The Impact of Video-assisted Thoracoscopic Versus Percutaneous Tunneled Pleural Catheter Techniques on Pleurodesis Outcomes

A Retrospective, Single-center Study

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Background: Tunneled pleural catheters (TPCs) generate an inflammatory reaction, which, along with frequent drainage, aids in achieving pleurodesis enabling removal in 30% to 50% of patients. However, it is unknown whether the technique of TPC placement influences pleurodesis outcomes.

Methods: This is a retrospective, single-center study of patients who underwent TPC placement from 2010 through 2018. Pleurodesis success was defined as TPC removal within 90 days of placement in the setting of no further drainage and in the absence of catheter malfunction, infection, patient's choice for another treatment modality, or other catheter-related complications. Pleurodesis failure was defined as patients who did not have TPC removal within 90 days of insertion.

Results: A total of 326 patients underwent TPC insertion by thoracic surgery, interventional pulmonology, or interventional radiology. Fourteen patients were excluded due to insufficient follow-up. Of the 312 patients included in the final analysis, 32.7% achieved pleurodesis. Patients who had their TPC inserted thoracoscopically achieved higher pleurodesis success compared with a percutaneous technique (61.2% vs 24.9%, $P < 0.001$). Thoracoscopically placed catheters had two times greater chance of removal than those inserted percutaneously (hazard ratio: 2.04, 95% CI: 1.14-3.64, $P = 0.02$) after controlling for pleural biopsies and sclerosing agents used during thoracoscopy.

Conclusion: Thoracoscopic TPC placements may be associated with higher pleurodesis rates compared with a percutaneous technique. Our results are only hypothesis-generating, and these findings warrant confirmation in prospective studies.

Key Words: pleurodesis, pleural catheter, pleural effusion, malignant, thoracoscopy

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Tunneled pleural catheters (TPCs) are widely used for the management of recurrent symptomatic pleural effusions.[1,2] TPCs offer palliation of symptoms and have been shown to improve quality of life and dyspnea.[3–5] Compared with chemical pleurodesis, TPC placement is associated with fewer hospitalization days and a lesser need for further pleural interventions.[4,5]

A TPC can be placed percutaneously or during thoracoscopy. In general, thoracic surgery (TS) and interventional pulmonology (IP) utilize both techniques, while interventional radiology (IR) places the catheter percutaneously. Once a TPC is placed, patients are instructed to drain their effusion at a frequency based on drainage protocols that are institution or service-dependent. For example, while TS and IP employ a daily drainage protocol at our institution, IR traditionally follows symptom-guided drainage.

A TPC can generate an inflammatory reaction within the pleura, which, combined with fluid drainage, can aid in achieving pleurodesis without using a sclerosing agent, enabling catheter removal.[6,7] Randomized controlled trials have demonstrated that 30% to 60% of patients who undergo percutaneous placement of TPC achieve pleurodesis.[3,8,9] Patients undergoing more frequent drainage achieve pleurodesis at a higher rate. In studies where daily drainage was performed, TPCs were removed in ~45% of

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The study protocol was reviewed and approved by the Institutional Review Board (IRB14-1576) and the need for individual patient consent was waived because of the retrospective nature of the study.

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patients at 3 to 6 months.[8,9] Thoracoscopy allows the provider to drain the pleural space entirely before TPC placement and break any adhesions that may loculate the pleural space. Subgroup analysis of 2 small single-center, retrospective studies demonstrated a 54% pleurodesis rate for patients who had their TPC thoracoscopically placed.[10,11]

Based on the available evidence from randomized trials, drainage frequency is the only modifiable factor impacting pleurodesis rates, enabling early TPC removal. Compared with a percutaneous technique, the apparent theoretical benefits of thoracoscopic placement of TPCs may lead to higher pleurodesis rates due to the differences in technique. Given that this association has not been previously well explored, the objective of our study was to retrospectively determine the effect of the TPC placement technique on pleurodesis rates.

