

**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Doerr CH, Allen MS, Nichols FC, 3rd, Ryu JH. Etiology of chylothorax in 203 patients. <i>Mayo Clin Proc.</i> 2005;80(7):867-870.	Review/Other-Dx	203 patients	To characterize the etiology of chylothorax in patients encountered at a single tertiary referral center and to compare the findings with those from previous studies.	We identified 203 patients with chylothorax; 92 were females (male-female ratio, 1.21). The median age was 54.5 years (range, 21 weeks' gestation to 93 years). Dyspnea, the most common presenting symptom, occurred in 98 (56.6%) of 173 patients in whom initial symptoms were recorded, whereas 64 (37.0%) had no respiratory symptoms. Median duration of symptoms before diagnosis was 7.5 weeks (range, 1 day to 4.5 years). Causes of chylothorax included surgery or trauma in 101 patients (49.8%), various medical conditions in 89 (43.8%), and unknown in 13 (6.4%). Among surgical procedures, esophagectomy (29 patients) and surgery for congenital heart disease (28 patients) were the most common causes of chylothorax. Among medical conditions, lymphoma (23 patients), lymphatic disorders (19 patients), and chylous ascites (16 patients) were the most common causes.	4
2. Maldonado F, Cartin-Ceba R, Hawkins FJ, Ryu JH. Medical and surgical management of chylothorax and associated outcomes. <i>Am J Med Sci.</i> 2010;339(4):314-318.	Observational-Tx	74 patients	To assess the modes of management for chylothorax in 74 adult patients ( $\geq 18$ years old) and associated outcomes.	Initial treatment approach was nonsurgical in 57 patients (77%) but a surgical procedure (pleurodesis, TD ligation, and/or surgical repair) was eventually performed in 44 patients (59%). The rate of resolution with initial treatment measures was significantly worse for patients with nontraumatic chylothorax compared with those with traumatic causes (27% vs 50%, $P=0.048$ ). Even after additional therapeutic maneuvers including surgery, chylous effusion recurred more commonly in nontraumatic chylothorax when compared with the traumatic group (50% vs 13%, respectively, $P<0.001$ ).	2

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3. Maldonado F, Hawkins FJ, Daniels CE, Doerr CH, Decker PA, Ryu JH. Pleural fluid characteristics of chylothorax. <i>Mayo Clin Proc.</i> 2009;84(2):129-133.	Review/Other-Dx	74 patients	To determine the biochemical parameters of chylous pleural fluids and better inform current clinical practice in the diagnosis of chylothorax.	The study consisted of 37 men (50%) and 37 women (50%), with a median age of 61.5 years (range, 20–93 years). Chylothorax was caused by surgical procedures in 51%. The chylous pleural fluid appeared milky in only 44%. Pleural effusion was exudative in 64 patients (86%) and transudative in 10 patients (14%). However, pleural fluid protein and lactate dehydrogenase levels varied widely. Transudative chylothorax was present in all 4 patients with cirrhosis but was also seen with other causes. The mean +/- SD triglyceride level was 728+/-797 mg/dL, and the mean +/- SD cholesterol value was 66+/-30 mg/dL. The pleural fluid triglyceride value was <110 mg/dL in 10 patients (14%) with chylothorax, 2 of whom had a triglyceride value lower than 50 mg/dL.	4
4. Chen E, Itkin M. Thoracic duct embolization for chylous leaks. <i>Semin Intervent Radiol.</i> 2011;28(1):63-74.	Review/Other-Tx	N/A	To describe the etiologies of chylothorax, patient population, outcomes, and long-term follow-up of TDE patients.	No results stated in abstract.	4
5. Itkin M, Kucharczuk JC, Kwak A, Trerotola SO, Kaiser LR. Nonoperative thoracic duct embolization for traumatic thoracic duct leak: experience in 109 patients. <i>J Thorac Cardiovasc Surg.</i> 2010;139(3):584-589; discussion 589-590.	Observational-Tx	109 patients	To demonstrate the efficacy of a minimally invasive, nonoperative, catheter-based approach to the treatment of traumatic chyle leak.	A total of 106 patients presented with chylothorax, 1 patient presented with chylopericardium, and 2 patients presented with cervical lymphocele. 20 patients (18%) had previous failed TD ligation. In 108/109 patients, a lymphangiogram was successful. Catheterization of the TD was achieved in 73 patients (67%). In 71/73 patients, TDE was performed. Endovascular coils or liquid embolic agent was used to occlude the TD. In 18/33 cases of unsuccessful catheterization, TD needle interruption was attempted below the diaphragm. Resolution of the chyle leak was observed in 64/71 patients (90%) postembolization. Needle interruption of the TD was successful in 13/18 patients (72%). In 17/20 patients who had previous attempts at TD ligation, embolization or interruption was attempted and successful in 15 (88%). The overall success rate for the entire series was 71% (77/109). There were 3 (3%) minor complications.	3

