

Tensioned space after pneumonectomy for cancer with mediastinal shift and cardiac tamponade-causes and treatment (Review)

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Abstract. Regarding the pleural space after pneumonectomy for malignancy, a vast number of studies have assessed early drop in the fluid level, suggesting a broncho-pleural fistula, but only a small number of studies reported on the abnormal increase in the fluid level—a potentially lethal complication. In the present study, the available databases worldwide were screened and 19 cases were retrieved, including 14 chylothorax and 3 hydrothorax cases, 1 pneumothorax and 1 haemothorax case. Tension chylothorax is caused by mediastinal lymph node dissection as an assumed risk in radical cancer surgery. For tensioned haemothorax, the cause has not been elucidated, although lymphatic stasis associated with deep venous thrombosis was suspected. Tensioned pneumothorax was caused by chest wall damage after extrapleural pneumonectomy combined with low aspiration pressure on the chest drain. No cause was determined for none of the tensioned hydrothorax—all 3 cases had the scenario of pericardial resection in addition to pneumonectomy in common. Tensioned space after pneumonectomy for cancer manifests as cardiac tamponade. Initial management is emergent decompression of the heart

and mediastinum. Final management depends on the fluid type (chyle, transudate, air, blood) and the medical context of each case. Of the 19 cases, 12 required a major surgical procedure as the definitive management.

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1. Introduction

The removal of one entire lung-pneumonectomy—is not a surgical decision to be taken lightly. Although technically considered the simplest anatomical resection, its high mortality [10-60% (1)] and difficulty to manage possible post-operative complications warrant careful selection of eligible cases.

As it is the only type of pulmonary resection that leaves the entire pleural cavity empty, specific changes are expected after pneumonectomy. Typically, after surgery, the empty space is filled with air, which is then gradually replaced by fluid. Then, in a course of 1-7 months (2), the pleural cavity should be entirely obliterated. Obviously, these changes also have an anatomic impact, such as the rise of the diaphragm and the shift of the mediastinum towards the empty cavity, also narrowing the intercostal spaces on the same side (Fig. 1).

Although patients eligible for pneumonectomy undergo a rigorous workup prior to surgery, certain post-operative complications still do occur. Complications may occur more frequently when oncological elective surgeries are delayed or

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even cancelled, e.g., due to associated comorbidities or due to the COVID-19 pandemic (3-5).

As for the post-operative management of any other type of pulmonary anatomical resection, the standard cautions and care apply when it comes to pneumonectomies, but there are specific post-operative complications that the patient must be monitored for: post-pneumonectomy empyema, post-pneumonectomy pulmonary oedema and post-pneumonectomy syndrome (1), followed by other more or less frequent complications (1,6,7) that are outlined in Table I, stratified by acute or chronic state.

2. Methodology of the review

Search strategy. Search strategy and selection criteria: All of the available studies were searched on PubMed (pubmed.ncbi.nlm.nih.gov) and MedLine (lwwreprints.ovidds.com/?utm_source=google&utm_medium=paidsearch&utm_campaign=2022-ga-las-rd-reprints-portal&gclid=CjwKCAjwIaVBhBkEiwAsr7-c8oqHpC-9zEiptQ4xQxiCUAsMK-gmcSQ5fDQY-3YNXkD8XsIYfiSMOxoCSj4QAvD_BwE). Case reports and studies on the chosen topic were retrieved using different combinations of the following key words: tension, hypertensive, hypertension, hydrothorax, haemothorax, pneumothorax, chylothorax, pneumonectomy, lung cancer, lung malignancy, and mesothelioma. No language restrictions were applied to the search. Cases regarding pneumonectomies for lung malignancy (carcinoma, sarcoma, mesothelioma) were included, while cases of traumatic tension pneumothorax or another non-neoplastic disease, such as dialysis-related or traumatic haemothorax, were excluded. The publication dates were set from inception until April 2021. The search was performed between May and August 2021 by authors VM and MN, independently.

Study screening and selection. After a rigorous search, a total of 19 case reports that matched the selection criteria were identified (2,8-20). Of these cases, 18 were with liquid in tension and 1 with air in tension into the post-pneumonectomy space, all after pneumonectomy for malignancy, as presented in Table II. As mentioned above, those cases that had pneumonectomy for other reasons than malignancy and patients that had a complication after pneumonectomy on the contralateral side were excluded.

These complications after pneumonectomy are not frequent in daily practice but they present usually as emergencies and their impact may be fatal.

