REVIEW ARTICLE

Treatment Options in Patients With Chylothorax

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SUMMARY

Background: Chylothorax arises when lymphatic fluid (chyle) accumulates in the pleural cavity because of leakage from lymphatic vessels. It is most commonly seen after thoracic surgery (in 0.5% to 1% of cases) and in association with tumors. No prospective or randomized trials have yet been performed to evaluate the available treatment options.

Methods: This review is based on a selective search of the PubMed database for pertinent publications from the years 1995 to 2013. Emphasis was laid on articles that enabled a comparative assessment of treatment options.

Results: Initial conservative treatment (e.g., parenteral nutrition or a special diet) succeeds in 20% to 80% of cases. When such treatment fails, the standard approach up to the present has been to treat surgically, e.g., with ligation of the thoracic duct, pleurodesis, or a pleuroperitoneal shunt. The success rates of such procedures have ranged from 25% to 95%. Most of the patients undergoing such procedures are severely ill; complication rates as high as 38% have been reported, with mortality as high as 25%. In more recent publications, however, morbidity and mortality were lower. Interventional radiological treatments, such as percutaneous thoracic duct embolization or the percutaneous destruction of lymphatic vessels, succeed in about 70% of cases and lead to healing in up to 80% of cases, even after unsuccessful surgery. The complication rate of percutaneous methods is roughly 3%.

Conclusion: Interventional radiological procedures have now taken their place alongside conservative treatment and surgery in the management of chylothorax, although they are currently available in only a small number of centers.

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Chylothorax is by definition a collection of chyle in the pleural cavity resulting from leakage from the lymphatic vessels, usually from the thoracic duct. The symptoms of chylothorax can occur in patients of any age; the condition has multiple possible causes, and may therefore be encountered in many fields of medicine. Incidence data are available for only postoperative chylothorax, which can occur after almost any surgical operation in the chest. It is most often observed after esophagectomy (about 3% of cases), or after heart surgery in children (up to about 6% of cases) (1, 2). Treatment options for chylothorax today range from the conservative to surgical and—more recently—interventional radiological procedures. Because of the rarity of the condition, no prospective studies have been carried out on how best to treat it, or for how long. For guidance, therefore, we describe the current state of the art of the diagnosis and treatment of this interdisciplinary disease entity.

Anatomy

The thoracic duct drains the cisterna chyli, in which the lymph from the lower half of the body and the abdominal cavity joins the chyle coming from the intestinal trunk, forming a mixture also referred to as chyle. Its typical course is shown schematically in *Figure 1*, although variations are seen in more than one third of the population (3, 4). Its close spatial relationships with other structures explain why it is at risk of injury during surgery along the course of this lymph drainage pathway (see below).

Pathophysiology

When the thoracic duct (or a large communicating lymph vessel) is leaky or damaged, the fluid that leaks out either collects locally and later breaks through into the pleural cavity, or it flows directly into the latter via existing pleural defects (e.g., caused by surgery). Rarely, chylothorax may occur due to transdiaphragmatic flow in a patient with chylous ascites.

Any lesions of the thoracic duct can quickly lead to the formation of large fluid collections, as the duct transports around 2 to 4 L of fluid a day (5). Different forms of chylothorax are distinguished on the basis of their etiology—traumatic, non-traumatic, and idiopathic (6) (*Box*)—the relative frequencies of which vary between patient populations. Today, the most

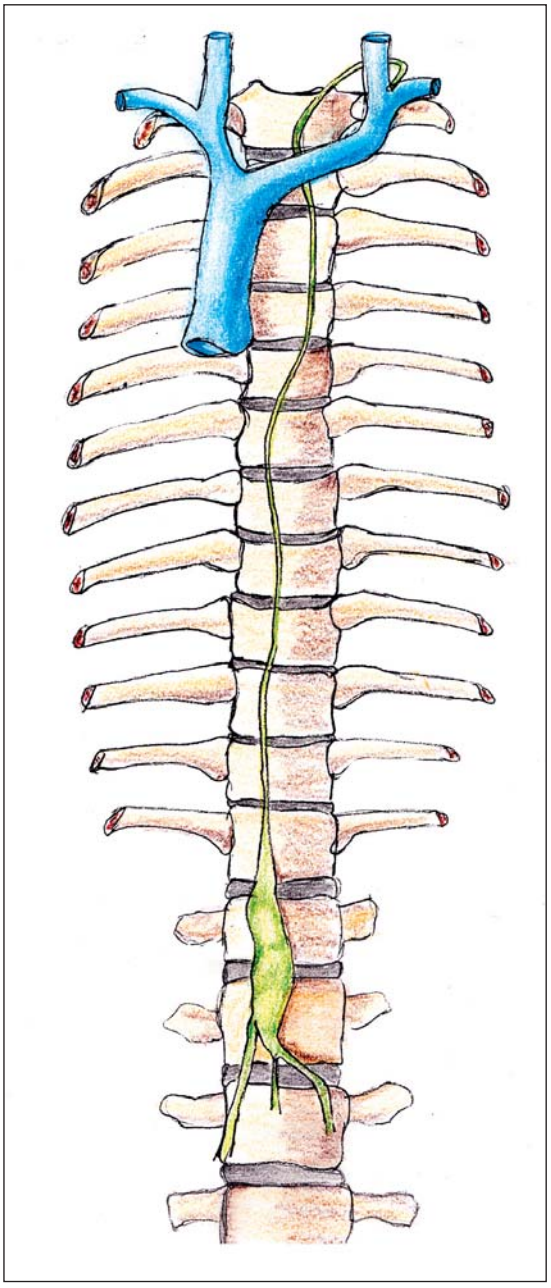


Figure 1:
Typical course of the thoracic duct, which extends prevertebrally from the cisterna chyli, first on the right side, then (from about T4) on the left side, finally curving posteriorly to end in the left venous angle. Variations are frequent

common traumatic cause is chest surgery (3), e.g., esophageal resection, which leads to chylothorax in about 3% of cases (1).

With non-traumatic chylothorax, leaks in the lymphatic pathways are due to direct infiltration or to impeded flow caused by compression and accumulation (*Box*). Relative impeded flow can occur where there is increased lymph production, as occurs in, for example, patients with raised central venous pressure, or those with portal hypertension or liver cirrhosis (7).