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6. Nadolski GJ, Itkin M. Thoracic duct embolization for nontraumatic chylous effusion: experience in 34 patients. <i>Chest</i> . 2013;143(1):158-163.	Observational-Tx	34 patients	To demonstrate efficacy of TDE in treating nontraumatic chylous effusions.	34 patients (mean age, 59 years; 27 female patients) with nontraumatic chylous effusions underwent TDE. Presentations included 21 unilateral chylothoraces (61.8%), 9 bilateral chylothoraces (26.5%), 2 isolated chylopericardiums (5.9%), and 2 pleural effusions with chylopericardium (5.9%). TDE was technically successful in 24/34 patients (70.6%). The TD could not be catheterized in 4/34 (11.8%). Cisterna chyli was not visualized in 6/34 patients (17.6%), and, thus, TDE was not attempted. Follow-up was available for 32 patients. 4 lymphangiographic patterns were observed: (1) normal TD in 17.6% of patients (6/34), (2) occlusion of TD in 58.8% (20/34), (3) failure to opacify TD in 17.6% (6/34), and (4) extravasation of chyle in 5.9% (2/34). Clinical success varied with the lymphangiographic pattern. The clinical success rate was 16% (1 of 6) in cases of normal TD, 75% (15/20 patients) in occlusions of the TD, 16% (1 of 6) in cases of failure to opacify the TD, and 50% in 2 cases of chyle extravasation. LAG alone cured 2 patients (6.5%).	3

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7. Pamarthi V, Stecker MS, Schenker MP, et al. Thoracic duct embolization and disruption for treatment of chylous effusions: experience with 105 patients. <i>J Vasc Interv Radiol.</i> 2014;25(9):1398-1404.	Observational-Tx	105 patients	To review the indications, technical approach, and clinical outcomes of TDE and TD disruption in patients with symptomatic chylous effusions.	The technical success rate was 79% (95/120); 53 TDEs were performed, resulting in a 72% clinical success rate (n = 38), whereas 42 TD disruptions showed a 55% clinical success rate (n = 23; $P=.13$ ). Procedures to treat postpneumonectomy chylous effusions had a success rate of 82% (14/17), compared with 47% (9/19) in postpleurectomy subjects ( $P<.05$ ). Clinically successful cases had lower 24-, 48-, and 72-hour postprocedural effusion volumes vs clinically unsuccessful cases ( $P<.05$ ), as well as greater rates of reduction in effusion volume at these time points ( $P<.05$ ). Clinical success rate in subjects with traumatic effusions was higher than in subjects with nontraumatic effusions (62% [60/97] vs 13% [1 of 8]; $P<.05$ ), and 6.7% of subjects (n = 7) experienced minor complications.	2
8. Boffa DJ, Sands MJ, Rice TW, et al. A critical evaluation of a percutaneous diagnostic and treatment strategy for chylothorax after thoracic surgery. <i>Eur J Cardiothorac Surg.</i> 2008;33(3):435-439.	Review/Other-Tx	36 patients	To critically evaluate an evolving percutaneous strategy for diagnosing and treating chylothorax.	LAG was successful in 36/37 patients (97%). Contrast extravasation, confirming clinical diagnosis, was present in 21/36 (58%). 21/36 patients underwent 22 lymphangiographically directed percutaneous interventions: 12 embolizations and 10 disruptions. Mortality was zero, with 2 manageable complications. Patients without percutaneous intervention were discharged a median of 7 days (range 4–58) after first LAG, 8 days (range 2–19) after percutaneous embolization, and 19 days (range 6–48) after first disruption. 8 patients had 9 subsequent reoperations for chylothorax, 2 with negative lymphangiograms; no embolization patient required reoperation.	4
9. Lyon S, Mott N, Koukounaras J, Shoobridge J, Hudson PV. Role of interventional radiology in the management of chylothorax: a review of the current management of high output chylothorax. <i>Cardiovasc Intervent Radiol.</i> 2013;36(3):599-607.	Review/Other-Tx	N/A	To review the etiology, diagnosis, and treatment of chylothorax, with a focus on interventional management techniques.	No results stated in abstract.	4

