Thoracic Duct Embolization: Technique and Applications

99

Benjamin C. Gillen, Bruce A. Bowser, Ryan M. Hegg, and Jeremy L. Friese

Contents

Introduction

Thoracic duct embolization (TDE) is an image-guided, minimally invasive alternative to surgical ligation for the treatment of chylothorax and chylopericardium [1, 2]. Chylothorax is a pleural effusion containing chyle. Thoracentesis commonly demonstrates a milky, lymphocytic predominate exudate. Laboratory assessment will reveal chylomicrons and often demonstrate elevated triglyceride levels (>110 mg/dL) [3]. Chylothorax can result from trauma, commonly iatrogenic, as well as a variety of nontraumatic causes including malignancy, congenital lymphatic disorders, lymphatic obstruction, increased venous pressure, and transdiaphragmatic passage of chylous ascites [3, 4]. Surgery in the chest, especially esophagectomy and aortic repair, is a common cause of iatrogenic chylothorax. In this chapter, we describe our approach to evaluating and treating chylothorax with TDE.

Indications and Alternative Treatment Options

Treatment of chylothorax ranges from conservative medical management to surgery. Selecting the appropriate course depends on the patient's condition, the cause of the chylothorax, and the amount of output. Medical management should be employed in cases where output is less 500–1,000 mL per day. Medical management includes, as necessary, thoracentesis; a low fat diet consisting of medium chain triglycerides, and/or total parental nutrition. Patients are restricted to medium and short chain fatty acids as they are absorbed directly into the bloodstream and do not contribute to increased lymphatic flow, while long chain fatty acids are incorporated into chylomicrons and increase lymphatic flow [5]. Octreotide administration is often used to decrease chyle flow through the thoracic duct [6]. Prolonged loss of chyle results in immunodeficiency and clinical improvement can be protracted [4, 7–9]. Criteria for TDE or surgical intervention include greater than 1,000 mL chyle output per day for 48 h, increasing

B.C. Gillen, MD (✉) • J.L. Friese, MD, MBA
Division of Vascular and Interventional Radiology, Department of Radiology, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA

B.A. Bowser, MD • R.M. Hegg, MD
Department of Radiology, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA

R.S. Dieter et al. (eds.), *Endovascular Interventions*,
DOI 10.1007/978-1-4614-7312-1_99, © Springer Science+Business Media New York 2014

output after 5 days of medical management, or persistent chylothorax after 2 weeks of medical management [4, 10].

Several surgical techniques can be effective for chylothorax depending on the location and etiology of the leak. Options include direct ligation of thoracic duct or mass ligation of tissues presumed to contain supradiaphragmatic lymphatic channels, pleurectomy or pleurodesis to collapse the pleural space, or pleuroperitoneal shunting. In the setting of an underlying malignancy, radiotherapy and pleurodesis are often optimal [4].

TDE Indications

Indications for TDE are identical to surgical intervention. At our institution, it is considered first-line therapy after medical management for two key reasons: diagnostic lymphangiography is helpful in surgical planning in the event of unsuccessful TDE, and TDE is safe and better tolerated than surgery.

Pre-procedure Evaluation

Before attempting percutaneous TDE, one must confirm that the effusion is indeed chylous with appropriate laboratory analysis. Optimal understanding of the patient's vascular, gastrointestinal, and adrenal anatomy is important. We evaluate this with careful surgical history and a CT of the chest and abdomen. Some interventionalists use MRI in hopes of identifying a suitable cisterna chyli. Contraindications include allergy to lymphangiographic contrast agents (isosulfan blue, methylene blue, or ethiodized poppy seed oil), bleeding disorders, or lack of a suitable needle trajectory [10].

Pertinent Anatomy

The cisterna chyli is formed by the junction of the paraaortic and paracaval lymphatic trunks at T12–L2 and receives lymphatic drainage from the lower extremities, abdomen, and pelvis. The cisterna chyli is a 5- to 7-cm-long midline structure that resides anterior to the spine and continues as the thoracic duct. Its diameter is quite variable, ranging from 2 to 16 mm but is usually 3–6 mm [9]. Rarely, the cisterna chyli is replaced by a network of small lumbar trunks [11].