In congenital chylothorax (incidence 1:20 000 pregnancies), possible causes are birth trauma or malformation of the lymph vessels (8). In general, chylothorax is less common in children (9).

Clinical manifestation

Low-volume or early chylothorax is clinically silent and no different from other pleural effusions. High-volume or, especially, rapidly occurring chylothorax can lead, not just to space-occupying effects, but also to dyspnea, cough, chest pain, and hypovolemic problems. Since chyle does not itself cause inflammatory irritation, pleuritic pain and fever are both absent (10–13).

Radiologically and sonographically, chylothorax is manifest as a non-specific, usually unilateral pleural fluid collection (2, 14). Typically, thoracocentesis obtains a milky fluid, but this is seen in only about half of all cases (10, 15). Patients who are fasting (e.g., peri- or postoperative patients) or those with congenital chylothorax produce little or no chyle, so the effusion may appear serous or clear, or, after trauma, it may be tinged with blood (10, 15). A milky appearance may also be seen in pleural empyema or so-called pseudochylothorax, but these conditions can usually be distinguished on the basis of clinical features and history (11, 14, 16, e1).

The important thing is always to consider the possibility of chylothorax in the differential diagnosis of a patient with an appropriate history. Typical constellations of symptoms are a sudden, otherwise unexplained pleural effusion or, in a postsurgical patient returning to normal nutritional intake, a marked increase in the fluid volume drained through a pleural drain (11).

Diagnostic laboratory tests

Chylothorax is diagnosed and differentiated from other forms of effusion (pseudochylothorax) on the basis of chemical analysis of the pleural fluid aspirate in a laboratory. A characteristic finding is the presence of chylomicrons – particles about 0.5 to 1.0 µm in size, made up of proteins and lipids (long-chain triglycerides), that are are absorbed and transported directly via the lymphatic pathways (2, 6, 10).

If lipoprotein analysis to demonstrate chylomicrons is not available, determining triglycerides and cholesterol will be helpful, as chylothorax is present in 99% of patients with an aspirate triglyceride content of >110 mg/dL and a cholesterol content <200 mg/dL, whereas

a triglyceride concentration <50 mg/dL almost rules out chylothorax. Pseudochylothorax, which is also milky, is characterized by a cholesterol concentration of >200 mg/dL and a lower triglyceride concentration (<110 mg/dL) (cholesterol:triglyceride ratio >1). Extended fasting or malnutrition can lower the triglyceride concentration below these values (10, 11, 14).

Most cases of chylothorax are exudative (high protein, low lactate dehydrogenase [LDH]), but in about 25% of cases it can be transudative. Transudative effusions indicate a hepatic (portal hypertension/cirrhosis) or cardiac etiology (11, 14, 15).

Course

Chylothorax is a condition that needs to be taken seriously: a patient who persistently loses chyle will be losing considerable amounts of fat and fat-soluble vitamins, proteins (chyle contains 12–60 g/L, depending on nutritional intake), electrolytes, immunoglobulins, and T-lymphocytes, with resulting malnutrition, weight loss, and an impaired immune system (2, 11, e2). After only 8 days of T-cell depletion due to external chyle drainage, patients are already at risk of septicemia (17). If the chylothorax is associated with a tumor, the underlying disease will also affect the prognosis.

About 50% of patients with untreated chylothorax die from the resulting complications (14, 18, e5). If chylothorax occurs postoperatively, 30-day mortality goes up fivefold (19).

Therapeutic options

Chylothorax requires careful and appropriate treatment, which will naturally depend on the cause and accompanying clinical conditions (e.g., effusion volume, accumulation rate, underlying disease, co-morbidities), and also on the locally available expertise (*Table 1*). For patients with high-volume chylothorax, especially if it is symptomatic or increasing, waiting is not an option.

Because this condition is so rare, there are no prospective or even randomized studies that give a clear answer to questions about how best to treat chylothorax and for how long. In general, conservative treatment is tried first, usually for a limited time, before more invasive measures are embarked on (12, 14) (*Figure 3*).

Conservative treatment

The cornerstones of treatment are adequate fluid and electrolyte replacement along with appropriate nutrition. Repeated thoracocentesis is usually only performed when improvement is expected from short-term treatment of the underlying disease, or clinical symptoms are present that only require occasional aspiration. Otherwise, in patients with high-volume or, especially, symptomatic chylothorax, continuous drainage is put in place to allow the lung to re-expand and to optimize pulmonary function (16, 20).

As part of initial conservative treatment, an attempt is made to reduce the flow of lymph through the

BOX

Important causes of chylothorax*

- **1. Traumatic**

  1.1 Iatrogenic/surgical (25% to 50%)
  - Most often reported after thoracic surgery, but may also occur after cervical or abdominal surgery (e.g., esophageal resection, surgery for congenital heart diseases, pulmonary resection, lymph node dissection including neck dissection, bypass surgery)
  - Injury during placement of a venous catheter or pacemaker

  1.2 Non-iatrogenic
  - Perforating injury (stab and shot wounds, acupuncture) and blunt trauma
  - Tearing due to raised pressure (peripartum, violent vomiting or coughing)

- **2. Non-traumatic/tumorous (25% to 50%)**
  - Obstruction of lymphatic outflow, lymph accumulation (e.g., diseases with raised central venous pressure or after surgery leading to raised venous pressure; thrombosis of effluent veins, lymphoma, Kaposi sarcoma, tumor, thoracic aortic aneurysm, sarcoidosis, tuberculosis, histoplasmosis, Behçet disease, filiariasis)
  - Diseases of the lymphatic pathways (e.g., lymphangio(leio)myomatosis, Gorham–Stout syndrome, yellow nail syndrome, Noonan syndrome)
  - Increased lymph production (e.g., portal hypertension, liver cirrhosis)
  - Changes in the composition of the lymph ("sludging" in chronic lymphocytic leukemia)
  - Chest irradiation