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10. Platis IE, Nwogu CE. Chylothorax. <i>Thorac Surg Clin.</i> 2006;16(3):209-214.	Review/Other-Tx	N/A	To review the diagnosis and management of chylothorax.	Chylothorax is a rare complication of pulmonary resection. It requires prompt treatment, which is initially conservative. This treatment consists of drainage, nutritional support, and measures to diminish chyle flow. Surgical intervention is indicated when conservative management is ineffective. Delay in surgical intervention leads not only to serious metabolic, nutritional, and immunologic disturbances from the loss of chyle but also increases the risk for adhesion formation, loculation, organization, and infection of the chylothorax, making subsequent surgical attempts difficult and increasing postoperative morbidity and mortality. Video-assisted thoracic surgery provides a minimally invasive approach for the treatment of chylothorax complicating pulmonary resection. Clipping of the TD or chemical pleurodesis may be performed with minimal morbidity and mortality. Conservative treatment is expensive and fails in most patients who have high-output chylous fistulae. On the other hand, video-assisted thoracic surgery is uniformly effective, is less expensive, and has low morbidity. Indeed, video-assisted thoracic surgery is rapidly becoming the preferred approach for the management of chylothorax complicating pulmonary resection. The need to prevent the occurrence of a chylothorax by careful dissection techniques and liberal clipping of lymphatic vessels particularly in areas of high anatomic risk during the initial operation cannot be overemphasized.	4

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11. Scorza LB, Goldstein BJ, Mahraj RP. Modern management of chylous leak following head and neck surgery: a discussion of percutaneous lymphangiography-guided cannulation and embolization of the thoracic duct. <i>Otolaryngol Clin North Am.</i> 2008;41(6):1231-1240, xi.	Review/Other-Tx	N/A	To discuss percutaneous LAG-guided cannulation and embolization of the TD.	High-output chylous leak beyond 5 to 7 days of conservative medical treatment should be treated promptly to avoid the risk for nutritional and immunologic depletion. Given the effectiveness and low morbidity of this minimally invasive treatment, this is a reasonable first option before surgical repair of TD leak not responsive to conservative medical treatment.	4
12. DePew ZS, Iqbal S, Mullon JJ, Nichols FC, Maldonado F. The role for tunneled indwelling pleural catheters in patients with persistent benign chylothorax. <i>Am J Med Sci.</i> 2013;346(5):349-352.	Review/Other-Tx	11 patients	To describe a cohort of patients with persistent benign chylothorax managed with tunneled indwelling pleural catheters.	11 patients (14 hemithoraces) had persistent benign chylothorax treated with placement of a tunneled indwelling pleural catheter during the inclusion time frame. Etiology of the chylothorax was nontraumatic in 8/11 patients, with the remaining 3 secondary to thoracic surgery. Pleurodesis was achieved in 9/14 hemithoraces, with a median time to pleurodesis of 176 days. All procedures were well tolerated, and no immediate periprocedural complications were reported. 1 serious complication was encountered in the form of a postoperative pulmonary embolism after replacement of an occluded tunneled indwelling pleural catheter, resulting in the patient's death. 2 patients had transient occlusions of their tunneled indwelling pleural catheters successfully treated with intracatheter thrombolytic therapy. No significant adverse nutritional, hemodynamic or immunologic outcomes were reported during follow-up for any included patient.	4
13. Murphy MC, Newman BM, Rodgers BM. Pleuroperitoneal shunts in the management of persistent chylothorax. <i>Ann Thorac Surg.</i> 1989;48(2):195-200.	Observational-Tx	16 patients	To review our clinical experience with the use of pleuroperitoneal shunts in infants with chylothorax.	12 (75%) of the 16 patients had excellent results with complete elimination of the chylothorax and resolution of symptoms. In 10 of these 12, the shunt has been removed. 4 had an unsatisfactory result: 3 had inferior vena cava hypertension, and 3 were low-birth-weight premature infants. 4 patients seen early in this series required revision of the position of the pleural catheter, with successful drainage in each instance.	3

