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Percutaneous Drainage of Pyogenic Lung Abscess

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Although lung abscesses are successfully treated with antibiotics in 80–90% of cases, this conservative approach may occasionally fail. In cases of failure, pulmonary resection is usually advised. Although it remains controversial, an alternative therapy in such situations is percutaneous transthoracic tube drainage (PTTD). Herein we review the medical literature on PTTD from the last 25 y, focusing on its efficacy, indications, technique, complications and mortality. We conclude that PTTD is a safe, simple and efficacious tool for the management of refractory lung abscess. Complications relating to the procedure occurred in 9.7% of cases and included catheter occlusion, chest pain, pneumothorax and hemothorax. The overall mortality rate secondary to lung abscess was acceptable (4.8%).

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INTRODUCTION

Percutaneous transthoracic tube drainage (PTTD) was first described in 1938 for the treatment of tuberculous lung cavities (1). It was later used routinely in the management of pyogenic lung abscess before the antibiotic era, with a mortality rate of 3% and a cure rate of 85–90%, and hence became the treatment of choice (1, 2). However, with the introduction of antibiotics, PTTD has given way to medical therapy.

Although 80–90% of pyogenic lung abscesses are now successfully treated with antibiotics, occasionally this conservative therapy may fail (3–5). This may be due to the virulence of the responsible pathogens or failure to achieve an adequate concentration of antibiotics within the abscess cavity (6, 7). Severe underlying lung disease and decreased lung compliance may play a role in the failure of an abscess cavity to drain spontaneously and hence the failure of medical therapy (6).

When conservative treatment fails, pulmonary resection, preferably lobectomy, is usually advised. However, it is important to emphasize that the mortality rates associated with lung abscess, even with surgical therapy, continue to be substantial, ranging from 15% to 20% (8–11). Another alternative therapy in such situations is percutaneous drainage. This procedure has not gained widespread popularity and has been mainly reported in severely ill patients with lung abscess who are unable to tolerate lobectomy (12). Currently, the role of PTTD in the management of pyogenic lung abscess remains controversial. Literature is scarce on this important issue and hence we deemed it worthwhile to review the literature concerning PTTD and to present the consensus opinion of various authors worldwide.

MATERIALS AND METHODS

The English language literature dealing with the use of percutaneous drainage for the treatment of pyogenic lung abscess was reviewed for the period January 1975 to December 2000 using MEDLINE. The search terms used were 'percutaneous drainage', 'lung abscess' and 'management'.

The efficacy, indications, technique, timing of insertion and removal, complications relating to the procedure and the mortality rate secondary to lung abscesses or sepsis, despite the use of PTTD, were all reviewed. The success rate was defined clinically as control of sepsis and avoidance of surgical resection and radiologically as resolution of signs of inflammation, i.e. consolidation, pleural effusion and cavities. It is of note that the presence of a residual cavity did not indicate failure of PTTD.

RESULTS

A total of 25 studies have been published in the English language literature since 1975. There were no controlled trials evaluating the role of PTTD for the treatment of lung abscesses, all studies being either case reports or case series. Five studies were excluded. Four of these (4, 26, 32, 35) were excluded because the patients were treated with pneumonostomy requiring operative rib resection. The study by Delarue et al. (13), which included 41 patients, was also excluded as these patients were studied at the beginning of the antibiotic era. The remaining 20 studies reported a total of 105 cases. Ten patients had secondary pyogenic abscess, 5 with pre-existing cysts and 5 with lung cancer. The remaining 95 cases had primary pyogenic abscesses. For these reported cases heterogeneous characteristics were available including age, surgical fitness of patients, abscess size and etiology (primary or secondary relating to bronchogenic malignancy or infection of preexisting cyst), duration of antibiotic use, catheter size, duration of drainage and use of bronchoscopy prior to PTTD (Table I).

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The efficacy, complications and mortality rate of PTTD are summarized in Table II. The success rate was 84.8% (89/105). The complication rate relating to the procedure was found to be 9.7% (9/97). As a complication of the abscess, the overall mortality rate was estimated to be 4.8% (5/105). Two studies (8, 36), involving a total of 12 patients, contained no data regarding complications and hence were excluded from calculation of the overall complication rate.