The thoracic duct extends from the superior end of the cisterna chyli, passes through the hiatus and initially travels along the right side of the thoracic spine. At T5/6, it crosses to the left side of the spine and into the posterior mediastinum. In 10 %, the thoracic duct is duplicated or temporarily bifurcated, traveling along each side of the thoracic spine [11, 12]. The thoracic duct generally terminates into the left internal jugular vein or at the junction of the left jugular and subclavian vein. A valve prevents retrograde blood flow and makes retrograde catheterization of the thoracic duct challenging [11, 12].

The thoracic duct has three divisions – abdominal, thoracic, and cervical, separated by the aortic hiatus and the thoracic inlet [11]. The cervical portion receives the left subclavian and left mediastinal lymphatic trunks from the left arm, left hemithorax, and the left side of the head and neck [11]. The thoracic portion receives drainage from the posterior mediastinum, thoracic wall, and heart [11]. A separate, right sided lymphatic vessel receives drainage from the right arm, right side of the head and neck, right hemithorax, and superior portion of the liver (bounded by the coronary ligament). This vessel terminates into the junction of the right subclavian and internal jugular veins [11].

Technique

Lymphangiography Technique

1. Inject 0.5 mL of methylene blue or isosulfan blue intradermally into the web spaces of the first three digits to visualize the pedal lymphatics. Unipedal approach is sufficient in most cases. While more expensive, we prefer isosulfan blue due to improved visualization.
2. After identifying a lymphatic duct (20–30 min), prepare the foot in sterile fashion and anesthetize. Make a 1-cm superficial transverse incision with a 15-blade scalpel in the dorsum of the foot directly over the selected lymphatic duct (Fig. 99.1a).
3. Using magnification glasses, blunt dissect the lymphatic duct free.
4. Cannulate the lymphatic duct with a lymphangiogram catheter with integrated 30-gauge needle (Cook, Bloomington, Indiana). Administer a tiny test injection to ensure no leakage and secure the needle by tying preplaced 4–0 silk around the cannulated duct (Fig. 99.1b).
5. Inject a maximum of 15 mL of ethiodized oil (Ethiodol, Savage Laboratories, Melville, New York) followed by an equal volume normal saline to help propel the contrast through the lymphatic vessels. A lymphangiogram pump or power injector set at 0.1 mL/min can be used (Note: pumps are no longer being manufactured) (Fig. 99.1c).
6. After obtaining several scout images of the chest and abdomen, perform intermittent fluoroscopy until there is opacification of the cisterna chili. Normal transit is approximately 1 h but can range from 45 min to 4 h.