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14. Cope C. Diagnosis and treatment of postoperative chyle leakage via percutaneous transabdominal catheterization of the cisterna chyli: a preliminary study. <i>J Vasc Interv Radiol.</i> 1998;9(5):727-734.	Review/Other-Tx	5 patients	To assess the feasibility of percutaneous transabdominal puncture and catheterization of the cisterna chyli or lymphatic ducts in patients with postoperative chyloperitoneum and chylothorax, and to identify and possibly embolize the chylous fistula.	Lymph ducts as small as 2–3 mm was catheterized successfully in 3 patients. The TD was catheterized in 2 patients; 1 TD fistula was embolized with cure of chylothorax. In 1 patient with a surgically tied TD, duct occlusion was confirmed despite continued pleural effusion. 3 fistulas, not seen with lymphography, were identified in 2 of 3 chylous ascites and 1 chylothorax. There was no morbidity. As a result of this procedure, 4 of 5 patients did not require repeated operation.	4
15. Cope C, Salem R, Kaiser LR. Management of chylothorax by percutaneous catheterization and embolization of the thoracic duct: prospective trial. <i>J Vasc Interv Radiol.</i> 1999;10(9):1248-1254.	Experimental-Tx	11 patients	To prospectively assess the efficacy of percutaneous transabdominal TD catheterization and embolization in the management of patients with high-output chylothoracic effusions.	There were no retroperitoneal ducts suitable for catheterization in 6 patients because of previous abdominal surgery, trauma, or lymphangioleiomyomatosis; the TD was successfully catheterized in 5 patients, a 45% technical success rate. TDE was performed in 4 patients, with cure of effusion in 2. In the other 2 patients, 1 with lymphangioleiomyomatosis and the other with nonchylous pleural fluid, continued effusion was successfully treated by means of pleurodesis. Of 2 patients with previous TD ligation, 1 was found to have the duct incompletely tied. The authors were surprised to find that previous major abdominal surgery, chronic aortic dissection, and lymphangioleiomyomatosis could obliterate major retroperitoneal lymphatic ducts and the cisterna chyli. Percutaneous study of the TD with aqueous contrast medium was more sensitive than lymphography with iodinated oil. There was no morbidity.	2