METHODS

A single-center retrospective analysis was performed on all adult patients who underwent TPC placement for any etiology from 2010 through 2018. The study protocol was reviewed and approved by the Institutional Review Board (IRB14-1676) and the need for individual patient consent was waived. The institution's bioinformatics department provided the database of patients after querying the CPT code "insertion of indwelling TPC with cuff." TPC insertion was confirmed with a detailed medical chart review.

Inclusion criteria were adult patients older than 18 years of age with a TPC placed for recurrent pleural effusion of any etiology. Exclusion criteria included patients with no follow-up after their catheter placement or if the insertion technique could not be determined from chart review. For thoracoscopically placed TPCs, patients who underwent any decortication were not included.

Pleurodesis success, defined as TPC removal due to lack of drainage, was assessed within 90 days of catheter placement.[12,13] Pleurodesis failure was defined as continued pleural fluid output that did not permit TPC removal within 90 days of placement. A 90-day follow-up period was employed based on prior randomized clinical studies.[9,12,13]

Medical records were reviewed for patient demographics, chest imaging reports, operative reports, laboratory values, pathology, pulmonary, TS, and oncology clinic visits. Data collected during TPC placement included age, sex, race, and body mass index. TPC-related data included the reason for placement, the date of insertion, laterality of insertion, the service that placed the catheter, the technique of placement (percutaneous or thoracoscopic), and the number of prior thoracenteses. The treating clinician decided the technique of placement. All percutaneously placed catheters were inserted under ultrasound guidance. Oncology visits were reviewed for chemotherapy and radiation treatment history. Pleural fluid chemistries, cell count, and cytology at the time of TPC insertion were collected. Evidence of trapped lung, defined as the inability of the lung to fully expand after drainage of pleural effusion, was determined by documentation in operative report findings (for thoracoscopically placed TPC) and by chest imaging. The use of pleurodesis agents or pleural biopsies during thoracoscopically placed TPCs was noted. The date and reason for TPC removal were collected from the procedure or clinic note documentation. The patient's last day of follow-up was defined as the date of their last filed note in the medical record. If patients had a pleural procedure documented on the ipsilateral effusion after TPC removal up until their last follow-up day, recurrence was noted.

Data were collected and managed in REDCap electronic database tools hosted by the Center for Research Informatics of the study center. Patient demographics were analyzed with descriptive statistics. Continuous variables between the pleurodesis success and failure groups were compared with the Mann-Whitney U test. The Kruskal-Wallis test was used to compare patient characteristics among the different services placing TPC. When appropriate, categorical variables were compared with the χ^2 test or Fischer exact test. Continuous variables are reported as median (interquartile range), and categorical variables are reported as number and frequency.

A Cox proportional hazards regression model evaluating the effect of team and technique of placement associated with successful pleurodesis was performed. The model controlled for multiple variables of clinical relevance, including age, race, type of cancer, malignant cytology, presence of trapped lung, and chemotherapy and radiation treatment. Patients who were lost to follow-up or who died in the 90-day period post-TPC placement were censored on the day of the last follow-up or the day of death. The censoring removed these patients from the cohort of patients who could potentially achieve the primary outcome of pleurodesis success. The data were analyzed using Stata version 16.1 (StataCorp LLC).

RESULTS

From October 2010 to September 2018, 326 patients underwent TPC placement by TS, IP, and IR for any etiology. Of these, 14 patients were excluded due to: no follow-up visit after initial catheter placement (n = 8) and inability to determine the technique of placement (n = 6). Any bilateral catheter placements were treated as individual events. In total, 312 patients were included in the analysis. Pleurodesis success, that is, catheter removal due to lack of drainage, was achieved in 102 patients (32.7%). No catheter was removed due to malfunction, dislodgement, infection, the patient's choice of another treatment modality, or other catheter-related complications. The remaining patients (67.3%) had pleurodesis failure. Among the pleurodesis failure group, TPC was not removed in 163 patients (77.6%), and TPC was removed more than 90 days after placement in 47 patients (22.4%). After TPC removal, ipsilateral pleural effusion recurrence requiring an intervention (ie, repeat thoracentesis) was noted in 9 (8.8%) patients in the pleurodesis success group and 7 (14.9%) patients in the failure group.