- **3. Idiopathic (up to 6%)**

* according to 2, 6–9, 11, 12, 14, 16, 21–23, 26, 29, 30, 34, e1, e4, e18

TABLE 1

Treatment options

a) Conservative treatment (1, 2, 5, 12, 16, 21–24, 29, e4, e8, e20, e30)	
Treatment	**Remarks**
	– First-line attempt at treatment! – Success rate particularly dependent on drain output: success unlikely if >1000 mL/day – Duration of conservative treatment attempt depends on clinical accompanying conditions, Reports vary: – Usually longer in children, but "stage-adjusted", i.e., short attempt (up to 3 days) if high-volume leakage, as fluid and electrolyte balance is very delicate – Usually 7–14 days in adults – Postoperative chylothorax usually about 5–7–14 days (depending on operation and drain output)
Diet including medium-chain triglycerides (MCT)	Often insufficient as sole therapy
Complete parenteral nutrition	Usually the first therapeutic step, especially postoperatively
Somatostatin/octreotide	Used as an adjunct to conservative treatment, especially in children; no prospective studies on indication, nature, or duration of treatment (!); study data are inconsistent
Thoracocentesis/drainage	Lung expansion to preserve/improve pulmonary function; also, a lung lying close up against the pleura will help to seal the leak
Irradiation, chemotherapy	Treatment option as part of management of the underlying disease

b) Surgical treatment (1, 5, 12, 14, 16, 19, 26, 29, e3, e5, e6, e9, e15, e25, e27–e29)	
Treatment	**Remarks**
	When conservative treatment attempt fails or does not promise success; open thoracotomy, thoracoscopic or video-assisted thoracotomy
Thoracic duct ligation	Most common surgical treatment, success rate about 95%; when thoracic duct cannot be identified, mass ligation may be performed
Suturing of thoracic duct leak	Technically difficult as the duct is fragile; no advantage over ligation
Suturing of pleural defects	Single case reports, in some cases as an adjunct to other measures
Pleurodesis	As sole therapy (especially in patients with malignant tumors) or combined with other surgical procedures, especially duct ligation (e.g., when duct cannot be identifed); likely to succeed only if the lung can expand
Pleurectomy	If pleurodesis fails or lung expansion is not expected (trapped lung) and patient life expectancy >6 months
Chylovenous anastomosis	Technically difficult, poor success rate, therefore no longer performed
Pleuroperitoneal shunt	In the absence of therapeutic alternatives (e.g., in patients with refractory central thrombosis); contraindicated in patients with concomitant chylous ascites
External catheter/intermittent drainage	If pleurodesis appears impossible/unlikely to succeed

c) Interventional radiology (4, 13, 30, 32, 36–40, e16, e17, e26)	
Treatment	**Remarks**
Transjugular intrahepatic stent shunt (TIPS)	In patients with hepatic chylothorax (cirrhosis, portal hypertension)
Lymphography	After lymphography, in some cases occlusion of a chyle fistula has been reported
Percutaneous closure of the thoracic duct	– Catheterization of the thoracic duct, usually as a percutaneous transabdominal procedure after lymphography, followed by embolization – Technically demanding, not available in all centers – Usually successful if the thoracic duct can be intubated
Percutaneous needle disruption of lymphatic pathways	Performed when percutaneous embolization is impossible on anatomic grounds (anatomic variants); success rate lower than for embolization

thoracic duct to the point that the lymph leak will close up and the chytothorax eventually heal itself. The patient can be given a diet containing medium-chain triglycerides (MCT), which are absorbed directly into the portal venous system without going through the intestinal lymph vessels and the thoracic duct. It is rare, however, that these measures alone will suffice, so although it is more expensive and is associated with more problems, complete parenteral nutrition has in many places become established as the first step (5, 16).

In addition to diet, it is possible to reduce lymph flow by means of medication using somatostatin or its analog octreotide. Neither chylothorax as an indication nor the dose, method, and duration of drug administration have been confirmed or standardized in prospective studies (e19–e24) (*eTable 1*). If a drain output that has previously remained unchanged halves within 48 hours of the start of additional octreotide administration, this suggests that the treatment is working and the drug should therefore be continued (2, e30).

When chylothorax is non-traumatic, treatment of the underlying disease (chemotherapy, irradiation) can lead to improvement, but success rates are limited (*eTable 1* and *2*), ranging for example from 0% to 20% or 33% (21, 22, e7). In postoperative chylothorax, mediastinal

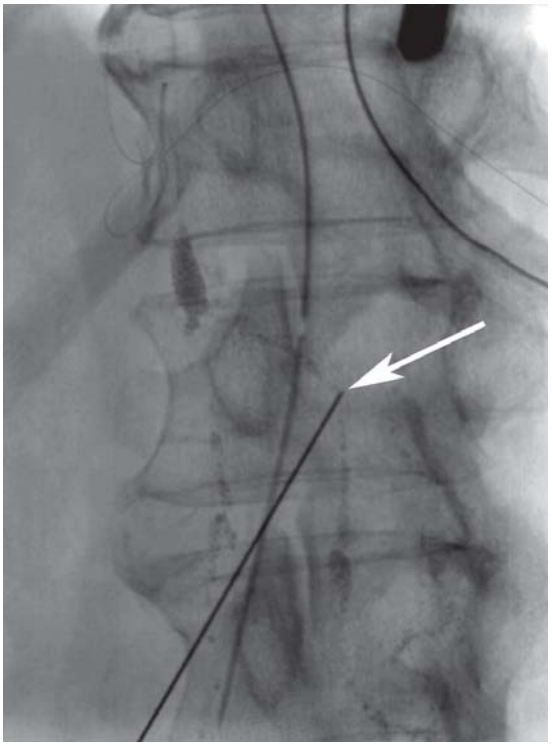
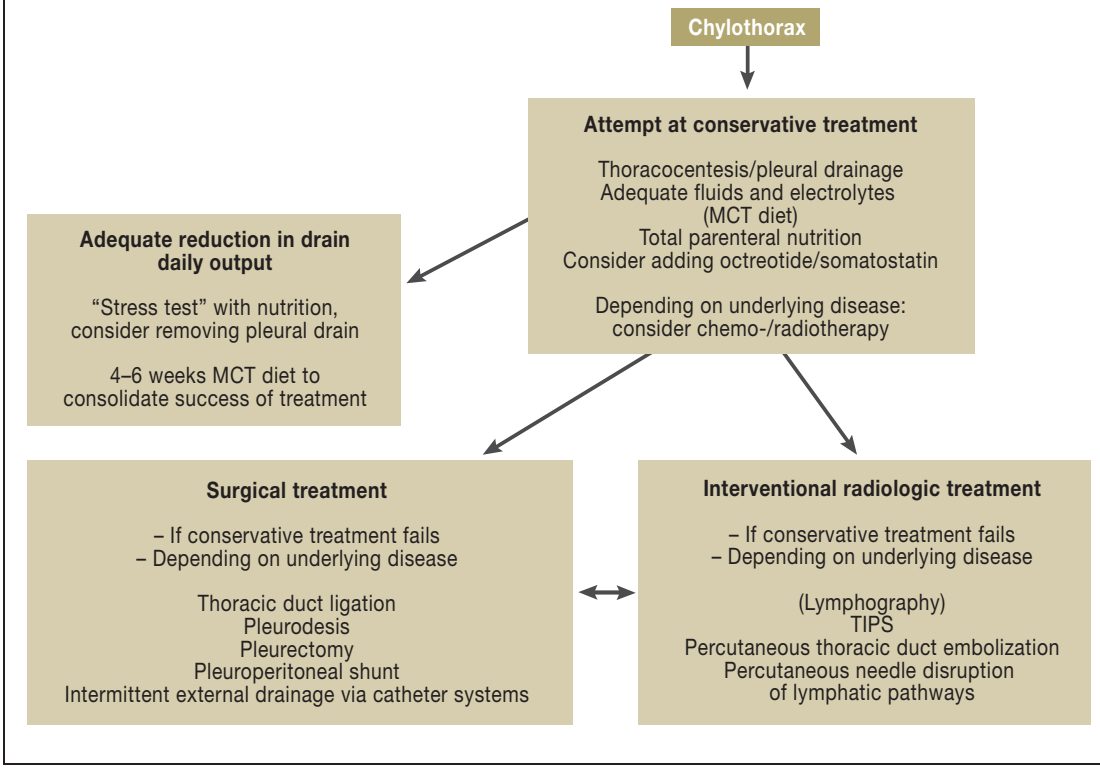


