Trapped lung: A review of literature and recent cases

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Abstract

A trapped lung, one that cannot expand due to a restrictive fibrous visceral pleural peel, is caused by malignancy, chest trauma, thoracic surgery, complicated infections, and autoimmune disorders. Suspicion for and evaluation of this condition should be considered early in patients with a history of the above disorders who present with a chronic pleural effusion of stable volume. The diagnosis is established with pleural fluid analysis, manometry that shows negative intrapleural pressure that is further reduced with fluid aspiration, and imaging that shows a chronic effusion and pleural thickening. Treatment depends on symptoms and the patient's overall condition and ranges from observation to fluid removal, fibrinolytic therapy, talc pleurodesis, indwelling pleural catheter placement, and surgical decortication. A review of English literature from the last 10 years, including case reports, case series, and observational reviews was conducted. The majority of these patients presented with trapped lung due to malignancy, infection, or autoimmune disorders. Treatment varied depending on the cause of the trapped lung, underlying comorbidities, and patient preference; a majority of these patients underwent either pleurodesis, intrapleural fibrinolytic therapy, or surgical decortication.

Keywords: Trapped lung, fibrous visceral pleural peel, malignant pleural effusion, pleurodesis, decortication

Background

A trapped lung is defined as a lung that is unable to fill the thoracic cavity due to a fibrinous restrictive visceral pleura that prevents expansion. This phenomenon was first described by Moore in 1967.[1] At that time, trapped lung was most commonly due to a therapeutic pneumothorax to treat tuberculosis. Current common causes include uremia, thoracic radiation, chest trauma, cardiothoracic surgery, autoimmune pleurisy, and complicated parapneumonic effusion.[1–3] The incidence of trapped lung is not readily known; however, several studies show that about 5–10% of patients who undergo thoracentesis, 20% of patients who undergo therapeutic thoracentesis, and 30% of patients with malignant pleural effusions will ultimately have a trapped lung.[4–6]

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Evaluation

Evaluation for trapped lung should be considered early in a patient with a history of pleural injury or pleural disease and chronic, recurrent pleural effusion of stable volume. Delaying the diagnosis poses a threat for inadvertent repetition of diagnostic procedures leading to further complications, local inflammation that can distort fluid analysis, and avoidable patient discomfort. Trapped lung should be differentiated from non-pleural causes of non-expandable lung, which include endobronchial obstruction due to bronchogenic carcinoma and interstitial disease.[2,3,6] It should also be recognized as an entity separate from, but on the late end of the spectrum of lung entrapment. An entrapped lung is caused by an active malignant or inflammatory process within the pleura that leads to restriction and

prevention of normal lung expansion. Most cases of entrapped lung are temporary and resolve with treating the underlying process and releasing the trap; those that do not resolve result in permanently trapped lung. In these cases, and although it is unclear why it occurs in some patients but not others, there is increased collagen deposition and the development of a mature, fibrous visceral pleural peel.[2,5–10]

Diagnosis

The basis for diagnosis is the inelasticity of transpulmonary pressure vs. lung volume, i.e., the lung acts as a container with rigid walls. The diagnosis of trapped lung requires documentation of chronicity, stability of volume, and the absence of active inflammatory or neoplastic processes, bronchial obstruction, or severe underlying lung disease.[2,6] The stability of volume hints at lung inelasticity or rigidity. Thoracentesis is a valuable tool to aid in diagnosis, offering information on intrapleural pressure as well as access to pleural fluid for analysis. Pleural manometry allows the direct measurement of pressure in the pleural space during thoracentesis. Data collected from manometry are plotted on a pressure vs. volume diagram, from which pleural elastance, or the tendency of the lung to recoil toward its original dimensions upon removal of a counteracting force, can be inferred.[3–5] The hallmark of trapped lung is a high pleural elastance (>14.5 cm H_2O/L of pleural fluid removed).[2,4,5] Since pleural manometry is time consuming and requires technical expertise, it is not routinely done.[4,6] In a trapped lung, despite the presence of pleural effusion, intrapleural pressure is low and drops significantly with fluid removal.[4–6] This negative intrapleural pressure drives fluid entry into the pleural space and reduces the tendency for this fluid to exit through the intrapleural lymphatic system. This ultimately causes the chronic, equivolume, negative pressure pleural effusion that occurs with a trapped lung, as well as worsening chest pain during aspiration of pleural fluid.[4,10] This is consistent with the theory that trapped lung is the result of imbalanced hydrostatic forces secondary to abnormal healing after infection or inflammation. Analysis of this fluid should reveal a transudative effusion with a low level of lactate dehydrogenase and paucity of mononuclear cells.[4,7,10] Ultimately, diagnosis can be confirmed with air-contrast computed tomography, which will show a thickened visceral pleura or with video-assisted thoracoscopic surgery (VATS) and direct visualization of a pleural rind.[2–4,6]