DISCUSSION

Efficacy

In an early study, Vainrub et al. (6) reported a successful response to PTTD, with closure of the abscess cavity within 4–5 weeks, in 3 patients with Gram-negative pyogenic lung abscess who failed to respond to medical treatment and were not suitable for lobectomy. In another study, Weissberg (12) described 7 patients with severe sepsis who were not suitable for surgery. Prompt clinical recovery post-PTTD was reported in all patients, with complete resolution of abscesses within 4–24 d and without complications. Rice et al. (15) described successful PTTD in 14 patients with cavities >4 cm in diameter. Three patients were treated with rib resection as the initial management while another 3 required subsequent rib resection for optimal drainage. Only 1 patient with bilateral pneumonia and unilateral abscess died, but death was attributed to sepsis resulting from progression of disease on the contalateral side to the drained abscess. Shim et al. (3) also reported results of PTTD in 4 patients with refractory lung abscess: all patients defervesced promptly and all cavities closed gradually over the course of 6–12 weeks. The patients tolerated the tube drainage well and there were no side-effects (3). These studies support the efficacy of PTTD for the treatment of pyogenic lung abscess, even in cases involving virulent Gram-negative organisms, giant abscesses and severe sepsis.

Another advantage of PTTD is the rapid clinical and radiological improvements of pyogenic lung abscess which may avoid the complications that can occur with conservative and prolonged treatment (16). VanSonnenberg et al. (16) described a cure rate of 100% in 19 unresponsive patients treated with CT-guided PTTD. The average duration of drainage was 9.8 d. In that study the major complication was hemothorax in 1 patient. More recently, Ha et al. (17) reported complete abscess resolution in 4/6 patients treated with small-size catheters with a mean drainage duration of 15.5 d. The remaining 2 patients showed partial response and no response, respectively. The failure of PTTD in the latter patient was due to persistent aspiration. There were no complications relating to the procedure (17).

Although most studies have demonstrated good results with PTTD, as mentioned above, it should be emphasized that the procedure is not always successful and its efficacy is still the subject of debate (18). Failure of PTTD was reported to occur in cases of multiloculation, poor definition of the cavity or a thick-walled cavity that may not have collapsed (4). Hirshberg et al. (8), in their cohort study, attempted PTTD in 11 patients; although the procedure was technically successful in 8 patients, 5 of these patients died. This is disappointing and in conflict with the result of other studies (3, 6, 12, 15–17). Secondary lung abscess, comorbid illnesses and virulent organisms were

Table I. *Use of PTTD in the management of lung abscess*

Year	Reference	No. of cases	Age (years)	Abscess size (cm)	Chest tube size (cm)	Drainage duration (days)
1978	(6)	3	59–62	NA	16–18	NA
1978	(19)	1	>55	>4	NA	NA
1979	(33)	1	63	Large	8	14
1982	(34)	1	47	Large	9	NA
1984	(12)	7	1–60	NA	36	4–24
1985	(20)	10	32–70	NA	12	6–30
1985	(14)	3	18–55	9–14	28	14–28
1987	(36)[a]	4	48	NA	6.5–12	NA
1987	(28)	6	2–78	NA	$\leqslant 10$	10–59
1987	(15)	11	57.6	>4	NA	NA
1987	(37)	4	0.61–14	NA	5–12	NA
1989	(38)	3	5–8	NA	8–12	19–24
1990	(3)	5	31–75	NA	NA	42–84
1991	(16)	19	8–74	3–15	9–20	4–38
1992	(39)	2	NA	NA	NA	NA
1993	(17)	6	6–66	5–13	8–10	7–18
1996	(40)	5	2–21	3–8.5	8.5	1–20
1997	(41)	1	34	NA	NA	NA
1999	(21)	5	0.04–19	4–100	8–12	4–14
1999	(8)	8	12–89	NA	NA	NA

[a] This study reviewed 44 patients in whom tube drainage was used for thoracic diseases, including 4 cases with lung abscess. The variables given are the means for the whole group. NA, Data not available.

Table II. *Efficacy, complications and mortality of PTTD for the treatment of lung abscess.*

Year	Reference	No. of cases	Success rate (%)	Complication rate (%)	Mortality rate (%)
1978	(6)	3	100	0	0
1978	(19)	1	100	0	0
1979	(33)	1	100	0	0
1982	(34)	1	100	0	0
1984	(12)	7	100	0	0
1985	(20)	10	70	0	0
1985	(14)	3	100	0	0
1987	(36)	4	100	NA	0
1987	(28)	6	83	50 (2 catheter exchange[b] due to inadequate drainage; 1 Pneumothorax)	0
1987	(15)	11	72.7	0	0
1987	(37)	4	75	0	0
1989	(38)	3	100	0	0
1990	(3)	5	100	0	0
1991	(16)	19	100	21 (2 catheter occulsions; 1 Hemothorax; 1 Increased cranial pressure)	0
1992	(39)	2	100	0	0
1993	(17)	6	66.7	0	0
1996	(40)	5	100	0	0
1997	(41)	1	100	0	0
1999	(21)	5	80	40 (2 episodes of local chest pain)	0
1999	(8)	8	37.5	NA	62.5
	Total	105	84.8	9.7[c]	4.8