Figure 2:
Percutaneous embolization of the thoracic duct: transabdominal fine-needle puncture of a lymph vessel (arrow marks the tip of the needle and the puncture site)

FIGURE 3



Treatment algorithm for chylothorax. Conservative treatment is performed first; there is no consensus as to how long this should be tried. If it fails, the basic choices are between interventional radiology and surgery. If surgery fails, interventional radiology may still achieve success. Surgery is required when percutaneous treatment is not available, does not appear feasible, or fails. At present there are no prospective studies that could provide guidance about specific measures in individual cases.
MCT diet, diet containing medium-chain triglycerides; TIPS, transjugular intrahepatic stent shunt

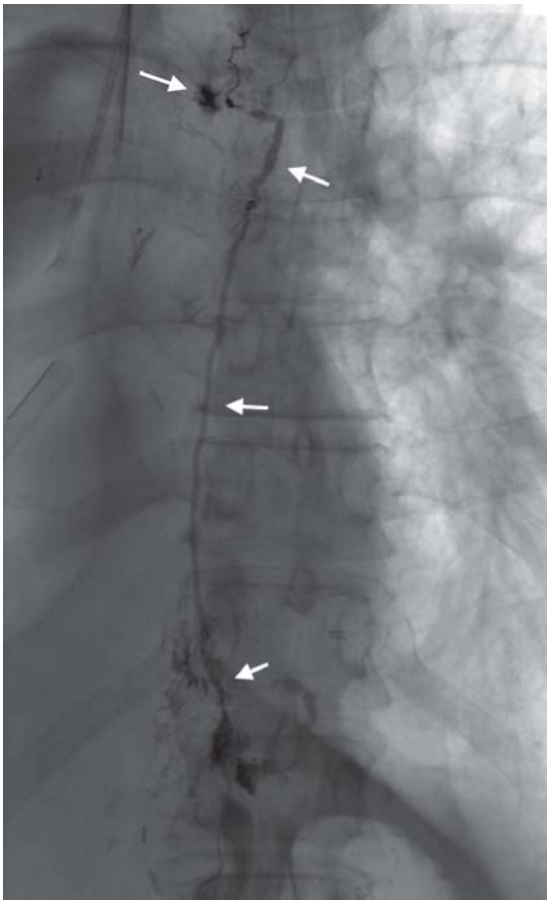


Figure 4: Percutaneous embolization of the thoracic duct. Upper arrow: lymph leak identifiable as contrast medium extravasation. At the level of the extravasation, an embolization coil has been placed in the duct. The thoracic duct (left-pointing arrows) is closed with tissue adhesive labelled with contrast medium

irradiation given as an adjuvant therapy has been described, but its real value is still unclear (23).

Generally, the success rate of conservative treatment ranges from 16% to more than 75% (24–26); at output rates of more than 1000 mL/day, the success rate of conservative treatment is low (12, 14). If the lymph leak is due to direct tumor or lymphoma infiltration, it is unlikely that permanent adhesive occlusion will be induced merely by reducing the lymph flow rate (21).

If the drain output reduces markedly under conservative treatment, it is advisable to consolidate the therapeutic outcome with a strict MCT diet for a few weeks (16, 24, e8).

Locating the exact site of a lymph leak is worthwhile only if the result is going to affect therapeutic management. Basically, a leak can be located non-invasively using radionuclides or magnetic resonance imaging (27, 28). Diagnostic MRI uses so-called fluid-sensitive sequences (analogous to magnetic resonance cholangiopancreatography, MRCP). Its accuracy in terms of locating the leak site is superior to that of radionuclide imaging, and it can be helpful in the planning of an interventional procedure (see below). Lymphography can also demonstrate a leak, but as the only invasive procedure is rarely indicated nowadays (29).

Surgical treatment

When conservative treatment failed, for a long time the only remaining treatment method was surgery, which—if used early—can reduce the mortality rate associated with chylothorax from 50% to 10% (30–32).

Operative treatment was and is regarded as indicated when, for example:

- More than (1000–)1500 mL chyle is being drained every day (in children the threshold is >100 mL/kg body weight [BW])
- For 5 treatment days drain output is up to 1000 mL/day, or, in children, 100 mL/year of age.
- A leak persists for more than 2 weeks (100 mL/day >2 weeks)
- The drain output remains unchanged over 1–2 weeks
- Clinical deterioration occurs, e.g., malnutrition or metabolic problems (2, 5, 9, 14, 16, 26, 30, e9–e11).