Treatment

Treatment depends on patient presentation and symptoms. A majority of patients with trapped lung are asymptomatic or have minimal dyspnea on exertion. In these patients, observation is sufficient.[2–4,11] In patients with dyspnea, thoracentesis is indicated.[12] Intrapleural fibrinolytic therapy with repeated doses of 4–6 mg of tissue plasminogen activator (TPA) left to dwell in the pleural space for 6–12 hours at a time can degrade fibrin strands and may release the trap. After the lung is released and re-expands, pleurodesis may prevent additional pleural effusion formation, but TPA is not definitive treatment unless the pleural effusion spontaneously resolves or can be prevented by pleurodesis.[6,14,15] Pleurodesis can be attempted with talc "slurry," a mixture of 4–5 grams of talc in 100 mL of saline that is introduced by a thoracostomy tube, or via "poudrage," the insufflation of talc powder into the pleural space during thoracoscopy. A 2005 randomized, multicenter trial compared these two methods and found benefits from both, namely improved pain control and less fatigue in patients receiving poudrage, lower risk of respiratory complications and a less invasive approach with slurry, and equivalent efficacy of both.[4] Due to the increased elastance that is pathognomonic for trapped lung, pleurodesis is sometimes ineffective. The likelihood of its failure increases with greater negative intrapleural pressure, lack of lung expansion despite pleural evacuation, and daily fluid output of more than 300 mL from a thoracostomy tube.[4,6,7,13] The only curative treatment is surgical decortication.[3,11] In patients with poor overall prognosis, those who are not good surgical candidates, and those with failed pleurodesis, palliation is the goal and can be achieved with as needed thoracenteses or indwelling catheter placement.[4,6] The above treatment will not be effective in lungs that cannot re-expand due to central airway obstruction.

Table 1. A summary of Case Series

Author	N	Age Sex	Source of Trapped Lung	Treatment(s)	Notes
Patino (14)	7		Varied sources, umbrella term "complex pleural effusion"	Tube thoracostomy and intrapleural fibrinolytics, decortication	
Abumossalam (15)	28		Chronic empyema; patients refused or were not candidates for surgery	Autologous blood patch or gel-foam talc slurry, n = 18	
				Trypsin/chymotrypsin tablets TID × 2 months, n = 10	
Minchev (18)	66		Malignant pleural effusion	VATS, n = 26	
				Talc pleurodesis and drainage, n = 40	
Kim (29)	4	24 M	Hepatic hydrothorax due to congenital hepatitis C	Prior to surgery: diuretics, PRN thoracenteses Post-surgical: 14 Fr chest tube × 48 hours, antibiotics	Total lung re-expansion 6 months after transplant
		68 F	NASH	PRN thoracenteses × 1 year; 16 Fr chest tube for PTX; VATS with decortication	Received transplant
		74 M	Hepatitis B	PRN thoracenteses × 2 years: small bore chest tube, VATS	Significant postoperative bleeding; died
		57 M	NASH	Chest tube, failed pleurodesis, IPC; TIPS with asymptomatic PTX; observation	

PTX: pneumothorax; NASH-nonalcoholic steatohepatitis; VATS-video-assisted thorascopic surgery; prn-as needed.

