016/j.pulmoe.2022.08.001
10. Robinson RD, Fullerton DA, Albert JD, et al. Use of pleural Tenckhoff catheter to palliate malignant pleural effusion. Ann Thorac Surg. 1994;57(2):286–288. doi: 10.1016/0003-4975(94)90984-9
11. Leff RS, Eisenberg B, Baisden CE, et al. Drainage of recurrent pleural effusion via an implanted port and intrapleural catheter. Ann Intern Med. 1986;104(2):208–209. doi: 10.7326/0003-4819-104-2-208
12. Grodzin CJ, Balk RA. Indwelling small pleural catheter needle thoracentesis in the management of large pleural effusions. Chest. 1997;111(4):981–988. doi: 10.1378/chest.111.4.981
13. https://www.accessdata.fda.gov/[Internet]. [cited 2024. May 12 1997]. Available from: https://www.accessdata.fda.gov/cdrh_docs/pdf/K971753.pdf
14. Tremblay A, Michaud G. Single-center experience with 250 tunnelled pleural catheter insertions for malignant pleural effusion. Chest. 2006;129(2):362–368. doi: 10.1378/chest.129.2.362
15. Sabur NF, Chee A, Stather DR, et al. The impact of tunneled pleural catheters on the quality of life of patients with malignant pleural effusions. Respir Int Rev Thorac Dis. 2013;85(1):36–42. doi: 10.1159/000342343
16. Davies HE, Mishra EK, Kahan BC, et al. Effect of an indwelling pleural catheter vs chest tube and talc pleurodesis for relieving dyspnea in patients with malignant pleural effusion: the TIME2 randomized controlled trial. Jama. 2012;307(22):2383–2389. doi: 10.1001/jama.2012.5535
    - **The first randomized controlled trial comparing TP to IPC, a landmark trial in the management of MPE.**
17. Mishra EK, Corcoran JP, Hallifax RJ, et al. Defining the minimal important difference for the visual analogue scale assessing dyspnea in patients with malignant pleural effusions. PLOS ONE. 2015;10(4):e0123798. doi: 10.1371/journal.pone.0123798
18. Thomas R, Fysh ETH, Smith NA, et al. Effect of an indwelling pleural catheter vs talc pleurodesis on hospitalization days in patients with malignant pleural effusion: the AMPLE randomized clinical trial. Jama. 2017;318(19):1903–1912. doi: 10.1001/jama.2017.17426
19. Boshuizen RC, Vd Noort V, Burgers JA, et al. A randomized controlled trial comparing indwelling pleural catheters with talc pleurodesis (NVALT-14). Lung Cancer (Amst Neth). 2017;108:9–14. doi: 10.1016/j.lungcan.2017.01.019
20. Putnam JB, Light RW, Rodriguez RM, et al. A randomized comparison of indwelling pleural catheter and doxycycline pleurodesis in the management of malignant pleural effusions. Cancer. 1999;86(10):1992–1999. doi: 10.1002/(SICI)1097-0142(19991115)86:10<1992:AID-CNCR16>3.0.CO;2-M
21. Demmy TL, Gu L, Burkhalter JE, et al. Optimal management of malignant pleural effusions (results of CALGB 30102). J Natl Compr Cancer Netw JNCCN. 2012;10(8):975–982. doi: 10.6004/jnccn.2012.0102
22. Dresler CM, Olak J, Herndon JE, et al. Phase III intergroup study of talc poudrage vs talc slurry sclerosis for malignant pleural effusion. Chest. 2005;127(3):909–915. doi: 10.1378/chest.127.3.909
23. Bhatnagar R, Piotrowska HEG, Laskawiec-Szkonter M, et al. Effect of thoracoscopic talc poudrage vs talc slurry via chest tube on pleurodesis failure rate among patients with malignant pleural effusions: a randomized clinical trial. Jama. 2020;323(1):60–69. doi: 10.1001/jama.2019.19997