There was no statistically significant difference between the patient demographics and pleural effusion characteristics in the pleurodesis success and failure groups (Table 1). The patient characteristics treated by the different teams are described in Table 2. We controlled for the differences noted in the race, the reason for TPC placement, and the type of malignant pleural effusion (MPE). At our institution, TS had a more significant proportion of patients with mesothelioma referred for TPC placement.

Of TPCs, 93% were placed for MPEs. The laterality of placement, the number of prior thoracenteses, and the etiology of pleural effusion did not vary significantly between the pleurodesis success and failure groups. In

TABLE 1. Patient Characteristics and Pleural Fluid Characteristics Among the Pleurodesis Success and Failure Groups

	All patients (n = 312)*	Pleurodesis failure group (n = 210); n (%) or median (IQR)	Pleurodesis success group (n = 102); n (%) or median (IQR)	*P*
Sex				
Male	115 (36.9)	80 (38.1)	35 (34.3)	0.30
Female	197 (63.1)	130 (61.9)	67 (65.7)	—
Race				
White	170 (54.7)	113 (54.1)	57 (55.9)	0.15
African American	122 (39.2)	84 (40.2)	38 (37.3)	—
Asian	14 (4.5)	11 (5.3)	3 (2.9)	—
Hispanic	3 (1.0)	1 (0.5)	2 (2.0)	—
Other	2 (0.7)	0	2 (2.0)	—
Age at time of insertion (y)	66.5 (57.7-74.6)	67.4 (59.6-76.5)	65.3 (55.4-73.1)	0.05
BMI (kg/m^2)	25.4 (22.9-28.8) n = 235	25.2 (22.8-28.7) n = 136	26.1 (23.3-29.6) n = 99	0.23
Left hemithorax	125 (40.2)	88 (42.1)	37 (36.3)	0.33
Right hemithorax	186 (59.8)	121 (57.9)	65 (42.1)	—
No. prior thoracenteses	2 (1-3) n = 280	2 (1-2) n = 178	2 (1-2) n = 102	0.26
Reason for TPC				
Malignancy	289 (92.6)	195 (92.9)	94 (92.2)	0.37
Cardiac	15 (4.8)	11 (5.2)	4 (3.9)	—
Chylothorax	2 (0.6)	2 (1.0)	0	—
Other (amyloidosis, postsurgical, radiation, transudate of unknown etiology)	7 (2.2)	3 (1.4)	4 (3.9)	—
Pleural fluid characteristics				
LDH (U/L)	269 (159-582) n = 187	267 (148-622) n = 121	276 (185-571) n = 66	0.67
Protein (g/dL)	4 (3.3-4.6) n = 202	3.8 (3.2-4.5) n = 128	4.2 (3.5-4.7) n = 74	0.06
Glucose (mg/dL)	102 (85-121) n = 174	102 (82-126) n = 111	102 (90-121) n = 63	0.77
pH	7.43 (7.37-7.48) n = 133	7.43 (7.37-7.49) n = 90	7.42 (7.36-7.46) n = 43	0.64
Albumin (g/L)	2.3 (1.9-2.7) n = 38	2.3 (1.9-2.7) n = 28	2.4 (2-2.8) n = 10	0.88
Cholesterol (mg/dL)	74 (63.5-92.5) n = 28	74.5 (69-87) n = 18	73 (50-108) n = 10	0.98
Triglycerides (mg/dL)	33 (25-67) n = 43	34 (23-205) n = 30	32 (29-51) n = 13	0.82
Malignant cells detected on cytology	165 (61.6)	103 (61.0)	62 (62.6)	0.71

*Variables with missing data will have a separately reported n.
BMI indicates body mass index; IQR, interquartile range; LDH, lactate dehydrogenase; TPC, tunneled pleural catheter.

addition, pleural fluid characteristics did not differ between the success and failure groups.