These guide values have not been confirmed by controlled studies. In patients with postoperative chylothorax, it must be remembered that early reoperation can put anastomoses at risk, so quite long attempts at conservative treatment are recommended, e.g., 2 to 4 weeks after esophagectomy (e5). Small children are at risk because of their delicate fluid and electrolyte balance. Early surgical treatment is recommended in young patients, those with a high-volume chyle leak, and those with a body weight below 4 kg (e12).

Table 1b summarizes the surgical options. Ligation of the thoracic duct—best established for traumatic chylothorax—is usually carried out above the right diaphragm between T8 and T12; after ligation, the lymph drains via lymphatic collaterals and lymphovenous anastomoses (13).

In general, the main difficulty in surgical treatment is identifying the thoracic duct or the leak. This becomes easier if cream is administered (e.g., intraoperatively via a stomach probe) (18). If the duct is still not identifiable, mass ligation of the tissue in the presumed course of the thoracic duct can help (12, e13).

Other problems that can lead to failure of surgery are failure to identify accessory lymphatic pathways, technically inadequate ligation, and surgical injury of the fragile duct during manipulation (25, 26).

If an operation has failed, or if thoracic duct ligation does not appear feasible or worthwhile, pleurodesis may heal the chylothorax (12, 14, 25, e4). Pleurodesis also offers a treatment option when a malignant tumor is the cause of the chylothorax. It is employed when treatment of the tumor has not resulted in sufficient improvement, or in situations where interrupting the thoracic duct is regarded as not feasible or worthwhile. It must be borne in mind that pleurodesis can only be successful in patients with expandable lungs (i.e., non-trapped lungs) (33). Creation of lymphovenous anastomoses has not become established as a therapy (e4). As a surgical last resort, creation of a pleuroperitoneal shunt or external intermittent permanent drainage through placement of a suitable catheter system may be considered (e10).

Clinically, surgical treatment is successful in about 90% of cases, although up to 11% of patients have to undergo several procedures (27).

For thoracic duct ligation, which is usually carried out in severely ill patients, complication rates of up to 38.3% and mortality rates up to 25% have been reported (16, 25, 28, e14, e15). In more recent publications, however, lower rates have been reported. This is believed to be because surgery is being performed earlier (in better time) and is less traumatic, and because better supportive measures have been introduced (e3, e9).

Interventional radiology

Today there are several radiological treatments that can be used in both traumatic and non-traumatic chylothorax (*Table 1c*), although some of these are still restricted to only a few centers.

In hepatic chylothorax, the portal venous pressure and hence the flow of lymph can be reduced by a transjugular intrahepatic portosystemic stent shunt (TIPS), with the result that the lymph leak site may close (adhere) spontaneously and the chylothorax heal (34).

In non-traumatic chylothorax, other radiological therapeutic possibilities have been described. After lymphography, healing of the chylothorax has been observed in about 6% to 50% of cases (35, 36). However, the therapeutic success of lymphography cannot be assessed, so given the existence of other, more effective measures, this procedure has not become an established therapy. Direct occlusion of the lymph leak site can be tried using targeted CT-guided injection of tissue adhesive near the leak (e16). Overall, there has not been much experience with these procedures.

Much more experience is available for percutaneous embolization of the thoracic duct (*eTable 3*), which can be performed as an alternative to thoracic duct ligation and can be performed in both adults and children (13, 30, 32, 37).

For thoracic duct embolization, first the abdominal lymph vessels, including the thoracic duct, are imaged lymphographically. After fine-needle puncture (21G) of a suitable lymph vessel (*Figure 2*), the thoracic duct is accessed with a thin guidewire (0.018 inch), and a microcatheter (F3) is introduced and placed below an identifiable leak (*Figure 4*) (4, 32, 36–38).

This technically demanding procedure cannot, however, always be performed as described, because the existence of anatomic variants means that up to 30% of patients do not have a cisterna chyli or lymph vessel that is suitable for puncture (32, e17). In these cases, the attempt may be made to "scratch" any prevertebral small lymph pathways identified lymphographically with a puncture needle ("needle disruption") and to reduce the flow of lymph by this means (4, 32, 39). In about one third of patients treated in this way, this leads to healing of the leak (32, e17). Embolization has a much higher success rate: if the thoracic duct can be intubated successfully, the procedure is successful in well over 90% of cases (13, 30, 32, 37). Percutaneous embolization can even lead to healing in patients who have been unsuccessfully treated with surgery (4) (*eTable 3*).

KEY MESSAGES

- The most frequent causes of chylothorax today are surgery and tumors.
- Clinically, chylothorax manifests non-specifically as a pleural effusion, typically with a triglyceride content of over 110 mg/dL. The diagnosis is confirmed by demonstrating the presence of chylomicrons in the aspirate.
- As a rule, conservative treatment is tried first. The aim is to bring about spontaneous closure of a lymph leak by reducing the flow of lymph.
- If conservative treatment fails, the next option to consider is surgery. This may be in the form of, for example, thoracic duct ligation, pleurodesis, or placement of a pleuroperitoneal shunt. Other alternatives available today are interventional radiological procedures such as percutaneous thoracic duct embolization.
- Individual case management is determined by the clinical situation and local availability of the various treatment options, since no prospective studies are available as a basis for guidance.

Clinical success depends on the underlying disease. The success rate is lower for non-traumatic than for traumatic chylothorax (36). Clinical success was achieved in 52% of cases of non-traumatic chylothorax (18, 34); for combined conservative/surgical treatment in these patients, success rates of 27% to 68% have been reported (29).

With a complication rate of around 3% and no complications with fatal outcome reported so far, percutaneous thoracic duct embolization is a relatively safe procedure (4, 13, 37, e16). In one long-term study, chronic leg swelling was observed in 7% of patients, and chronic diarrhea in about 12%. Whether these findings are a consequence of the procedure remains unknown at present (40).

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Conflict of interest statement
The authors declare that no conflict of interest exists.

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REFERENCES

1. Hölscher AH, Vallböhmer D, Brabender J: The prevention and management of perioperative complications. Best Practise & Research Clinical Gastroenterology 2006; 20: 907–23.
2. Soto-Martinez M, Massie J: Chylothorax: Diagnosis and management in children. Paediatric Respiratory Reviews 2009; 6: 8.