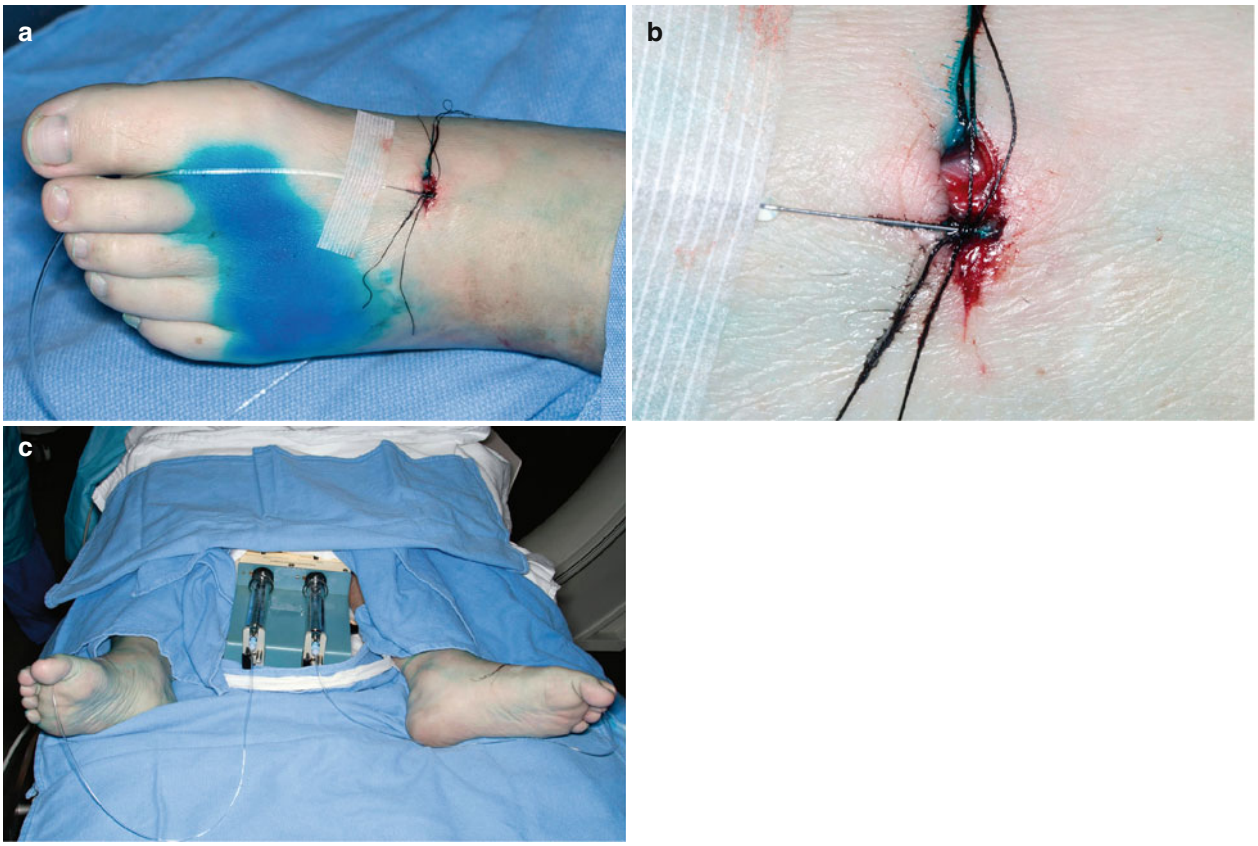

Fig. 99.1 (**a**) Photograph of the foot shows blue dye staining at the dorsal foot with cutdown and cannulation of a now-visible lymphatic channel. (**b**) Magnified view of the cutdown, lymphatic vessel cannulation, and suture securing the needle. (**c**) Lymphangiogram pump setup for a bipedal lymphangiogram

Thoracic Duct Embolization Technique

1. While some administer 1–2 cups of barium the night before the procedure and a barium milkshake immediately before the procedure to stimulate lymphatic flow and visualize the colon, this is not our routine practice.
2. Following opacification of cisterna chyli, the right upper quadrant is sterilely prepped and draped and conscious sedation administered.
3. A transabdominal or transhepatic path is chosen and liver and colon identified with a US and fluoroscopy. This decision is often aided by pre-procedure CT or MRI. Retrograde cannulation of the thoracic duct via the subclavian vein is possible in cases where access from the abdominal lymphatic pathway is impossible or inappropriate [13].
4. Needle trajectory is assessed with fluoroscopy, skin marked and anesthetized.
5. Using bulls-eye technique, the cisterna chyli is punctured with a 21–22-gauge Chiba needle.
6. Insert a 0.018-in. hydromer-coated guidewire into the thoracic duct. We prefer the 300-cm V18 wire (Boston Scientific, Natick, Massachusetts) because its stiffness prevents buckling during later steps.
7. Over the 0.018-in. guidewire, insert a 3-F microcatheter into the thoracic duct.
8. Remove the guidewire and inject iodinated contrast to opacify the thoracic duct and identify the site of leakage.
9. Advance a microcatheter beyond the site of disruption.
10. Place 3–5-mm-diameter platinum microcoils across the site of leakage extending approximately 5 cm. Improved clinical success is noted when both coils and glue are used (Note: chylous fluid has fewer clotting factors than blood which leads to slow or inadequate thrombus formation around coils alone) [1].
11. Infuse 1.0–1.5 mL of n-butyl cyanoacrylate glue (TrueFill, Codman, Raynham, Massachusetts), or Onyx (ev3, Irvine, California). We prefer Onyx and, therefore, exchange the microcatheter for an Onyx-compatible catheter.
12. Remove the catheter promptly after introducing the glue to prevent difficulty in removing the catheter.
13. In the event that the thoracic duct cannulation is unsuccessful, the cisterna chyli can be disrupted by needle maceration (termed type II TDE). This is considerably less effective and we rarely employ.