The reviewed pneumonectomies were performed for spindle lung sarcoma (1 case), mesothelioma (3 cases), and primary lung carcinoma (15 cases).

All 19 patients underwent pneumonectomy for malignancy. There were 16 intrapleural pneumonectomies (of which 3 were with intrapericardial approach) and 3 extrapleural pneumonectomies (Table II). The complications appeared immediately after surgery (1 case), early after surgery-in the first 15 post-operative days (14 cases), and late after surgery-between 6 and 17 months (4 cases), as presented in Fig. 2.

3. Types of fluid in the post-pneumonectomy space

Occurrence. Tension chylothorax after pneumonectomy for malignancy was the most frequent complication described,

Table I. Most common complications after pneumonectomy (6,7).

Type	Items
Acute complications	Early bronchopleural fistula Cardiac herniation Haemorrhage Early empyema Chylothorax Pulmonary edema Pneumonia Acute lung injury
Chronic complications	Tumor recurrence Late on-set empyema Postpneumonectomy syndrome Late bronchopleural fistula
Other common complications	Intrathoracic transdiaphragmatic herniation after extrapleural pneumonectomy Cardiovascular complications: Arrhythmias, myocardial infarction, acute heart failure Pulmonary embolism Vocal cord paralysis (permanent or transitory) <i>Cor pulmonale</i>

accounting for 14 patients out of 19 (73.68%); however, chylothorax is a rare complication with an incidence of <0.7% (10). Tension chylothorax was followed in incidence by tension hydrothorax (3 cases; 15.78%), tension haemothorax (1 case; 5.26%) and tension pneumothorax (1 case; 5.26%).

Tension chylothorax. The development of tension chylothorax after pneumonectomy for malignancy may be explained by the injury during subcarinal or subaortic dissection of small lymphatics that drain the lung or the mediastinal lymph nodes directly into the thoracic duct (21).

Tension chylothorax occurred only after classic pneumonectomies (intrapleural extrapericardial), 7 right and 7 left (Table II; cases 1-14). On the right, it occurred between post-operative days 5 and 15 (mean, 9.14 days) and on the left between post-operative days 2 and 14 (mean, 6.22 days). Perhaps after left pneumonectomy, recovery is faster compared to the right and the patient is allowed to ingest normal food earlier, thus causing the chylothorax to manifest earlier.

Tension hydrothorax. After pneumonectomy, given an uneventful post-operative course, effusion in the post-pneumonectomy space usually accumulates *ex vacuo* as pleural pressure equilibrates to zero (18). The fluid builds up gradually in weeks to months as the air resorbs partially or totally, as exemplified in Fig. 1. As this happens, the mediastinum is still shifted to the operated site but when an abnormal level of fluid rapidly accumulates or air is present, the mediastinum is pushed to

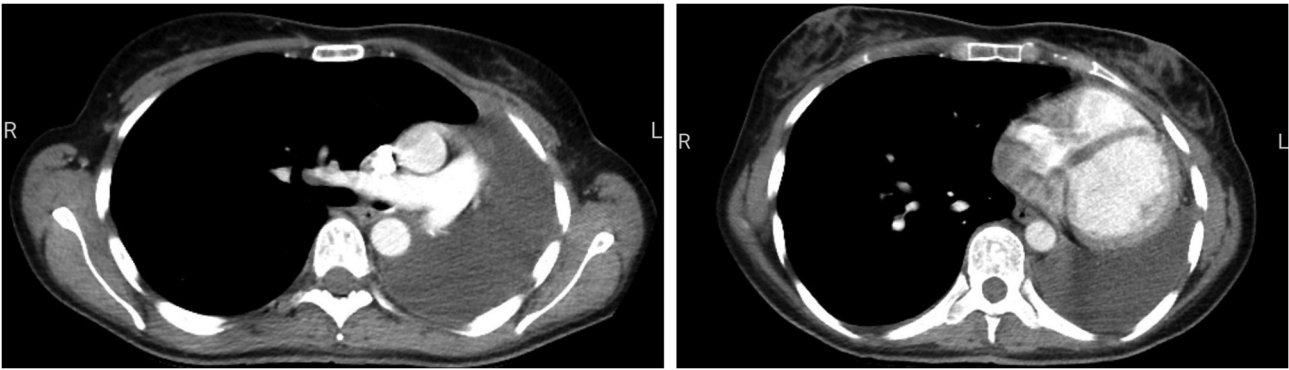


Figure 1. Normal post-pneumonectomy aspect-CT scan at 2 months after left pneumonectomy for cancer using video-assisted thoracic surgery, for a central typical carcinoid with lung destruction after one year of evolution, in a 23-year-old female patient-section at the level of the great vessels (left) and at the level of the heart ventricles (right).