[a]See text for definition.
[b]In this study, although a total complication rate of 20% was reported for the 44 patients (of which only 4 had lung abscess), it was not clear whether the complications occurred in patients with lung abscess or in those with other lung conditions.
[c]Two studies (8, 36) involving a total of 12 patients provided no data regarding complications and hence were excluded from the calculation of the total complication rate.

found to be poor prognostic indicators in the report of Hirshberg et al. (8). However, it was not clear whether any of these factors contributed to the mortality in the 5 patients who died.

Single percutaneous aspiration of abscess content can also be therapeutically successful (21). Hoffer et al. (21) described 14 children with lung abscess. After failure of medical therapy, single percutaneous aspiration was performed in 10 of them. Nine responded and recovered completely, while the remaining child required percutaneous drainage. Percutaneous aspiration cultures were often diagnostic and informative and hence the treatment plan could be modified accordingly. Yang et al. (22) described a series of 23 patients, 10 of whom (43%) had their antibiotic regimen changed depending on the results of percutaneous aspiration culture and sensitivity. Seven out of 10 patients (70%) improved within 1–3 weeks as a result of the new antibiotic coverage. It can be concluded that aggressive interventional therapy can be of diagnostic and therapeutic value in lung abscesses (22–25).

Indication

The main indication for PTTD is when medical therapy fails as a substitute for thoracotomy and lobectomy. It is particularly useful when the risks associated with surgery are prohibitive, but may also be considered in those who are clinically fit for surgery, as suggested by Yellin et al. (20). These authors studied 50 patients with primary pyogenic lung abscess during the period 1972–82. Seven of these patients (14%) did not respond to conservative medical therapy and were candidates for lobectomy. All were treated with PTTD, with complete recovery, no complications and no relapse after a follow-up period of 2–5 y. The complete recovery following external drainage raises the question of whether lobectomy is needed at all, especially as it involves resection of functional lung parenchyma and causes much greater trauma than PTTD. Indeed, several studies have reported that complications were greater after surgery than after tube drainage, despite the fact that patients treated with drainage were more ill and hence more prone to complications (6, 14, 15, 26, 27). Furthermore, the postoperative mortality rate after surgery for lung abscess has been reported to range from 11% to 16% (13, 26). In contrast, no mortality was reported with PTTD in any of the studies reviewed in this article, with the exception of the study of Hirshberg et al. (8).

The size of an abscess is considered to be 1 of the criteria indicating PTTD, as patients with large abscesses are at risk of aspiration of their own secretions. Surgical drainage of abscesses >4–8 cm in diameter has been advocated by several authors (14–16). In 1 study that reviewed mortality in patients with lung abscess (9), it was found that 22% of

33 fatalities may have been due to aspiration of the abscess content. More recently, larger abscess size was shown to be associated with poorer prognosis and increased morbidity, although not with an increase in mortality (8). Accordingly, a more aggressive approach to treating such patients was recommended.

PTTD is also indicated in debilitated patients who are unable to cough effectively so as to achieve adequate spontaneous drainage of pus (16). This is seen in particular in the intensive care setting, in which patients are sedated, intubated and mechanically ventilated. Although there is a concern that PTTD may interfere with respiratory support in these patients and increase the rate of complications, Rice et al. (15) reported 9 patients with respiratory failure requiring mechanical ventilation in whom tube drainage was successfully performed and did not interfere with respiratory management.

A possible indication for PTTD occurs when the abscess cavity does not contain an air-fluid level and is homogeneous, as some degree of tension may be present and sudden endobronchial decompression may be disastrous (28). Moreover, avoiding massive hemoptysis may be a potential advantage of PTTD. This may be achieved by ensuring prompt evacuation of the abscess contents and hence stopping further growth of the cavity (14). Although PTTD is not usually recommended for the treatment of lung abscess with massive hemoptysis, it may be considered for hemodynamically unstable patients unfit for lobectomy. This condition was described in 1/7 cases reported by Weissberg (12) in whom PTTD was successful for treating both sepsis and massive hemoptysis.