Case Examples

Case 1

A 54-year-old man underwent Ivor-Lewis esophagogastrectomy for esophageal cancer. A right pleural effusion developed on postoperative day #4. Thoracentesis showed fluid consistent with chyle and total parenteral nutrition was initiated. A chest tube was replaced on postoperative day 7 and yielded 3 L of chyle, which had accumulated over 48 h. Drain output was 1,200 cc the next day, prompting referral to interventional radiology on postoperative day 9. Lymphangiography showed a leak from the thoracic duct (Fig. 99.2a, b). The cisterna chyli was cannulated with a needle, and a guidewire was advanced into the thoracic duct (Fig. 99.2c). The disruption could not be crossed, so multiple 3-mm-diameter Nester coils (Cook, Bloomington, Indiana) were placed immediately inferior. Onyx glue was then infused to the level of the cisterna chili (Fig. 99.2d). The chest tube output tapered off rapidly over the next 48 h, the chest tubes were removed, and the patient had no further issues with chylothorax at 1-year follow-up.

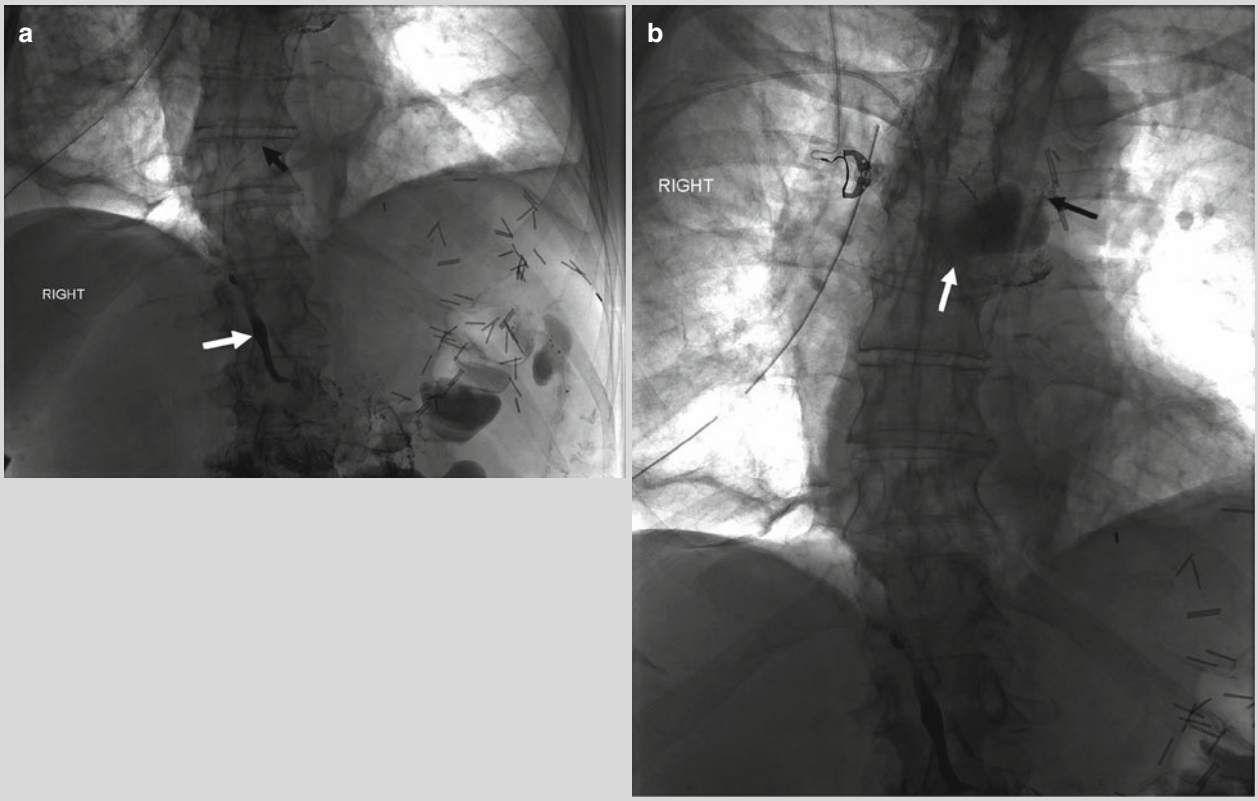

Fig. 99.2 (**a**) Lymphangiogram: cisterna chyli (*white arrow*) and thoracic duct (*black arrow*). Note the thoracic duct crossing midline. (**b**) Abrupt termination of the thoracic duct (*black arrow*) with adjacent pooling of contrast (*white arrow*) consistent with thoracic duct injury and chyle leak. (**c**) Needle tip in cisterna chyli with guidewire in the thoracic duct. (**d**) Thoracic duct embolization (TDE) with coils (*black arrow*) and Onyx (*white arrow*) below the level of injury