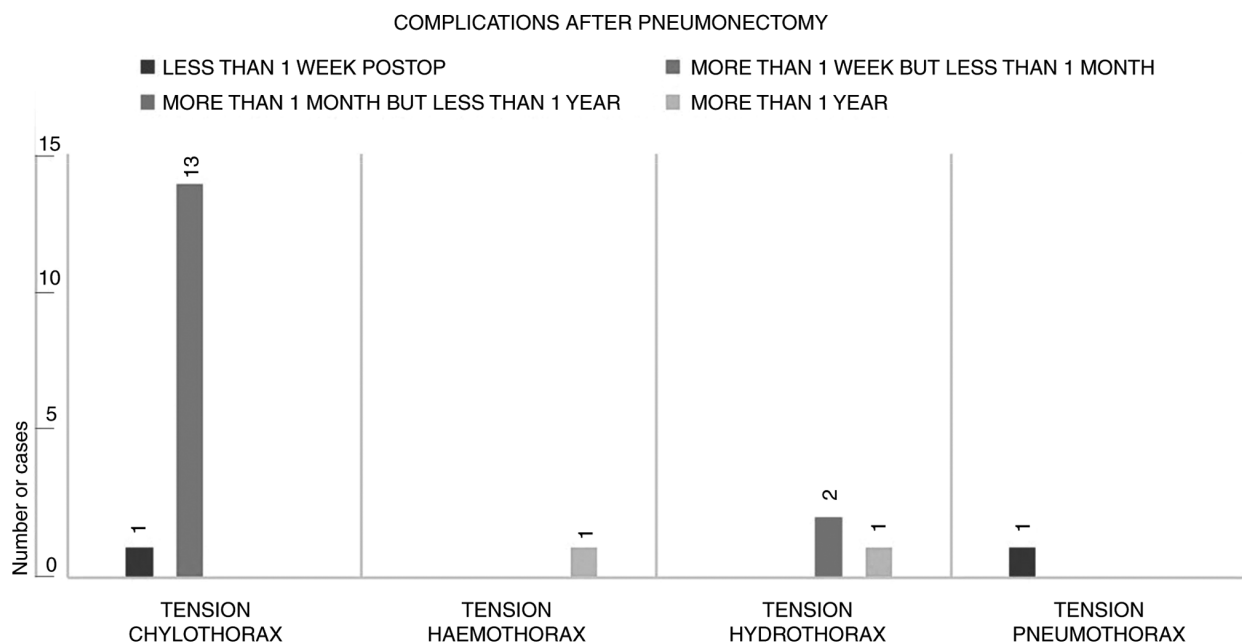


Figure 2. Incidence of complications reported for the 19 cases that matched the review criteria, stratified by time or occurrence after surgery.

the contralateral side, the heart is compressed and the patient usually has a certain form of cardiovascular and respiratory symptomatology (tachycardia, hypotension, high venous pressure, tachypnoea, marked dyspnoea at rest, cardiac tamponade, pericarditis).

Tension hydrothorax after pneumonectomy is more frequent in patients who undergo peritoneal dialysis (22). However, after pneumonectomy for cancer, tension hydrothorax was reported for only 3 cases—two left extra-pleural-pneumonectomies for diffuse malignant mesothelioma (16,17) and 1 left intrapericardial pneumonectomy with partial pericardiectomy for lung sarcoma (18). They occurred at 6, 9 and 17 post-operative months, respectively (Table II; cases 15, 16, 17). The first suspicion was of malignancy progression causing fluid accumulation, but this was excluded by cytology/pleural biopsy. In all 3 cases, the pericardium was resected and the heart cavities were exposed to the pressure of the fluid from the post-pneumonectomy space, causing cardiac compression.

Tension pneumothorax. One case of tension pneumothorax after pneumonectomy for malignancy was reported, which was attributed by the authors to the chest wall damage after extra-pleural pneumonectomy and a lower suction pressure of the chest drain was selected in order to avoid cardiac herniation (19). It occurred on the first post-operative day (case 18-Table II).