24. Psallidas I, Hassan M, Yousuf A, et al. Role of thoracic ultrasonography in pleurodesis pathways for malignant pleural effusions (simple): an open-label, randomised controlled trial. Lancet Respir Med. 2022;10(2):139–148. doi: 10.1016/S2213-2600(21)00353-2
25. Ost DE, Jimenez CA, Lei X, et al. Quality-adjusted survival following treatment of malignant pleural effusions with indwelling pleural catheters. Chest. 2014;145(6):1347–1356. doi: 10.1378/chest.13-1908
26. Mitchell MA, Deschner E, Dhaliwal I, et al. Patient perspectives on the use of indwelling pleural catheters in malignant pleural effusions. Thorax. 2023;78(11):1111–1117. doi: 10.1136/thorax-2022-219449

• **Multicenter survey of patient experiences with IPCs that may help clinicians understand patients' perspective.**

27. Dipper A, Bhatnagar R, Maskell N. Outpatient talc administration via indwelling pleural catheters for malignant effusions. Curr Opin Pulm Med. 2019;25(4):380. doi: 10.1097/MCP.0000000000000587
28. Wahidi MM, Reddy C, Yarmus L, et al. Randomized trial of pleural fluid drainage frequency in patients with malignant pleural effusions. The ASAP trial. Am J Respir Crit Care Med. 2017;195(8):1050–1057. doi: 10.1164/rccm.201607-1404OC
29. Muruganandan S, Azzopardi M, Fitzgerald DB, et al. Aggressive versus symptom-guided drainage of malignant pleural effusion via indwelling pleural catheters (AMPLE-2): an open-label randomised trial. Lancet Respir Med. 2018;6(9):671–680. doi: 10.1016/S2213-2600(18)30288-1
30. Bhatnagar R, Keenan EK, Morley AJ, et al. Outpatient talc administration by indwelling pleural catheter for malignant effusion. N Engl J Med. 2018;378(14):1313–1322. doi: 10.1056/NEJMoa1716883
31. Sivakumar P, Fitzgerald DB, Ip H, et al. The impact of outpatient versus inpatient management on health-related quality of life outcomes for patients with malignant pleural effusion: the optimum randomised clinical trial. Eur Respir J. 2024;63(2):2201215. doi: 10.1183/13993003.01215-2022
32. Shrager JB, Bhatnagar R, Kearney CT, et al. Silver nitrate–coated versus standard indwelling pleural catheter for malignant effusions: the SWIFT randomized trial. Ann Am Thorac Soc. 2022;19(10):1722–1729. doi: 10.1513/AnnalsATS.202111-1301OC
33. Li P, Graver A, Hosseini S, et al. Clinical predictors of successful and earlier pleurodesis with a tunnelled pleural catheter in malignant pleural effusion: a cohort study. CMAJ Open. 2018;6(2):E235–E240. doi: 10.9778/cmajo.20170163
34. Bibby AC, Clive AO, Slade GC, et al. Survival in patients with malignant pleural effusions who developed pleural infection: a retrospective case review from six UK centers. Chest. 2015;148(1):235–241.
35. Chalhoub M, Saqib A, Castellano M. Indwelling pleural catheters: complications and management strategies. J Thorac Dis. 2018;10(7):4659–4666. doi: 10.21037/jtd.2018.04.160
36. Gilbert CR, Wilshire CL, Gorden JA. Retained granulation cuff as a complication of indwelling pleural catheter removal. J Bronchol Interv Pulmonol. 2021;28(2):156–159. doi: 10.1097/LBR.0000000000000723
37. Fysh ETH, Wrightson JM, Lee YCG, et al. Fractured indwelling pleural catheters. Chest. 2012;141(4):1090–1094. doi: 10.1378/chest.11-0724
38. Wang S, Zhang R, Wan C, et al. Incidence of complications from indwelling pleural catheter for pleural effusion: a meta-analysis. Clin Transl Sci. 2022;16(1):104–117. doi: 10.1111/cts.13430

• **Meta-analysis on frequency of complications in IPCs.**

39. Miller RJ, Chrissian AA, Lee YCG, et al. AABIP evidence-informed guidelines and expert panel report for the management of indwelling pleural catheters. J Bronchol Interv Pulmonol. 2020;27(4):229. doi: 10.1097/LBR.0000000000000707