Before considering the failure of medical therapy and the need for PTTD, it is important to rule out bronchial obstruction and bronchogenic malignancy as these are indications for surgical resection and not PTTD. This can be achieved using bronchoscopy, which should be performed before attempting PTTD. In our review, only 41/105 (39.0%) of the cases for whom information was available had bronchoscopy prior to PTTD. Yellin et al. (20) reported 3 cases of lung cancer who presented with lung abscess in whom PTTD failed and lobectomy was performed. However, PTTD may have a palliative role for the relief of sepsis in the presence of unresectable lung cancer. Lawrence and Rubin (19) described 3 cases of lung abscess associated with unresectable lung cancer that were successfully treated with tube drainage but required rib resection.

Technique of percutaneous drainage

Insertion of the drainage catheter is usually performed under local anesthesia using either fluoroscopic, ultrasonographic or CT guidance so as to avoid the uninvolved part of the lung. Radiographic guidance is also helpful for assessing pleural involvement, detecting loculated cavities and determining the optimal position of the catheter (17). However, it has been reported that PTTD can be performed safely as a bedside procedure without the aid of imaging (20). The postulate was that after a few weeks of medical treatment, the diseased area adheres to the chest wall, minimizing the risk of intrapleural spread and hence obviating the need for imaging guidance (20). Once the catheter is in place and the abscess has been evacuated, gentle irrigation with normal saline is performed until the retrieved fluid is clear (16). The tube is then connected to an underwater seal employing a negative pressure (12, 20) or directly to a suction pump (16, 28). Irrigation using 5–15 ml of normal saline should be performed daily (16, 17, 28). Such irrigation may facilitate and expedite percutaneous drainage (14, 16, 29). The role of intracavitary fibrinolytic agents for shortening the duration of percutaneous drainage has not been assessed. In a prospective randomized study of patients with peritoneal, retroperitoneal and parenchymal abscesses, Haaga et al. (30) examined urokinase and saline as abscess cavity irrigants. They concluded that although the remission rate did not differ between the 2 groups, urokinase was effective in shortening the treatment time and improved the clinical course (30). Post drainage, contrast sinography may offer information on cavity closure (19); however, plain chest radiographs are normally sufficient for follow-up (16).

There is a wide variation in the ideal size of the percutaneous tube (12, 16, 17, 20, 28). However, it is well established that a small tube (10–14 F) can adequately and effectively drain pus (16, 28). In 1 report, exchanging a 7 F catheter for a 10 F catheter was necessary in 2 patients in order to maintain adequate drainage (28). Although the use of a large tube size appears unnecessary, as it may cause undesirable trauma to the lung (16), it may still be indicated in patients with extremely tenacious and viscous material (14, 20).

Timing of PTTD

It is not known for how long PTTD should be delayed before commencing the procedure. However, percutaneous drainage should not be delayed for too long in cases of refractory lung abscess (12, 16). A 10–14 d period of conservative medical therapy without clinical improvement has been suggested to be a suitable delay (28). In cases of sepsis or in patients whose condition is deteriorating, the abscess should be drained without any delay (12, 15). Whether immediate PTTD is indicated for the management of giant lung abscess without prior antibiotic therapy is unknown. In 1 study, successful drainage was performed in 2 patients with giant abscesses within 24 h from the time of presentation with no complications, death or recurrence (14).

For conditions associated with a high mortality rate, the threshold for a more aggressive approach should be low, and hence PTTD should be considered as a result of early signs of conservative therapy failure, such as virulence of the organisms and severity of the underlying conditions. Recently, a high mortality rate was reported to be associated with Pseudomonas spp., Klebsiella spp. and Staphylo-

coccus aureus (8). Similarly, the severity of the underlying disease will greatly influence the outcome of patients with lung abscess. The mortality rate in uncomplicated cases approaches 0%, in contrast to that of $\geq 35\%$ in patients with concomitant diseases (31).

Duration of drainage

The optimum duration of tube drainage has also not yet been determined and the criteria for removal vary from 1 report to another (3, 17, 28). A remarkable reduction in abscess size with cessation of purulent drainage for at least 3 d and the absence of clinical signs of abscess even before the abscess cavity is completely resolved are reasonable criteria for tube drainage removal (17).