Discussion

The key words "trapped lung" and "trapped lung syndrome" were used to identify case reports, case series, and observational reviews written in English within the last ten years in PubMed and Google Scholar. Forty-nine case reports and case series are detailed in Table 1 and the supplementary table. One-hundred forty-three patients in total were reported. Patient age, when reported, ranged widely, from 19 to 90 years old; the cases had a male predominance. The leading cause of trapped lung was malignant pleural effusion secondary to a variety of carcinomas, including mucoepidermoid carcinoma, squamous cell carcinoma from the buccal mucosa and penis, carcinoma of unknown primary, clear cell renal carcinoma, and colon adenocarcinoma. The second most common cause was infection, followed by autoimmune disorders, such as systemic lupus erythematosus, sarcoidosis, Behcet's disease, Graves' disease, and rheumatoid arthritis. Forty-eight of the 143 patients (33.6%) were treated with decortication by either VATS or an open thoracotomy. Sixty-two of the 143 patients (43.4%) had talc pleurodesis; three of these procedures were recorded as unsuccessful. Eight had indwelling pleural catheter placement; 1 of these patients subsequently underwent decortication. Six patients received intrapleural fibrinolytics, and four later underwent decortication. Twenty-three patients received problem-specific treatment, such as shunt revision and sphincterotomy with stent placement. Five patients pursued palliative care only. Finally, two of the 143 patients were asymptomatic and were simply observed.

This review also focused on trapped lung formation in malignant pleural effusions. These effusions occur more frequently in patients with thoracic malignancies.[16] It appears that the consensus with malignant pleural effusions is that poudrage via VATS is the gold standard of treatment in patients who can tolerate the procedure.[13,17,18] In patients who cannot, an indwelling pleural catheter is a safe, effective alternative treatment; however, these patients have a shorter life expectancy–18 months survival in those who received VATS poudrage as compared to 6 months in those who received an indwelling catheter placed.[13,18–20] A component of these outcomes is likely explained by the patient's performance status immediately prior to assignment of treatment group, as patients undergoing VATS must be considered healthy enough to undergo surgery.

Summary

Based on this literature review, the most common disorders associated with trapped lung are malignant pleural effusions, infections, and autoimmune disorders. Patients with trapped lung who are healthy enough to undergo a procedure benefit the most with VATS and decortication. In those with trapped lung and malignant pleural effusion who are healthy enough for anesthesia, VATS with talc poudrage has been an effective treatment. In patients with trapped lung, malignant pleural effusion, and additional severe comorbid conditions or terminal cancer can still receive some benefit in quality of life with an indwelling pleural catheter.

Supplementary table: Case reports identified and literature review.

Supplementary Table. A Summary of Case Reports

Author	Age	Sex	Diagnosis	Treatment	Notes
Maharaj (21)	23	F	Systemic lupus erythematosus	Decortication, antibiotics	
Foo (22)	19	M	Chest wall trauma causing hemothorax	Thoracostomy tubes x4 to negative suction, intrapleural fibrinolytic therapy	
Matthew (23)	35	F	Catamenial hemothorax	VATS with thoracostomy tube placement	Lung expansion did not occur until POD #81
Walayat (24)	63	M	Pasteurella multocida from cat bite	Antibiotics, VATS with decortication	
Amabile (25)	78	M	Congestive heart failure	Thoracentesis x1	Post-mortem findings
Tian (26)	61	M	History of untreated, asymptomatic pneumothorax 14 years prior	VATS with decortication	
Dalphy (27)	40	F	Intrathecal-to-pleural shunt placed at age 14 for hydrocephalus	Shunt revision to intrathecal-to-peritoneal	
Ali (28)	41	F	Pancreaticopleural fistula	Bilateral thoracostomy tubes, ERCP and EUS with sphincterotomy and stent placement to direct fluid internally	

Supplementary Table. A Summary of Case Reports (*Continued*)