3. Skandalakis JE, Skandalakis LJ, Skandalakis PN: Anatomy of the lymphatics. Surg Oncol Clin N Am 2007; 16: 1–16.
4. Chen E, Itken M: Thoracic duct embolization for chylous leaks. Semin Intervent Radiol 2011; 28: 63–74.
5. Ilczyszyn A, Ridha H, Durrani AJ: Management of chyle leak post neck dissection: A case report and literature review. J Plast Reconstr Aesthet Surg 2011; 64: e223–30.
6. Doerr CH, Allen MS, Nichols FC 3rd, Ryu JH: Etiology of chylothorax in 203 patients. Mayo Clin Proc 2005; 80: 867–70.
7. Dumont AE, Clauss RH, Reed GA, Tice DA: Lymph drainage in patients with congestive heart failure: comparison with findings in hepatic cirrhosis. N Engl J Med 1963; 269: 949–52.
8. Rustico MA, Lanna M, Covello D, et al.: Fetal pleural effusion. Prenat Diagn 2007; 27: 793–99.
9. Yekeler E, Ulutas H: Bilateral chylothorax after severe vomiting in a child. Ann Thorac Surg 2012; 94: e21–3.
10. Staats BA, Ellefson RD, Budahn LL, Dines DE, Prakash UB, Offord K: The lipoprotein profile of chylous and nonchylous pleural effusions. Mayo Clin Proc 1980; 55: 700–4.
11. Skouras V, Kalomenidis I: Chylothorax: diagnostic approach. Curr Opin Pulm Med 2010; 16: 387–93.
12. Nair SK, Petko M, Hayward MP: Aetiology and management of chylothorax in adults. Eur J Cardiothorac Surg 2007; 32: 362–9.
13. Boffa DJ, Sands MJ, Rice TW, et al.: A critical evaluation of a percutaneous diagnostic and treatment strategy for chylothorax after thoracic surgery. Eur J Cardiothorac Surg 2008; 33: 435–9.
14. McGrath EE, Blades Z, Anderson PB: Chylothorax: Aetiology, diagnosis and therapeutic options. Respir Med 2010; 105: 1–8.
15. Maldonado F, Hawkins FJ, Daniels CE, et al.: Pleural fluid characteristics of Chylothorax. Mayo Clin Proc 2009; 84: 129–33.
16. Benedix F, Lippert H, Meyer F: Ätiologie, Diagnostik und Behandlung der lymphokutanen Fistel, des Chylaszites und Chylothoraxes als seltene, aber ernsthafte Komplikation chirurgischer Operationen. Zentralbl Chir 2012; 137: 580–6.
17. Breaux J, Marks C: Chylothorax causing reversible T-cell depletion. J Trauma 1988; 28: 705–7.
18. Shackcloth MJ, Poullis M, Lu J, Page RD: Preventing of chylothorax after oesophagectomy by routine pre-operative administration of oral cream. Eur J Cardiotharac Surg 2001; 20: 1035–6.
19. Shah RD, Luketich JD, Schuchert MJ, et al.: Postesophagectomy chylothorax: Incidence, risk factors, and outcomes. Ann Thorac Surg 2012; 933: 897–904.
20. DePew ZS, Iqbal S, Nichols FC, Mullon JJ, Maldonado F: The role for tunneled indwelling pleural catheters in patients with persistent benign chylothorax. Am J Med Sci 2013; 0: 1–4
21. O'Callaghan AM, Mead GM: Chylothorax in lymphoma: Mechanisms and management. Ann Oncol 1995; 6: 603–7.
22. Teng CL, Li KW, Yu JT, et al.: Malignancy-associated chylothorax: a 20-year study of 18 patients from a single institution. Eur J Cancer Care 2012; 21: 599–605.
23. Sziklavari Z, Allgäuer M, Hübner G, et al.: Radiotherapy in the treatment of postoperative chlylothorax. J Cardiothorac Surg 2013; 8: 72.
24. Gómez-Caro AA, Moradiellos Diez FJ, Marrón CF, Larrú Cabrero EJ, Martín de Nicolás JL: Conservative management of postsurgical chylothorax with octreotide. Asian Cardiovasc Thorac Ann 2005; 13: 222–4.
25. Cerfolio RJ, Allen MS, Deschamps C, Trastek VF, Pairolero PC: Postoperative chylothorax. J Thorac Cariovasc Surg 1996, 112: 1361–5.
26. Zabeck H, Muley T, Dienemann H, Hoffmann H: Management of chylothorax in adults: when is surgery indicated. Thorac Cardiovasc Surg 2011; 59: 243–6.
27. Pui MH, Yueh TC: Lymphszintigraphy in chyluria, chyloperitoneum and chylothorax. J Nucl Med 1998; 39: 1292–6.
28. Yu-XX, Ma XX, Wang Q, Zhang Y, Li C-F: Morphological changes of the thoracic duct and accessory lymphatic channels in patients with chylothorax: detection with unenhanced magnetic resonance imaging. Eur Radiol 2013; 23: 702–11.
29. Maldonado F, Cartin-Ceba R, Hawkins FJ, Ryu JH: Medical and surgical management of chylothorax and associated outcomes. Am J Med Sci 2010; 339: 314–8.
30. Itkin M, Krishnamurthy G, Naim MY, Bird GL, Keller MS: Percutaneous thoracic duct embolization as a treatment for intrathoracic chyle leaks in infants. Pediatrics 2011; 128: e237.
31. Orringer MB, Bluett M, Deeb GM: Aggressive management of chylothorax complicating transhiatal esophagectomy without thoracotomy. Surgery 1988; 104: 720–6.
32. Cope C, Kaiser L: Management of unremitting chylothorax by percutaneous embolization and blockage of retroperitoneal lymphatic vessels in 42 patients. J Vasc Interv Radiol 2002; 13: 1139–48.
33. Sahn SA: Management of malignant pleural effusions. Monaldi Arch Chest Dis 2001; 56: 394–9.
34. Lutz P, Strunk H, Schild HH, Sauerbruch T: Transjugular intrahepatic portosystemic shunt in refractory chylothorax due to liver cirrhosis. World J Gastroenterol 2013; 19: 1140–2.
35. Alejandre-Lafont E, Krompiec C, Rau WS, Krombach GA: Effectiveness of therapeutic lymphography on lymphatic leakage. Acta Radiol 2011; 52: 305–11.
36. Nadolski GJ, Itkin M: Thoracic duct embolization for nontraumatic chylous effusion: Experience in 34 Patients. Chest 2013; 143: 158–63.
37. Itkin M, Kucharczuk JC, Kwak A, Trerotola SO, Kaiser LR: Nonoperative thoracic duct embolization for traumatic thoracic duct leak: experience in 109 patients. J Thorac Cardiovasc Surg 2010; 139: 584–9.
38. Schild H, Hirner A: Percutaneous translymphatic thoracic duct embolization for treatment of chylothorax. RöFo 2001; 173: 580–2.
39. Litherland B, Given M, Lyon S: Percutaenous radiological management of high output chylothorax with CT-guided needle disruption. J Med Imaging Radiat Oncol 2008; 52: 164–7.
40. Laslett D, Trerotola SC, Itkin M: Delayed complications following technically successful thoracic duct embolization. J Vasc Interv Radiol 2012; 23: 76–9.