Complications

It is of interest that the most common complication of PTTD reported is inadequate drainage or clogging of the catheter requiring tube exchange, which is probably related to the use of small-sized tubes (16, 28). However, the main complication post-PTTD is contamination of the pleural cavity by pus during the insertion of the drainage tube, which may result in empyema and bronchopleural fistula. Mengoli (14) reviewed 184 patients for the presence or absence of persistent bronchopleural fistula, and found that this complication was reported in 8% of cases. Using CT, ultrasound or fluoroscopy to assess possible pleural symphasis and to determine a skin site closest to the abscess wall may reduce the risk of empyema. Thus inserting the chest tube at the site where the wall of the abscess is in contact with the pleural surface may avoid spillage of pus into the pleural cavity and hence the development of empyema (17). This may explain the absence of empyema and significant bronchopleural fistula as complications of PTTD in our review.

Pneumothorax, hemothorax and intrabronchial hemorrhage are other potential side-effects of PTTD. In our review, only 1 case of pneumothorax and 1 of hemothorax were reported (16, 28). These complications may be related to the use of a standard chest tube and may be avoided by using a smaller one, thus causing less trauma (28). On the other hand, avoiding puncture of normal lung parenchyma would prevent pneumothorax and hemothorax (16, 17). In a previous report, 1/2 patients in whom normal lung was unavoidably transversed by the catheter developed a hemothorax (11). At present, abscesses completely surrounded by normal lung parenchyma should probably not be subjected to PTTD until sufficient clinical evidence to the contrary becomes available.

Mortality

The overall mortality rate in our review was 5/105 (4.8%) and all 5 cases were from the same report (8). It was not clear how many of these had secondary abscesses, as in this report the mortality rate was greater in patients with secondary (26%) as opposed to primary lung abscess (18%) (8). In a similar report, which reviewed the literature between 1950 and 1985, the mortality rate was 13% in 694 patients treated with PTTD (14). The difference in mortality rate compared to that found in our review may be due to (i) recent developments in the PTTD technique, such as the use of smaller-sized tubes and the abandonment of general anesthesia and rib resection; (ii) the type of patients treated (i.e. those with comorbid illnesses, severe infections, etc. have a worse prognosis); (iii) the use of more advanced imaging techniques; and/or (iv) the difference in the number of cases reviewed. The incidence of secondary surgical resection after primary drainage was reported to be only 11% in a series of 295 patients (14). This is almost 3 times that found in this review (4/105; 3.8%), which may indicate

Table III. *Summary of features of PTTD for the management of pyogenic lung abscess.*

Advantages	1. Provides immediate drainage of pus 2. Avoids the need for thoracotomy 3. Avoids the aspiration of pus 4. Avoids the risk of rupturing of the abscess cavity
Indications	1. Failure of medical therapy 2. Patients clinically unfit for surgical intervention 3. Abscesses >4 cm in diameter 4. Inability to cough effectively to achieve adequate spontaneous drainage 5. Homogeneous cavity without an air-fluid level
Tube size	10–14 F
Timing of PTTD insertion	1. A 10–14 d period of conservative medical therapy 2. As soon as possible in cases of sepsis, deteriorating patient condition, and perhaps giant lung abscess
Timing of PTTD removal	1. Remarkable reduction in abscess size with cessation of purulent drainage for at least 3 d 2. Absence of clinical signs of abscess even before the abscess cavity is completely resolved
Complications	1. Empyema 2. Bronchopleural fistula 3. Pneumothorax 4. Hemothorax 5. Intrabronchial hemorrhage 6. Tube clogging
Complication rate	9.7%
Causes of failure	1. Multiloculation 2. Thick-walled or poorly defined lung abscess
Mortality rate	4.8%

that PTTD is becoming more efficacious in terms of avoiding more invasive procedures.

Despite all the promising aspects of PTTD, lobectomy still has a role in the management of lung abscess. It is required for multiloculated, thick-walled or poorly defined lung abscesses. It is also indicated in the presence of malignancy, bleeding, empyema and massive tissue necrosis (20).

CONCLUSION

PTTD is a safe and effective method for treating lung abscess and is probably the surgical treatment of choice in a medically complicated patient with a poorly draining lung abscess. In addition, PTTD should be considered as an alternative to lobectomy even in patients who are fit for surgery. However, it is worth remembering that the available evidence regarding the efficacy of PTTD is of level 5, i.e. uncontrolled case series, emphasizing the need for randomized trials to further confirm the role of PTTD in the management of lung abscess. A summary of the features of PTTD is given in Table III.

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