Overall, pleurodesis success was achieved in 24.9% of the TPC placed percutaneously, compared with 61.2% of TPC placed thoracoscopically ($P < 0.001$; Table 3). In the Cox proportional hazards regression model, thoracoscopically placed catheters had a 2.22 times greater chance of pleurodesis success than catheters placed percutaneously [hazard ratio (HR): 2.22, 95% CI: 1.22-4.04, $P = 0.009$].

We also controlled for drainage frequency by performing a subsequent analysis with catheters placed only by IP and TS—services with the same drainage protocol. The analysis showed that even after controlling for drainage frequency, thoracoscopically placed catheters had a 2.6 times greater chance of successful pleurodesis than percutaneously placed catheters (HR: 2.6, 95% CI: 1.51-4.70, $P = 0.001$).

After adjusting for the use of sclerosing agents and pleural biopsies in the success (3 with talc and 25 pleural biopsies) and failure (1 with mechanical, 1 with doxycycline, and 12 pleural biopsies) groups, thoracoscopically placed catheters still had a significantly higher chance of pleurodesis success compared with those placed percutaneously (HR: 2.04, 95% CI: 1.14-3.64, $P = 0.02$).

Median time to removal did not differ significantly between TPC placed percutaneously or thoracoscopically [44 (35 to 59) days vs 36 (25 to 56) days, respectively, ($P = 0.20$)] for the pleurodesis success group. We also analyzed pleurodesis outcomes based on teams placing the catheter. Significantly more patients who had TPC placed by TS and IP achieved pleurodesis success, compared with those that had TPC placed by IR (48.9% and 34.3%, vs 7.6%; $P < 0.001$; Tables 4 and 5). The Cox proportional hazards regression model showed that in comparing the teams to IP, IR was significantly less likely to achieve pleurodesis success (HR: 0.31, 95% CI: 0.12-0.78, $P = 0.014$).

In comparing TS to IP, there was no difference in pleurodesis success rates (HR: 0.62, 95% CI: 0.26-1.06, $P = 0.08$). In a subgroup analysis of patients who had their catheter placed percutaneously, there was a significant

TABLE 2. Patient Characteristics and Pleural Fluid Characteristics Among Teams Placing TPC

	All patients (n = 312)*	IP (n = 160); n (%) or median (IQR)	TS (n = 86); n (%) or median (IQR)	IR (n = 66); n (%) or median (IQR)	*P*
Sex					
Male	115 (36.9)	55 (34.4)	39 (45.4)	21 (31.8)	0.15
Female	197 (63.1)	105 (65.6)	47 (54.7)	45 (68.2)	—
Race					0.002
White	170 (54.7)	79 (49.4)	60 (69.8)	31 (47.7)	—
African American	122 (39.2)	71 (44.4)	19 (22.1)	32 (49.2)	—
Asian	14 (4.5)	9 (5.6)	3 (3.5)	2 (3.1)	—
Hispanic	3 (1.0)	1 (0.6)	2 (2.3)	0	—
Other	2 (0.7)	0	2 (2.3)	0	—
Age at time of insertion (y)	66.5 (57.7-74.6)	65.5 (56.3-73.4)	69.0 (60.4-76.7)	66.8 (57.4-77.0)	0.36
BMI (kg/m^2)	25.4 (22.9-28.8) n = 235	25.7 (23-29.3)	24.9 (22.9-28.6)	25.3 (22.7-31.0)	0.85
Left hemithorax	125 (40.2)	72 (45)	26 (30.2)	27 (41.5)	0.08
Right hemithorax	186 (59.8)	88 (55)	60 (69.8)	38 (58.5)	—
No. prior thoracenteses	2 (1-3) n = 280	2 (1-3)	1 (1-2)	1.5 (1-2)	0.17
Reason for TPC					
Malignancy	289 (92.6)	154 (96.3)	78 (90.7)	57 (86.4)	0.04
Cardiac	15 (4.8)	3 (1.9)	4 (4.7)	8 (12.1)	—
Malignancy type					< 0.001
Lung	94 (32.8)	56 (36.4)	27 (34.6)	11 (19.3)	—
Breast	49 (17.1)	25 (16.2)	8 (10.3)	16 (28.1)	—
Mesothelioma	34 (11.9)	6 (3.9)	28 (35.9)	0	—
Lymphoma	7 (2.4)	7 (4.6)	0	0	—
Pleural fluid characteristics					
LDH (U/L)	269 (159-582) n = 187	283 (172-584) n = 106	241 (159-412) n = 47	340 (111-764) n = 34	0.59
Protein (g/dL)	4 (3.3-4.6) n = 202	4 (3.4-4.5) n = 112	4.2 (3.4-4.8) n = 55	3.6 (2.6-4.4) n = 35	0.03
Glucose (mg/dL)	102 (85-121) n = 174	107 (93-126) n = 95	98 (78-113) n = 49	113 (78-120) n = 30	0.18
pH	7.43 (7.37-7.48) n = 133	7.42 (7.38-7.46) n = 81	7.44 (7.32-7.49) n = 30	7.44 (7.26-7.5) n = 22	0.97
Malignant cells detected on cytology	165 (61.6)	80 (57.1)	57 (70.4)	28 (59.6)	0.25