Tension haemothorax. One case of tension haemothorax was reported and the complication appeared almost 1 year after pneumonectomy, causing fatigue, dyspnoea, and oedema of the left arm; internal jugular, subclavian and axillary left veins presented thrombosis; the case was presented by our group in 2014 (20) (case 19-Table II). Thoracoscopic evacuation and pleural biopsies were performed. The liquid analysis indicated no malignancy but given the pleural aspect found during surgery, it was deemed to be the mechanism of appearance. However, pleural biopsies proved no malignancy. At four months after therapeutic anticoagulation for the deep venous thrombosis, left haemothorax recurrence developed, with

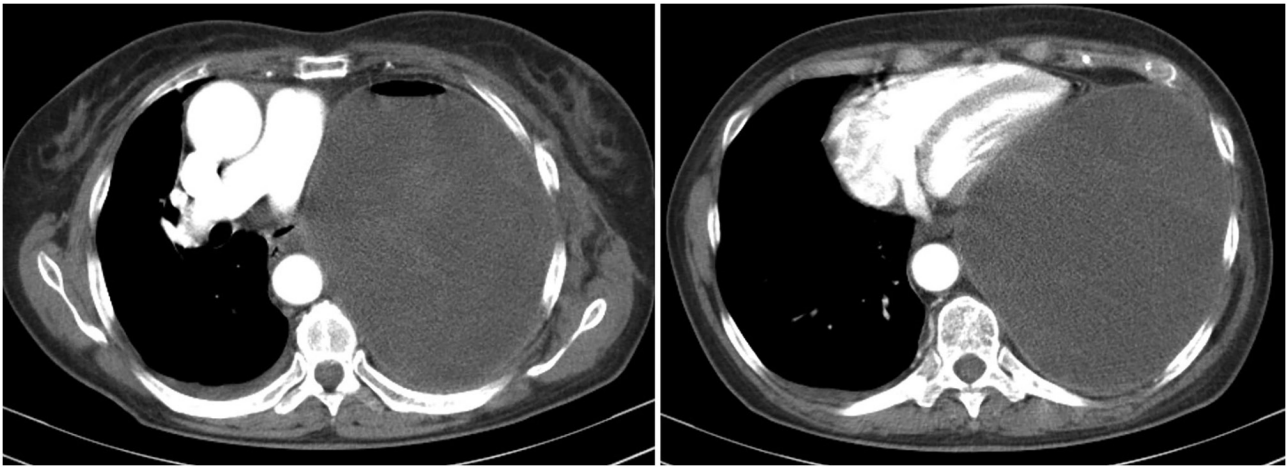


Figure 3. CT scan presenting the tension haemothorax case (20)-recurrence 4 months after thoracoscopic evacuation and biopsies, at 1 year and a half after left pneumonectomy for lung adenocarcinoma in a female patient 66y (case 19 from Table II); CT section at the level of the great vessels (left image) and at the level of the heart ventricles (right image).

cardiac compression and hypodiastolia (Fig. 3), and emergency evacuation was performed. At present, 8 years after left pneumonectomy, the patient is alive and in a good clinical condition.

4. Treatment of the tensioned post-pneumonectomy space

Once the diagnosis is established, the treatment for the tensioned space is imperative, as this complication frequently poses a fatal risk. Normally, without a strong reason, thoracentesis and pleural puncturing are not the best solutions after pneumonectomy, since seeding the pleural cavity may lead to empyema. However, thoracentesis may be a lifesaving intervention in tension fluid-thorax; which was the most common initial approach in the literature: 9 thoracenteses, 2 for diagnostic and 7 for therapeutic purposes (Table II).

The final treatment was surgical in 12 cases, either by video-assisted thoracic surgery or open surgery: 10 thoracic duct ligations, 1 thoracoscopic exclusion of malignancy, and 1 evacuation of clots (Table II).

For tensioned chylothorax (14 cases), initial management was decompression in 10 cases, followed by either conservative or surgical management. In 4 cases of tensioned chylothorax, the initial management was surgical duct ligation. The general management of chylothorax is not the subject of this paper and will therefore not be further discussed, but the cause is the same: lymphatics interrupted during the mediastinal lymph node dissection.

For tension hydrothorax (3 cases), the initial management was evacuation thoracentesis, followed by exclusion of malignancy through cytology in one case, thoracoscopy and laparoscopy with pigtail catheter in another case and indwelling pleural catheter in the third case. No specific causes were observed.

In the case of tensioned pneumothorax, the adopted solution was the simplest and solved the problem: Increasing suction pressure and maintaining the drainage until the air leak disappeared.

In the case of tensioned haemothorax with recurrence, the evacuation of haemorrhagic fluid was performed thoracoscopically the first time and through thoracotomy the second

time (fluid + clots). The cause was determined to be the anticoagulant therapy administered for venous thrombosis of the left internal jugular, subclavian and axillary veins.