Author	Age	Sex	Diagnosis	Treatment	Notes
Ahmed (30)	65	M	Rheumatoid arthritis	Unsuccessful talc pleurodesis with small PTX; observation as patient was asymptomatic	
Rosenburg (31)	26	M	Lymphedema, yellow nail syndrome	VATS with decortication	
Thomas (32)	58	M	Mucoepidermoid carcinoma of lung	Palliative chemotherapy and radiation	Partial re-expansion
Jha (33)	65	M	Pleural sarcoidosis	Bronchoscopy with EBUS, TBB; thoracocentesis; oral steroids	Bronchoscopy and thoracocentesis to rule out other causes
Tesfaye (34)	30	M	Gunshot wound to chest; biliopleural fistula	Chest tube; then clot evacuation, decortication, biliary and liver laceration repair	
Panigrahi, MH (35)	64	M	Malignant pleural effusion of unknown primary	Bronchoscopy to rule out endobronchial lesions; palliative therapy	End stage cancer
Erul (36)	26	M	Behcet's disease treated with infliximab, then developed fungal and bacterial pneumonia with parapneumonic effusion	Antibiotics and antifungals; iatrogenic PTX developed when obtaining pleural fluid; then, decortication and bronchopleural fistula repair	Long course of antimicrobials (~45 days)
Merchant (37)			Chest wall trauma falling off horse	VATS and rib plating	Initially, rib fractures were managed medically
Villano (38)	74	M	Malignant pleural effusion	Open window thoracostomy, decortication, drainage	Presented with failed intrapleural catheter for MPE
Sorino (39)	60	M	Malignant pleural mesothelioma	Failed talc poudrage; chemotherapy until progression, palliative thoracentesis x2	Refused further treatment after disease progression
Itani (40)	43	M	Metastatic penile squamous cell carcinoma	Chest tube placement; open decortication	
Brewster (41)	36	M	Grave's disease on methimazole	Chest tube; then, VATS with thoracotomy and decortication	
Broderick (42)	69	F	Silicone breast implant rupture (placed 20 years ago after bilateral mastectomy)	Washout and decortication	

(*continued*)

Supplementary Table. A Summary of Case Reports (*Continued*)

Author	Age	Sex	Diagnosis	Treatment	Notes
Calleja (43)	48	M	Secondary spontaneous PTX due to tuberculosis	Closed tube thoracostomy with plan for VATS later; returned with empyema and received pleural window	
Htun (44)	83	M	Chronic aspiration with dementia	Antibiotics, thoracentesis with resultant PTX, chest tube, then IPC	
Soni (45)	46	M	Sarcoidosis; history of treated tuberculosis 15 years prior	Decortication; prednisone and methotrexate for sarcoidosis	
Yang-Nagano (46)	37	F	Exposure to biomass fuel, history of treated tuberculosis 22 years prior	Open decortication	
Lal (47)	26	M	Clear cell renal cell carcinoma	Thoracentesis x3; palliative treatment	Patient refused chemical pleurodesis, was not a candidate for surgery or IPC
Qadeer (48)	73	F	Metastatic colon adenocarcinoma with Listeria monocytogenes empyema	Intrapleural fibrinolytic therapy, intravenous antibiotics	
Bandikatla (49)	60	M	Squamous cell carcinoma of buccal mucosa, MPE	Thoracentesis, medical thoracoscopy, IPC	Pneumothorax ex-vacuo remained
Alam (50)	85	M	Unspecified	IPC	
Jain (51)	40	F	Necrotizing MSSA pneumonia	Pigtail chest tube insertion, surgical sealant for persistent air leak, endobronchial valve x2, second chest tube; continuous suction	Chest tubes remained in place for 57 days
Chopade (52)	35	M	Cirrhosis secondary to hepatitis C	Chronic indwelling pleural catheter, TIPS, antibiotics for MRSA empyema; then treated with intrapleural fibrinolytics, developed another infection, then underwent thoracotomy and decortication	Chest tubes removed on day 56; resumed drug use and died 6 months after diagnosis of cirrhosis
Singh (53)	62	M	Streptococcus constellatus aspiration pneumonia	Tube thoracostomy, intrapleural fibrinolytics, VATS with decortication, second chest tube placement	

Supplementary Table. A Summary of Case Reports (*Continued*)

Author	Age	Sex	Diagnosis	Treatment	Notes
Edriss (54)	48	M	Coccidioidomycosis lung infection and bronchopleural fistula; chylothorax	Endobronchial valves x3, chest tube, pleurodesis; decortication and wedge resection; then chylothorax formed and was treated with intrapleural amphotericin B and IPC	
Amlani (55)	59	M	End stage renal disease	Bronchoscopy to rule out endobronchial lesions; then IPC	
Velez (56)	90	M	Streptococcus mitis due to chronic aspiration	Chest tube, antibiotics, intrapleural fibrinolytics	Discharged on indefinite antibiotic therapy
Adetiloye (57)	73	F	Klebsiella due to chronic aspiration	Chest tube, then decortication	
Owen (58)	67	F	Hepatic hydrothorax due to hepatitis C, chylothorax	IPC, hospice	Poor prognosis and rapid decline
Gaztamibide (59)	21	F	Lemierre's syndrome	Chest tube with intrapleural fibrinolytics, VATS, decortication	

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