*Variables with missing data will have a separately reported n.

BMI indicates body mass index; IP, interventional pulmonology; IQR, interquartile range; IR, interventional radiology; LDH, lactate dehydrogenase; TPC, tunneled pleural catheter; TS, thoracic surgery.

difference in pleurodesis success based on the team (30.1% for IP, 36.4% for TS, and 7.6% for IR; $P = 0.001$). However, there was no significant difference in pleurodesis success based on the team in patients who underwent thoracoscopic placement (78% for IP and 56.6% for TS, $P = 0.13$; Table 6).

DISCUSSION

This study showed successful pleurodesis (catheter removal at the 90 d mark) in 32.7% of patients, comparable to prior published reports.[3,9] The technique of TPC placement was significantly associated with different rates of successful pleurodesis. Thoracoscopically placed TPC was associated with higher pleurodesis success compared with those placed percutaneously, even when we controlled for drainage frequency. The odds of pleurodesis success were two times higher for thoracoscopically placed catheters than for those placed percutaneously by TS and IP teams, even after adjusting for sclerosant administration. We believe the difference is attributable to the difference in the procedural technique itself. We suspect the initial total fluid evacuation during thoracoscopy is a good head start in maintaining a dry space and allows for faster apposition of the visceral and parietal pleura.

In contrast, we suspect the gradual drainage of the pleural space with TPC placed percutaneously leads to lower pleurodesis rates. In addition, the ability to break adhesions that may compartmentalize the pleural space during thoracoscopic placement may contribute to the higher pleurodesis rates for thoracoscopically placed catheters. Another theoretical advantage of thoracoscopically

TABLE 3. Pleurodesis Success Rate Based on Procedure Technique

x	Local anesthesia	Thoracoscopy	*P*
All patients (n = 312)	245	67	< 0.001
Pleurodesis failure group; n = 210 (67.3%)	184 (75.1)	26 (38.9)	—
Pleurodesis success group; n = 102 (32.7%)	61 (24.9)	41 (61.1)	—

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TABLE 4. Pleurodesis Overall Success Rate Based on the Service

Team	IP	TS	IR	*P*
All patients (n = 312)	160	86	66	<0.001
Pleurodesis failure group; n = 210 (67.3%)	105 (65.7)	44 (51.1)	61 (92.4)	—
Pleurodesis success group; n = 102 (32.7%)	55 (34.3)	42 (48.9)	5 (7.6)	—

IP indicates interventional pulmonology; IR, interventional radiology; TS, thoracic surgery.

placed catheters is the ability to visually direct and place catheters in the desired location to facilitate drainage, which is not always achieved with percutaneously placed catheters.