5. Conclusions

Tensioned post-pneumonectomy space is a rare but potentially fatal complication. To date, a total of 19 cases of tensioned post-pneumonectomy space after pneumonectomy for cancer were published in the literature.

Tension chylothorax is the most frequent type (14 cases) and is most probably caused by mediastinal lymph node dissection (MLND); it is an assumed complication because MLND is mandatory for radical resection of lung cancer. It appeared after a maximum of 15 days post-pneumonectomy and it was solved similarly to any post-operative chylothorax.

Tension hydrothorax is the second-most frequent type (3 cases) and it appeared after complex pneumonectomies for mesothelioma and sarcoma.

Tension haemothorax and tension pneumothorax have one published case each, and each was caused by a particular condition of the case.

Shifted mediastinum with cardiac compression (leading to cardiac tamponade) causes haemodynamic instability and dyspnoea; in such cases, emergency thoracentesis may be required. After stabilization, a major surgical procedure may be necessary to definitively treat the cause of the tensioned post-pneumonectomy space.

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Table II. Cases screened in literature matching the review criteria, presented according to the type of tensioned fluid from the post-pneumonectomy space.

Nr. crt	Author (year)	Initial diagnosis	Right/left lung	Type of surgery	Time between surgery and complication (number of post-operative time units)	Time of complication	Sex	Pleural fluid	First management	Analysis of pleural liquid	Definitive management	Known follow-up	(Refs.)
1	Ammori (2006)	Lung squamous cell carcinoma T2N1M0	Right	Intrapleural extrapericardial pneumonectomy	14 days	Tension chylothorax	M	Chyle	Diagnosis thoracentesis	N/A	Surgery-mass ligation of the thoracic duct at the level of the diaphragm Chest drain	No recurrence	(8)
2	Coco (2020)	Adenocarcinoma	Left	Intrapleural extrapericardial pneumonectomy	48 h	Tension chylothorax	F	Chyle	Evacuatary thoracentesis	1,922 leu/ μ l, trgly 825 mg/dl, chol 83 mg/dl	Chest drain	No recurrence	(9)
3	Hemang (2014)	Lung squamous cell carcinoma (st.IIB T2N1M0)	Right	Intrapleural extrapericardial pneumonectomy	9 days	Tension chylothorax	F	Chyle	Chest drain	Milky white, trgly 1,729 mg/dl	First case without duct ligation: Pigtail catheter, daily instillation of antibiotic solution (gentamicin/polymixin B) Surgery-ductal ligation	Day 13 pigtail catheter removed	(10)
4	Huwer (1991)	N/A	Left	Intrapleural extrapericardial pneumonectomy	Between the 5th and the 8th day	Tension chylothorax	N/A	Chyle	Chest drain	N/a	Surgery-ductal ligation	N/A	(11)
5	Huwer (1991)	N/A	Left	Intrapleural extrapericardial pneumonectomy	Between the 5th and the 8th day	Tension chylothorax	N/A	Chyle	Surgery	N/a	Surgery-ductal ligation	N/A	(11)
6	Van Mulders (1984)	Lung squamous cell carcinoma	Left	Intrapleural extrapericardial pneumonectomy	4 days	Tension chylothorax	M	Chyle	Evacuatary thoracentesis	Trgly 387 mg/dl, LDH 176, chol 46 mg/100 ml	Surgery-ductal ligation	3 days post-discharge from ICU	(12)
7	Sarsam (1994)	Primary lung cancer	Left	Intrapleural extrapericardial pneumonectomy	Between the 5th and the 6th day	Tension chylothorax	N/A	Chyle	Chest drain	Chyle	Reinsertion of the chest drain. Surgery-direct suturing of the leak site	No recurrence	(13)
8	Sarsam (1994)	Primary lung cancer	Left	Intrapleural intrapericardial pneumonectomy	Between the 5th and the 6th day	Tension chylothorax	N/A	Chyle	Surgery-ductal ligation-below the aortic arch, posterior to the bronchial suture line	Chyle	Surgery-ductal ligation-below the aortic arch, posterior to the bronchial suture line	No recurrence	(13)
9	Sarsam (1994)	Primary lung cancer	Right	Intrapleural Extrapericardial pneumonectomy	Between the 5th and the 6th day	Tension chylothorax	N/A	Chyle	Surgery-ductal ligation-in the vicinity of the inferior pulmonary vein stump, medial to the esophagus	Chyle	Surgery-ductal ligation-in the vicinity of the inferior pulmonary vein stump, medial to the esophagus	No recurrence	(13)
10	Sarsam (1994)	Primary lung cancer	Right	Intrapleural intrapericardial pneumonectomy	Between the 5th and the 6th day	Tension chylothorax	N/A	Chyle	Surgery-ductal ligation-in the vicinity of the inferior pulmonary vein stump, medial to the esophagus	Chyle	Surgery-ductal ligation-in the vicinity of the inferior pulmonary vein stump, medial to the esophagus	No recurrence	(13)

Table II. Continued.