•• **IPC management suggestions based on best available evidence or expert opinion.**

40. Sethi DK, Webber MA, Mishra EK. Indwelling pleural catheter infection and colonisation: a clinical practice review. J Thorac Dis. 2024;16(3). doi: 10.21037/jtd-23-1761
41. Sidhu C, Davies HE, Muruganandan S, et al. Indwelling pleural catheter: management of complications. Semin Respir Crit Care Med. 2023;44(04):454–461. doi: 10.1055/s-0043-1769093
42. Wilshire CL, Chang SC, Gilbert CR, et al. Association between tunneled pleural catheter use and infection in patients immunosuppressed from antineoplastic therapy. A multicenter study. Ann Am Thorac Soc. 2021;18(4):606–612. doi: 10.1513/AnnalsATS.202007-886OC
43. Mekhaiel E, Kashyap R, Mullon JJ, et al. Infections associated with tunnelled indwelling pleural catheters in patients undergoing chemotherapy. J Bronchol Interv Pulmonol. 2013;20(4):299–303. doi: 10.1097/LBR.0000000000000001
44. Hak CCW, Sivakumar P, Ahmed L. Safety of indwelling pleural catheter use in patients undergoing chemotherapy: a five-year retrospective evaluation. BMC Pulm Med. 2016;16(1):41. doi: 10.1186/s12890-016-0203-7
45. Porcel JM, Torres M, Pardina M, et al. Predictors of indwelling pleural catheter removal and infection: a single-center experience with 336 procedures. J Bronchol Interv Pulmonol. 2020;27(2):86. doi: 10.1097/LBR.0000000000000632
46. Gilbert CR, Lee HJ, Skalski JH, et al. The use of indwelling tunneled pleural catheters for recurrent pleural effusions in patients with hematologic malignancies: a multicenter study. Chest. 2015;148(3):752–758. doi: 10.1378/chest.14-3119
47. Fysh ETH, Tremblay A, Feller-Kopman D, et al. Clinical outcomes of indwelling pleural catheter-related pleural infections: an international multicenter study. Chest. 2013;144(5):1597–1602. doi: 10.1378/chest.12-3103
48. Feller-Kopman DJ, Reddy CB, DeCamp MM, et al. Management of malignant pleural effusions. An official ATS/STS/STR clinical practice guideline. Am J Respir Crit Care Med. 2018;198(7):839–849. doi: 10.1164/rccm.201807-1415ST
49. Thomas R, Piccolo F, Miller D, et al. Intrapleural fibrinolysis for the treatment of indwelling pleural catheter-related symptomatic loculations: a multicenter observational study. Chest. 2015;148(3):746–751. doi: 10.1378/chest.14-2401
50. Fitzgerald DB, Muruganandan S, Tsim S, et al. Intrapleural fibrinolytics and deoxyribonuclease for treatment of indwelling pleural catheter-related pleural infection: a multi-center observational study. Respir Int Rev Thorac Dis. 2021;100(5):452–460. doi: 10.1159/000514643
51. Efthymiou CA, Masudi T, Thorpe JAC, et al. Malignant pleural effusion in the presence of trapped lung. Five-year experience of PleurX tunnelled catheters. Interact Cardiovasc Thorac Surg. 2009;9(6):961–964. doi: 10.1510/icvts.2009.211516
52. Wilshire CL, Louie BE, Aye RW, et al. Safety and efficacy of fibrinolytic therapy in restoring function of an obstructed tunneled pleural catheter. Ann Am Thorac Soc. 2015;12(9):1317–1322. doi: 10.1513/AnnalsATS.201503-182OC
53. Mitchell MA, Li P, Pease C, et al. Catheter tract metastasis in mesothelioma patients with indwelling pleural catheters: a retrospective cohort study. Respir Int Rev Thorac Dis. 2019;97(5):428–435. doi: 10.1159/000494500
54. Janes SM, Rahman NM, Davies RJO, et al. Catheter-tract metastases associated with chronic indwelling pleural catheters. Chest. 2007;131(4):1232–1234. doi: 10.1378/chest.06-2353
55. Clive AO, Taylor H, Dobson L, et al. Prophylactic radiotherapy for the prevention of procedure-tract metastases after surgical and large-bore pleural procedures in malignant pleural mesothelioma (SMART): a multicentre, open-label, phase 3, randomised controlled trial. Lancet Oncol. 2016;17(8):1094–1104. doi: 10.1016/S1470-2045(16)30095-X
56. Thomas R, Budgeon CA, Kuok YJ, et al. Catheter tract metastasis associated with indwelling pleural catheters. Chest. 2014;146(3):557–562. doi: 10.1378/chest.13-3057
57. Jimenez CA, Mhatre AD, Martinez CH, et al. Use of an indwelling pleural catheter for the management of recurrent chylothorax in patients with cancer. Chest. 2007;132(5):1584–1590. doi: 10.1378/chest.06-2141
58. Shafiq M, Simkovich S, Hossen S, et al. Indwelling pleural catheter drainage strategy for malignant effusion: a cost-effectiveness