Our model revealed that catheters placed by IR were 69% less likely to achieve pleurodesis success than those placed by IP. We believe the observed differences were due not only to technique but also to pleural fluid drainage protocol—where daily drainage has been proven to be superior in achieving pleurodesis success in prior prospective randomized trials evaluating drainage frequency.[3,9] This observed difference was not due to the team or providers placing the catheters. The ASAP trial demonstrated that daily drainage resulted in higher rates of spontaneous pleurodesis than every other day drainage protocols (47% vs 24% at 12 wk) without an increase in adverse events or significant difference in the quality of life.[9] In the AMPLE-2 trial, a higher rate of spontaneous pleurodesis was seen with daily drainage compared with symptom-guided protocols (37.2% vs 11.4% at 60 d).[3] At our institution, IP and TS services instruct patients to follow initial daily drainage protocols. IR's drainage protocol is symptom-guided. Our study suggests that pairing daily drainage protocols and a thoracoscopic approach could lead to higher pleurodesis rates and, in turn, fewer days with the catheter in place.

When the TPC has minimal drainage for several days, the catheter is removed in a clinic or an outpatient procedure room. Control of the effusion is either due to achieving true pleurodesis (ie, symphysis between the visceral and parietal pleura) or disease control (ie, tumor response to treatment with systemic therapy and/or radiation). At the time of TPC removal, spontaneous pleurodesis and disease control have not been distinguished in prior publications and cannot be accurately retrospectively elucidated in our study. We suspect that the 16 patients who had their catheter removed but then had a recurrence of effusion, likely had disease control. Similarly, we cannot conclude whether the 47 patients who had their catheter removed after 90 days and did not achieve the predefined definition of pleurodesis success had disease control or delayed pleurodesis. To define pleurodesis success,

TABLE 5. Pleurodesis Success Rate Through Local Anesthesia Technique Based on Service

Team	IP	TS	IR	*P*
All patients (n = 245)	146	33	66	0.001
Pleurodesis failure group; n = 184 (75.1%)	102 (69.9)	21 (63.6)	61 (92.4)	—
Pleurodesis success group; n = 61 (24.9%)	44 (30.1)	12 (36.4)	5 (7.6)	—

IP indicates interventional pulmonology; IR, interventional radiology; TS, thoracic surgery.

TABLE 6. Pleurodesis Success Rate Through Thoracoscopy Technique Based on Service

Team	IP	TS	*P*
All patients (n = 67)	14	53	0.13
Pleurodesis failure group; n = 26 (38.8%)	3 (21.4)	23 (43.4)	—
Pleurodesis success group; n = 41 (61.2%)	11 (78.6)	30 (56.6)	—

IP indicates interventional pulmonology; TS, thoracic surgery.

we chose a 90-day time frame that has been consistently used in prior studies.[12,13] The 90-day period is necessary for clinical and research purposes to determine the frequency in which an event occurs in a pre-established time frame. Currently, there is no way to definitively know whether true pleurodesis has occurred. Whether lung ultrasonography at the time of TPC removal can accurately distinguish between true pleurodesis versus disease control remains to be determined.[14]

There are several limitations of our current study. The patient populations treated by the 3 teams were noted to be significantly different in race, the reason for catheter placement, type of malignancy, and pleural fluid protein level. TS treated significantly more patients with mesothelioma due to physician referral patterns at our institution. Patients with pleural mesothelioma may experience contraction of the ipsilateral thoracic cavity during their illness, with obliteration of the pleural space and potential spontaneous pleurodesis. Thus, for studying pleurodesis rates, it is important to ensure an even distribution of patients with pleural mesothelioma, potentially resulting in a higher rate of pleurodesis among the study arms. This was not performed in our study, and the study arm with the highest rate of pleurodesis included a disproportionately high proportion of patients with pleural mesothelioma. However, to our knowledge, there are no published studies regarding increased or decreased pleurodesis success with mesothelioma-related pleural effusions compared with MPEs from other tumor etiologies. These variables were controlled for in our analysis. Also, while protein levels were different among the patients cared for by the different teams, there have been no published studies showing that protein levels affect pleurodesis outcomes. Pleural fluid pH and lactate dehydrogenase have been associated with pleurodesis outcomes.[15,16] We also acknowledge that there needs to be more data on the pleural fluid chemistries as there is no standardized protocol at our institution across the 3 specialties regarding consistently sending pleural fluid chemistries around the time of TPC placement which leads to discrepancies in the data in a retrospective study. Therefore, firm conclusions cannot be made regarding the pleural fluid chemistries and their association with pleurodesis. In addition, because of the single-center nature of the study, our findings may not necessarily be generalizable to other institutions with differences in procedural practice, technique, and drainage protocols. The outcome looked at in our study was pleurodesis success. We recognize that there are other outcome measures that are more patient-centric, such as symptom palliation, improvement in dyspnea scores, quality of life, and adverse events from catheter placement, that were not evaluated in this retrospective study. These variables have been well-studied, however, in previous prospective randomized trials.[3,4] Our main goal was to generate a hypothesis triggered by a