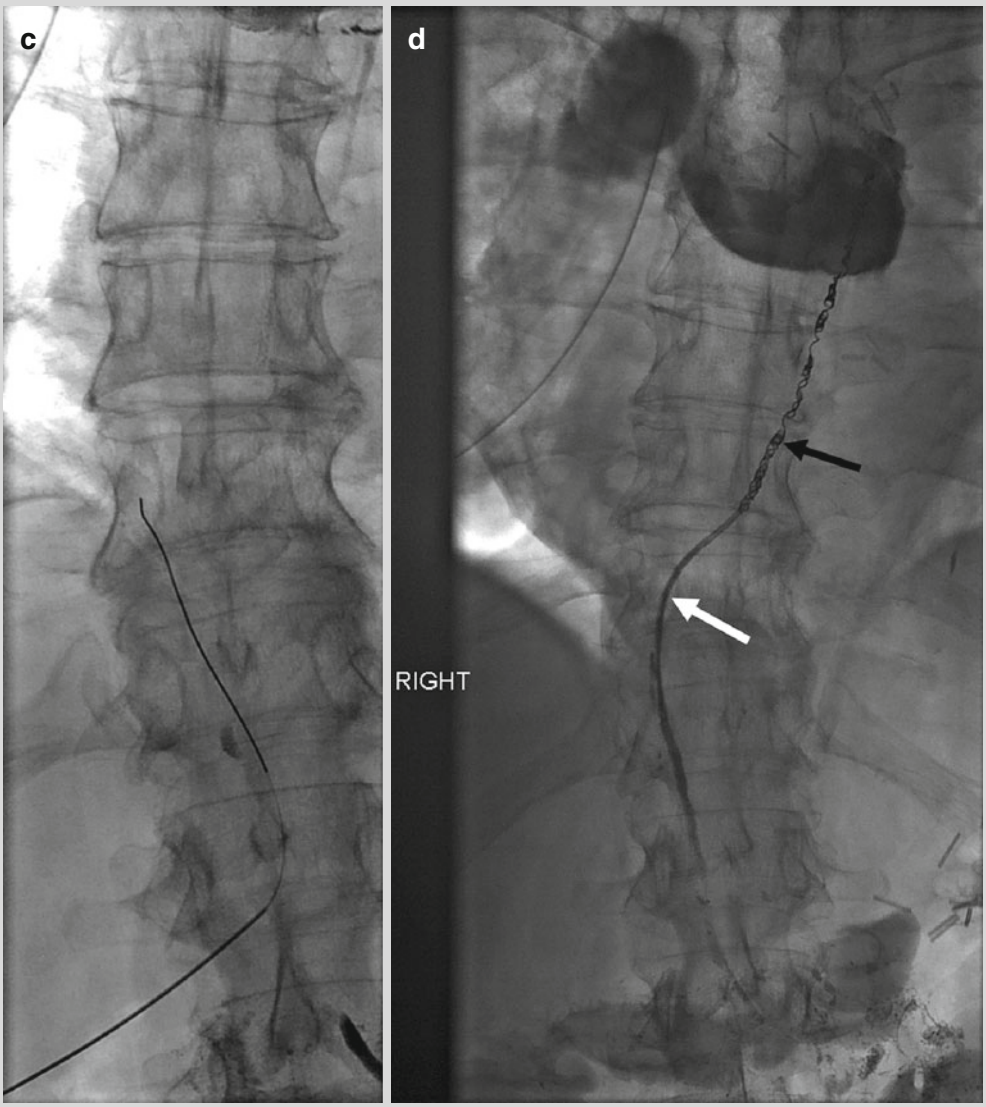

Fig. 99.2 (continued)