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REVIEW ARTICLE

Treatment Options in Patients With Chylothorax

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eREFERENCES

e1. Sassoon CS, Light RW: Chylothorax and pseudochylothorax. Clin Chest Med 1985; 6: 163–71.

e2. Wasmuth-Pietzuch A, Hansmann M, Bartmann P, Heep A: Congenital chylothorax: lymphopenia and high risk of neonatal infections. Acta Paediatr 2004; 93: 220–4.

e3. Wemyss-Holden SA, Launois B, Maddern GJ: Management of thoracic duct injuries after oesophagectomy. Br J Surg 2001; 88: 1442–8.

e4. Ryu JH, Tomassetti S, Maldonado F: Update on uncommon pleural effusions. Respirology 2011; 16: 238–43.

e5. Hölscher AH, Fetzner UK, Bludau M, Leers J: Komplikationen und Komplikationsmanagement in der Ösophaguschirurgie. Zentralbl Chir 2011; 136: 213–23.

e6. Maldonado F: The role for tunneled indwelling pleural catheters in patients with persistent benign chylothorax. Am J Med Sci 2013; 0: 1–4.

e7. Larsen S, Manoharan A, Fermanis G, et al.: An unusual case of chylothorax complicating Non-Hodgkin's Lymphoma. Leuk Lymphoma 2000; 38: 207–9.

e8. Collard JM, Laterre PF, Boemer F, Reynart M, Ponlot R: Conservative treatment of postsurgical lymphatic leaks with somatostatin-14. Chest 2000; 117: 902–5.

e9. Paul S, Altorki NK, Port JL, et al.: Surgical management of chylothorax. Thorac Cardiovasc Surg 2009; 57: 226–8.

e10. Gupta D, Ross K, Piacentino V, et al.: Use of LeVeen pleuroperitoneal shunt for refractory high-volume chylothorax. Ann Thorac Surg 2004; 78: e9–12.

e11. du Rieu MC, Mabrut JY: Management of postoperative chylothorax. Journal of Visceral Surgery 2011; 148: e346–52.

e12. Matsuo S, Takahashi G, Konishi A, Sai S: Management of refractory chylothorax after pediatric cardiovascular surgery. Pediatr Cardiol 2013; 34: 1094–1099. DOI: 10.1007/s00246–012–0607-y.

e13. Bölükbas S, Kudelin N, Dönges T, et al.: Therapiemanagement des Chylothorax. Chirurg 2010; 81: 255–65.

e14. Alexiou C, Watson M, Beggs D, Salama FD, Morgan WE: Chylothorax following oesophagogastrectomy for malignant disease. Eur J Cardiothorac Surg 1998; 14: 460–6.

e15. Dugue L, Sauvanet A, Farges O, Goharin A, Le Mee J, Blghiti J: Output of chyle as an indicator of treatment for chylothorax complicating oesophagectomy. Br J Surg 1998; 85: 1147–9.

e16. Gaba RC, Owens CA, Bui JT, Carrillo TC, Knuttinen MG: Chylous ascites: a rare complication of thoracic duct embolization for chylothorax. Cardiovasc Intervent Radiol 2011; 34: 245–9.

e17. Binkert CA, Yucel K, Davison BD, Sugarbaker DJ, Baum RA: Percutaneous treatment of high-output chylothorax with embolization or needle disruption technique. J Vasc Interv Radiol 2005; 16: 1257–62.

e18. Akin H, Olcmen A, Isgorucu O, Denizkiran I, Dincer I: Approach to patients with chylothorax complicating pulmonary resection. Thorac Cardiovasc Surg 2012; 60: 135–9.

e19. Das A, Shah PS: Octreotide for the treatment of chylothorax in neonates. Cochrane Database Syst Rev 2010; 8: CD006388.

e20. Berg B: Octreotid in der Behandlung des Chylothorax bei Erwachsenen. Analyse der klinischen Medikamentenwirkung und -nebenwirkungen. Inaugural-Dissertation. Tübingen: Med. Fakultät der Eberhard Karls Universität 2012.

e21. Cannizzaro V, Frey B, Bernet-Buettiker V: The role of somatostatin in the treatment of persistent chylothorax in children. Eur J Cardio Thorac Surg 2006; 30: 49–53.

e22. Roehr CC, Jung A, Proquitté H, et al.: Somatostatin or octreotide as treatment options for chylothorax in young children: a systematic review. Intensive Care Med 2006; 32: 650–7.

e23. Sharkey AJ, Rao JN: The successful use of octreotide in the treatment of traumatic chylothorax. Tex Heart Inst J 2012; 39: 428–30.

e24. Shah D, Sinn JK: Octreotide as therapeutic option for congenital idiopathic chylothorax: a case series. Acta Paediatr 2012; 101: e151–5.

e25. Pego-Fernandes PM, Nascimbem MB, Ranzani OT, et al.: Video-assisted thorasocopy as an option in the surgical treatment of chylothorax after cardiac surgery in children. J Bras Pneumol 2011; 37: 28–35.