clinical practice observation of a faster time to TPC removal in patients who have the catheter placed thoracoscopically. We did not quantify the amount of residual fluid (if any) immediately post-catheter removal. We chose not to do this as not all teams consistently ordered a chest x-ray immediately following catheter removal. Patients had these catheters removed in a clinic or a procedure room. While all catheters were removed because of lack of fluid drainage in the absence of catheter malfunction, dislodgement, infection, or other catheter-related issues, based on the nature of this study, we cannot comment on radiographic findings (full lung expansion, partial stable expansion) at the time of catheter removal. Moreover, since IR followed a symptom-guided drainage protocol, it was not possible to collect the number of drainages in this group of patients. However, we were able to compare between services (IP and TS) that used the same drainage protocols. Similar to other studies, including large prospective trials,[3,9,17] although patients had education before and immediately after the procedure, as well as during the follow-up visits, we have no objective documentation of the number of vacuum bottles used per week or patient logs of drainage intervals once the patients were discharged, a limitation inherent to studies evaluating such interventions on an outpatient basis.

It is not clear from existing literature whether patients with histologically benign and malignant effusions have significantly distinct pleurodesis rates. However, although small, the number of patients who received TPC for cardiac effusions was not evenly distributed among the 3 groups (8 for IR, 4 for TS, and 3 for IP), which could potentially affect pleurodesis rates. Our analysis included all patients who underwent TPCs at our institution during the study period. Due to the retrospective nature of this study, objective documentation of performance status was not available. This may be a limitation, as patients with poorer performance status might have been selected for the percutaneous technique due to high surgical risk, but this selection bias may be simply due to practice patterns and it is not clear whether it affects the outcomes as defined in this analysis. Also, in this study, the date of death was inconsistently reported in the EMR; therefore, the last day of follow-up was determined based on the last documented note in the EMR, which either was (1) the last clinic note or (2) the note documenting death. For this reason, we did not separately report these variables. We speculate that total fluid evacuation and possibly breaking adhesions are responsible for the higher pleurodesis rates seen with the thoracoscopic technique, but we have no data regarding the proportion of thoracoscopy patients undergoing adhesiolysis; this will require objective documentation in a prospective study. We point out that reported pleurodesis rates in our study may be underestimated. There might have been cases where catheters were left in place after 90 days even if pleurodesis was achieved (patient's preference, delay in follow-up). This problem is compounded by the retrospective nature of our study, as it is challenging to be certain of the actual reasons for catheter retention in a retrospective analysis. The cost-effectiveness of either a percutaneous or thoracoscopic technique was not determined in our study and should be evaluated in future prospective studies to better inform clinicians on the most cost-effective TIPC insertion technique.

CONCLUSIONS

Our study suggests that the thoracoscopic placement of TPC compared with the percutaneous technique may be associated with higher pleurodesis rates. Pairing thoracoscopic placement and daily drainage protocols may lead to higher pleurodesis rates. Patients treated by teams that have pleural disease content experts can offer different types of techniques and are likely to have better outcomes than those treated by purely technical services. Our findings are only hypothesis-generating. Prospective, randomized trials are needed to evaluate whether a thoracoscopic placement is superior to percutaneously placed TPC for pleurodesis success and quality of life.

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