Case 2

A 29-year-old woman underwent bilateral first rib decompression surgery for thoracic outlet syndrome. She developed dyspnea several days post-discharge and was found to have large bilateral chylothoraces. Medical management failed and a video-assisted thoracoscopic surgery (VATS) thoracic duct ligation was performed. Bilateral chylothoraces persisted, and she was transferred to our facility. After several days of TPN and octreotide, her bilateral chest tube outputs remained greater than 600 cc daily. Lymphangiography showed no discrete cisterna chyli (Fig. 99.3a). Multiple tiny chyle leaks were identified in the mediastinum. Numerous tiny lymphatic collaterals were seen throughout the mediastinum on fluoroscopy and chest CT (Fig. 99.3b). The lack of cisterna chyli or suitable lymphatic collateral prohibited lymphatic cannulation. Bilateral VATS with mechanical and talc pleurodesis and suture ligation of multiple tiny left apical chyle leaks was performed by thoracic surgery. The patient's chest tube drainage rapidly tapered off, and she was doing well at 4-month follow-up.

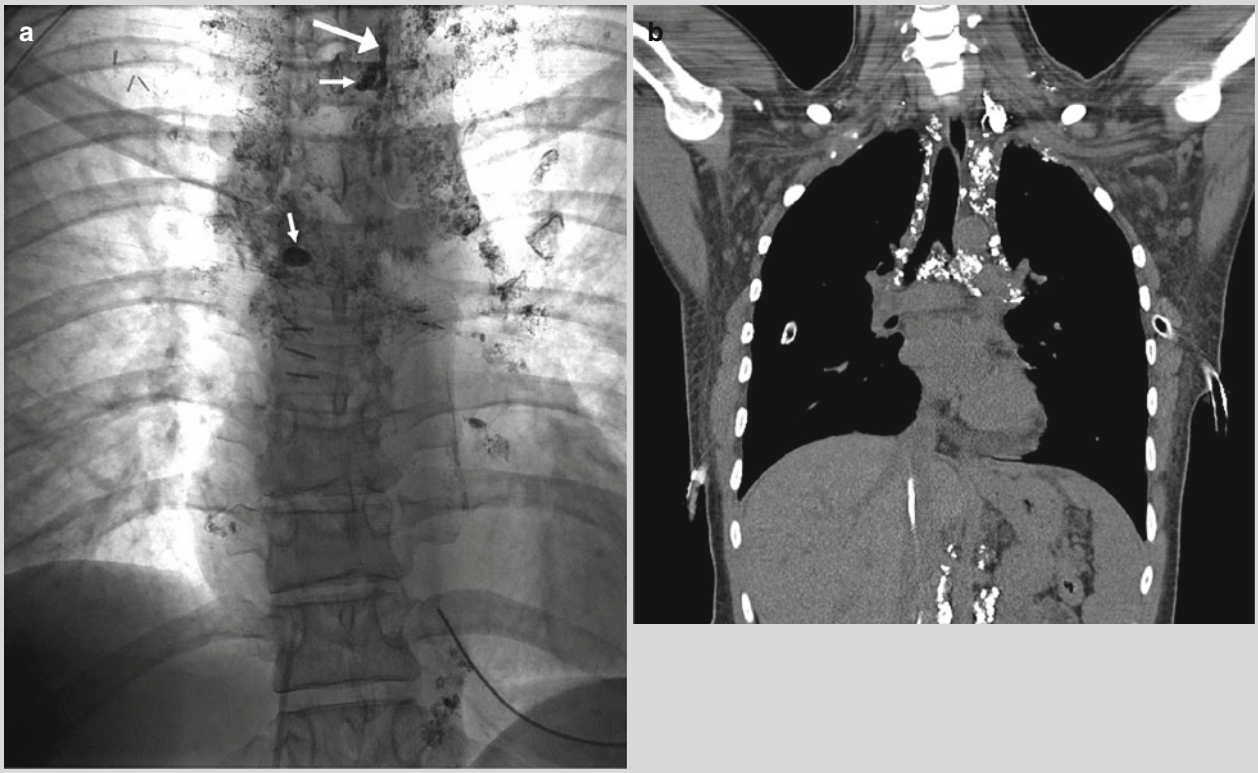

Fig. 99.3 (**a**) Lymphangiogram showed no cisterna chyli or lower thoracic duct, with reconstitution of only a small segment of the superior thoracic duct (*large white arrow*). Several areas of chyle leak were noted (*small white arrows*). (**b**) Coronal reformat CT image following lymphangiogram showed innumerable tiny lymphatic collaterals with no distinct cisterna chyli or thoracic duct

Post-procedure Management and Follow-Up

Medical management should be continued following TDE until chylous output nearly ceases. No specific follow-up imaging or procedures are otherwise necessary if the patient improves clinically.