analysis. Ann Am Thorac Soc. 2020;17(6):746–753. doi: 10.1513/AnnalsATS.201908-615OC
59. Penz ED, Mishra EK, Davies HE, et al. Comparing cost of indwelling pleural catheter vs talc pleurodesis for malignant pleural effusion. Chest. 2014;146(4):991–1000. doi: 10.1378/chest.13-2481
60. Olfert JAP, Penz ED, Manns BJ, et al. Cost-effectiveness of indwelling pleural catheter compared with talc in malignant pleural effusion. Respirol Carlton Vic. 2017;22(4):764–770. doi: 10.1111/resp.12962
61. Aboudara M, Roller L, Lentz R, et al. A survey-based study of patient-centered costs associated with indwelling pleural catheters. Am J Hosp Palliat Care. 2021;38(4):361–365. doi: 10.1177/1049909120954810
62. clinicaltrials.gov [Internet]. Hospices Civils de Lyon. Creation of a pleural carcinomatosis tissue bank. 2024. [cited 2025. Mar 15]. Available from: https://clinicaltrials.gov/study/NCT04844827
63. clinicaltrials.gov [Internet]. RS Oncology LLC. A translational phase 1/2 dose-escalation and expansion study to determine safety, tolerability, and recommended phase 2 dose of RSO-021 in patients with malignant pleural effusion due to advanced/metastatic solid tumors including mesothelioma. 2024. [cited 2025. Mar 15]. Available from: https://clinicaltrials.gov/study/NCT05278975
64. clinicaltrials.gov [Internet] University of Oxford. Prospective data collection on clinical, radiological and patient reported outcomes after pleural intervention. 2023. [cited 2025. Mar 15]. Available from: https://clinicaltrials.gov/study/NCT05910112
65. clinicaltrials.gov [Internet] Lee YG. The Australasian malignant pleural effusion (AMPLE) trial - 3: a randomised study of the relative benefits of combined indwelling pleural catheter (IPC) and talc pleurodesis therapy or video-assisted thoracoscopic surgery (VATS) in the management of patients with malignant pleural effusion. 2023. [cited 2025. Mar 15]. Available from: https://clinicaltrials.gov/study/NCT04322136
66. clinicaltrials.gov [Internet] M.D. Anderson Cancer Center. A prospective observational cohort study of indwelling pleural catheters versus indwelling pleural catheters plus doxycycline pleurodesis for treatment of malignant pleural effusions. 2024. [cited 2025. Mar 15]. Available from: https://clinicaltrials.gov/study/NCT03465774
67. clinicaltrials.gov [Internet] M.D. Anderson Cancer Center. A randomized trial of alteplase versus placebo through an indwelling pleural catheter for management of symptomatic septated MPE. 2024. [cited 2025. Mar 15]. Available from: https://clinicaltrials.gov/study/NCT06184321