Nr. crt	Author (year)	Initial diagnosis	Right/left lung	Type of surgery	Time between surgery and complication (number of post-operative time units)	Time of complication	Sex	Pleural fluid	First management	Analysis of pleural liquid	Definitive management	Known follow-up	(Refs.)
11	Karwande (1986)	Lung squamous cell carcinoma	Right	Intrapleural intrapericardial pneumonectomy	5th day	Tension chylothorax	M	Chyle	vein stump, medial to the esophagus Evacuatary thoracentesis	High trgly, low chol	vein stump, medial to the esophagus Surgery-supra diaphragmatic ligation of the thoracic duct and matted suture of the leak at the hilum area Repeated evacuatory thoracentesis followed by 18 gauge chest drain	No recurrence	(14)
12	Karwande (1986)	Hilar adenocarcinoma	Right	Intrapleural extrapericardial pneumonectomy	15th day	Tension chylothorax	F	Chyle	Evacuatory thoracentesis	High trgly, low chol	Repeated evacuatory thoracentesis followed by 18 gauge chest drain	Patient deceased due to comorbidities (hemoragic duodenal ulcer). The high-output chylothorax persisted until her death no recurrence	(14)
13	Kanjanauthai (2009)	Primary lung cancer	Left	Intrapleural extrapericardial pneumonectomy	14 days	Tension chylothorax	N/A	Chyle	Evacuatory thoracentesis	Chylothorax	Surgery-thoracic duct ligation	no recurrence	(2)
14	Valliers (1993)	NSCLC adenocarcinoma	Right	Intrapleural extrapericardial pneumonectomy	11 days	Tension chylothorax	F	Chyle	Diagnosis thoracentesis	High trgly, low chol	Chest drain with instillation of antibiotic solution	No recurrence. 96 h after the pleurostomy, the chest drain was removed N/A	(15)
15	Maguire (2013)	Mesothelioma	Left	Extrapleural pneumonectomy	6 months	Tension hydrothorax	M	Exudative pleural effusion	Evacuatory thoracentesis	No malignant cells	(Cefazolin+ gentamicin)	N/A	(16)
16	Sawar (2006)	Mesothelioma	Left	Extrapleural pneumonectomy	9 months	Tension hydrothorax	M	Exudative pleural effusion	Evacuatory thoracentesis	No malignant cells	Thoracoscopy, laparoscopy-	N/A	(17)
17	Vakil (2017)	Lung high grade spindle cell sarcoma	Left	Intrapleural pneumonectomy with partial pericardectomy	17 months	Tension hydrothorax	F	Exudative pleural effusion	Evacuatory thoracentesis	Cytology negative for malignancy. Cultures negative for microorganisms	Malignancy excluded; pigtail	No recurrence	(18)
18	Sakuraba (2018)	Thymoma st. IVb	Invasion of right lung hilum	Extrapleural pneumonectomy	0 (zero) days	Tension pneumothorax	M	Air	Suction pressure increased from -5 to -15 cm H ₂ O	N/A	Catheter	No recurrence	(19)
19	Rus (2014)	Adenocarcinoma (T3N0M0)	Left	Intrapleural extrapericardial pneumonectomy	15 months	Tension hemothorax	F	Hematic pleural liquid	Thoracoscopy	N/A	Evacuatory thoracentesis	No recurrence; alive and well in March 2022	(20)

NSCLC, non-small cell lung cancer; M, male; F, female; N/A, not available; trgly, triglycerides; chol, cholesterol; LDH, lactate dehydrogenase; ICU, intensive care unit.

Availability of data and materials

Not applicable.

Authors' contributions

NM and VM contributed to the conception and design of the study, performed the literature review and wrote the manuscript. OR, MD, MCCI and OGT analyzed the data, integrated the medical information and prepared the figures. NM, VM, BS and MCC contributed to manuscript revision. All authors have read and approved the final manuscript. Data authentication is not applicable.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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