Complications of percutaneous TDE are rare and mostly related to the lymphangiography. Methylene blue can result in tattooing of the foot. Ethiodol-related pulmonary embolism is rare [10] and avoided by using 10–15 mL [12]. In the seminal series of 58 patients, no procedural morbidity or death occurred [12]. In a contemporary series of 109 patients, one case of asymptomatic pulmonary embolization with glue was reported. There were also two wound infections from the lymphangiography. Risks of intra-abdominal hemorrhage, peritonitis, chylous ascites, and thoracic duct rupture or microcoil misplacement also exist.

Discussion

Persistent or high-output chylothorax is a serious condition with a high mortality rate secondary to malnutrition and immune compromise. For patients who have failed conservative management, TDE represents an alternative to surgery and is considered first-line therapy at our institution. While TDE is technically challenging, it has minimal morbidity. Success rate for TDE is approximately 70 % (90 % if cannulated) which is comparable or superior to surgical thoracic duct ligation or pleurodesis [14, 15]. Technical failure of TDE is most often related to the inability to catheterize the thoracic duct. When the thoracic duct cannot be catheterized, disruption of the cisterna chyli with multiple needle punctures can result in closure of the thoracic duct leak but is less successful [14, 16]. Given the significant success rate and positive safety profile, TDE is a reasonable first-line therapy for treatment of persistent or high-output chylothorax refractory to conservative therapy. Surgical options for management of chylothorax may be pursued if TDE is unsuccessful.

References

1. 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(9):1248–54.
2. Schild HH, Simon B, Kuhl CK, et al. Percutaneous treatment of idiopathic chylopericardium. J Vasc Interv Radiol. 2009;20(6):842–6.
3. Skouras V, Kalomenidis I. Chylothorax: diagnostic approach. Curr Opin Pulm Med. 2010;16(4):387–93.
4. Nair SK, Petko M, Hayward MP. Aetiology and management of chylothorax in adults. Eur J Cardiothorac Surg. 2007;32(2):362–9.
5. van Goor AT, Kroger R, Klomp HM, de Jong MA, van den Brekel MW, Balm AJ. Introduction of lymphangiography and percutaneous embolization of the thoracic duct in a stepwise approach to the management of chylous fistulas. Head Neck. 2007;29(11):1017–23.
6. Kalomenidis I. Octreotide and chylothorax. Curr Opin Pulm Med. 2006;12(4):264–7.
7. Sieczka EM, Harvey JC. Early thoracic duct ligation for postoperative chylothorax. J Surg Oncol. 1996;61(1):56–60.
8. Merigliano S, Molena D, Ruol A, et al. Chylothorax complicating esophagectomy for cancer: a plea for early thoracic duct ligation. J Thorac Cardiovasc Surg. 2000;119(3):453–7.
9. Baum S, Pentecost MJ, editors. Abrams' angiography interventional radiology. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2006.
10. Mauro M, editor. Image-guided interventions. Philadelphia: Saunders Elsevier; 2008.
11. Kadir S, editor. Atlas of normal and variant angiographic anatomy. Philadelphia: WB Saunders Co; 1991.
12. Cope C. Management of chylothorax via percutaneous embolization. Curr Opin Pulm Med. 2004;10(4):311–4.
13. Mittleider D, Dykes TA, Cicuto KP, Amberson SM, Leusner CR. Retrograde cannulation of the thoracic duct and embolization of the cisterna chyli in the treatment of chylous ascites. J Vasc Interv Radiol. 2008;19(2):285–90.
14. Cope C, Kaiser LR. Management of unremitting chylothorax by percutaneous embolization and blockage of retroperitoneal lymphatic vessels in 42 patients. J Vasc Interv Radiol. 2002;13(11):1139–48.
15. 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(3):584–9; discussion 589–90.
16. Binkert CA, Yucel EK, Davison BD, Sugarbaker DJ, Baum RA. Percutaneous treatment of high-output chylothorax with embolization or needle disruption technique. J Vasc Interv Radiol. 2005;16(9):1257–62.