e26. Cope C, Salem R, Kaiser LR: Management of chylothorax by percutaneous catheterization and embolization of the thoracic duct: prospective trial. J Vasc Interv Radiol 1999; 10: 1248–54.

e27. Nath DS, Savla J, Khemani RG, et al.: Thoracic duct ligation for persistent chylothorax after pediatric cardiothoracic surgery. Ann Thorac Surg 2009; 88: 246–51.

e28. Seow C, Murry L, McKee RF: Surgical pathology is a predictor of outcome in post-operative lymph leakage. Int J Surg 2010; 8: 636–8.

e29. Sieczka EM, Harvey JC: Early thoracic duct ligation for postoperative chylothorax. J Surg Oncol 1996; 61: 56–60.

e30. Lim KA, Kim SH, Huh J, et al.: Somatostatin for postoperative chylothorax after surgery for children with congenital heart disease. J Korean Med Sci 2005; 20: 947–51.

eTABLE 1

Outcome of supportive treatment with somatostatin/octreotide (e19–e24)

Study	Cases	Drug	Outcome
Das A, Shah PS 2010 (e19)	Neonatal chylothorax 19 case reports with octreotide s.c. or i.v.	Octreotide	14 successful 4 unsuccessful 1 unclear “no practice recommendations can be made”
Berg B 2012 (e20)	11 with octreotide	100–150 µg octreotide s.c. every 6–8 hours	With octreotide, tendency to greater drain output, longer treatment duration
Cannizzaro V et al. 2006 (e21)	n = 13	Somatostatin 3.5–12 µg/kg/h	6/13 successful
Roehr CC et al. 2006 (e22)	n = 35 (review article)	10 x somatostatin (10–288 µg/kg/day i.v.) 25 x octeotide (i.v. 7.2–240 µg/kg/day or s.c. 2–68 µg/kg/day)	32/35 successful
Sharkey AJ, Rao JN 2012 (e23)	2 traumatic chylothorax	Octreotide 50 µg 3 x daily s.c. 200 µg 3 x daily s.c.	2/2 successful
Shah D, Sinn JK 2012 (e24)	6 congenital chylothorax	Octreotide 0.5–10 µg/kg/h	5/6 successful

eTABLE 2

Outcome of conservative and surgical treatment

Study	Patients	Treatment and outcome
Maldonado F et al. 2010 (29)	n = 74 40 traumatic 34 non-traumatic	Conservative treatment successful – 17/35 (49%) traumatic chylothorax – 5/21 (24%) non-traumatic chylothorax Surgical treatment successful – 24/25 (92%) traumatic chylothorax – 13/19 (68%) non-traumatic chylothorax
Matsuo S et al. 2013 (e12)	n = 15 after surgery for congenital heart defect	10/15 (66%) conservative treatment successful
Zabeck H et al. 2011 (26)	n = 82 37 postoperative 45 non-traumatic	Postoperative chylothorax – 12/37 (33%) conservative treatment successful Non-postoperative chylothorax (17 associated with malignancies) – 1/44 (2.5%) conservative treatment successful Conservative treatment – 14/82 (17%) successful, including 12 postop. chylothorax Surgical treatment – 69/82 (84%) required surgery, of these 9 (9/69 = 13%) needed several operations
Paul S et al. 2009 (e9)	n = 29 19 postoperative 6 lymphoma 4 other	21/22 duct ligation successful 5/6 pleurodesis successful
Pego-Fernandes PM et al. 2011 (e25)	n = 64 after heart surgery in children	50/64 (78.1%) conservative treatment successful 12/14 (85%) successful duct ligation (among these 3 deaths in the later course, severely ill patients/ severe underlying disease)
Akin H et al. 2012 (e18)	26 patients after pulmonary resection	19/26 conservative treatment successful 7/7 surgical treatment successful
DePew Z et al. 2013 (20)	14 hemithoraces in 11 patients	Drainage (PleurX catheter) led to pleurodesis in 9/14 patients after 176 (24–558) days; changed 3 times owing to catheter obstruction
Teng CL et al. 2012 (22)	18 patients with malignant tumors (11 lymphomas)	6/18 cases: chylothorax disappeared

eTABLE 3

Outcome of percutaneous treatment by thoracic duct embolization or needle disruption of the lymphatic pathways

Study*	Procedure /patients	Success rate	Complications
Cope C et al. 1999 (e26)	Embolization (prospective feasibility study)	– 4/11 (45 %) embolizations technically/anatomically practicable – 2/4 successful	None
Cope C, Kaiser LR 2002 (32)	n = 26 embolization n = 16 disruption	– 22/26 embolizations – 5/16 disruptions (2 x reduced drain output)	– No intervention-related relevant complications; 8/42 (19 %) patients died in the course of 3 months
Binkert CA et al. 2005 (e17)	n = 6 embolization n = 3 disruption	– 5/6 embolizations (1 failure with spiral occlusion without tissue adhesive) – 2/3 disruptions	None ("no minor or major adverse events")
Itkin M et al. 2011 (30)	Embolization: 32-day-old child and 5-month-old child after failed thoracic duct ligation following cardiac surgery	2/2 embolizations	None
Itkin M et al. 2010 (37)	106 patients, 20 of them with previous unsuccessful surgical duct ligation – 73 embolization – 18 disruption	Technical success: – 73/106 (67%) duct intubation possible – 71/73 embolization possible – 18/33 disruption possible Clinical success: – 64/71 (90%) embolizations – 13/18 (72%) disruptions 15/17 previously operated patients successfully treated	3% – 1 x asymptomatic pulmonary embolism from embolic agent – 2 x leg edema – 1 x dehiscence at lymphography access wound
Laslett D et al. 2012 (40)	Follow-up study of patients after percutaneous treatment	106/169 (69%)	4/49 leg swelling 4/49 diarrhea
Nadolski GJ, Itkin M 2013 (36)	32 patients with non-traumatic chylothorax, 2 of them with previous surgical ligation	Embolization in 22 cases technically feasible 16/32 clinically successful ("intention to treat")	– 1 x symptomatic pulmonary embolism (embolic agent) – 1 x infection at lymphography access wound
Boffa DJ et al. 2008 (13)	21 patients after thoracic surgery	Clinical success: – 12/12 embolizations – 5/10 disruptions	– 1 bile leak (treated endoscopically)

* Single case reports not included