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16. Cope C, Kaiser LR. Management of unremitting chylothorax by percutaneous embolization and blockage of retroperitoneal lymphatic vessels in 42 patients. <i>J Vasc Interv Radiol.</i> 2002;13(11):1139-1148.	Experimental-Tx	42 patients	To demonstrate the applicability, technique, and efficacy of percutaneous transabdominal catheter embolization or needle disruption of retroperitoneal lymphatic vessels in the treatment of high-output or unremitting chylothorax.	The TD was catheterized in 29 patients and embolized in 26 patients. In patients with lymph trunks that could be catheterized, treatment resulted in cure within 7 days in 16 patients and partial response with cure within 3 weeks in 6 patients. In the patients with lymph trunks that could not be catheterized (n = 16), disruption with use of needles resulted in cure in 5 patients and partial response in 2 patients. Cure and partial response rates after TDE and needle disruption were 73.8%, with no morbidity. Surgical TD ligation was performed in 7 patients. The nonprocedural mortality rate was 19%. Follow-up was 3 months or longer.	2
17. Binkert CA, Yucel EK, Davison BD, Sugarbaker DJ, Baum RA. Percutaneous treatment of high-output chylothorax with embolization or needle disruption technique. <i>J Vasc Interv Radiol.</i> 2005;16(9):1257-1262.	Review/Other-Tx	8 patients	To look at the outcome of TDE and needle disruption technique for high-output chylothorax.	In 4 patients, the TD was embolized with use of coils and glue. In the other 4 patients, lymphatic ducts were disrupted by multiple needle punctures. The median chest tube drainage substantially decreased in both patient groups from more than 1,300 mL the day before the procedure to <300 mL 2 days after the procedure. The median times to chest tube removal were 7 days in the embolization group and 3.5 days in the needle disruption group.	4
18. Laslett D, Trerotola SO, Itkin M. Delayed complications following technically successful thoracic duct embolization. <i>J Vasc Interv Radiol.</i> 2012;23(1):76-79.	Observational-Tx	78 patients	To determine the rate of delayed complications after technically successful TDE.	Follow-up information was available in 78/106 patients (73.6%). Mean length of follow-up was 34 months. During follow-up, 32 patients (41%) died of causes unrelated to TDE, and 46 (59%) were alive at the end of follow-up. The families of 3 deceased patients were available for interview. 4/49 patients (8%) had chronic leg swelling that was probably related to the procedure, 3 (6%) had abdominal swelling, and 6 (12%) had chronic diarrhea. In 4 of these 6 cases, diarrhea was considered “probably related” to the procedure. Overall, a 14.3% rate of probably-related long-term complications after TDE was recorded.	3



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19. Amorosa JK, Bramwit MP, Mohammed TL, et al. ACR appropriateness criteria routine chest radiographs in intensive care unit patients. <i>J Am Coll Radiol.</i> 2013;10(3):170-174.	Review/Other-Dx	N/A	Evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition.	No results stated in abstract.	4
20. Eibenberger KL, Dock WI, Ammann ME, Dorffner R, Hormann MF, Grabenwoger F. Quantification of pleural effusions: sonography versus radiography. <i>Radiology.</i> 1994;191(3):681-684.	Observational-Dx	51 patients	To develop a practical method of estimating the volume of pleural effusions with sonography.	Sonographic measurements correlated statistically significantly better with actual effusion volume ( $r = .80$ ) than did radiographic measurements ( $r = .58$ ) ( $P \leq .05$ ). With sonographic measurement, an effusion width of 20 mm had a mean volume of 380 mL +/- 130 (SD), while 1 of 40 mm had a mean volume of 1,000 mL +/- 330. Prediction error with sonographic measurement (mean, 224 mL) was statistically significantly less ( $P \leq .002$ ) than that with radiographic measurement (mean, 465 mL).	3
21. Nadolski GJ, Itkin M. Feasibility of ultrasound-guided intranodal lymphangiogram for thoracic duct embolization. <i>J Vasc Interv Radiol.</i> 2012;23(5):613-616.	Observational-Tx	12 patients	To show the feasibility of opacifying the TD using ultrasound-guided intranodal lymphangiogram for TDE.	The procedure of opacification, catheterization, and embolization of the TD was successful in all cases. Cumulative times (mean +/- SD) in the intranodal lymphangiogram and pedal LAG groups from start of the procedure until (i) initial lymphangiogram were 20.5 minutes +/- 8.6 and 46.5 minutes +/- 22.6, (ii) identification of a target lymphatic for catheterization were 60.5 minutes +/- 18.2 and 110.5 minutes +/- 31.6, (iii) catheterization of the TD were 79.0 minutes +/- 28.9 and 128.2 minutes +/- 37.0, and (iv) completion of procedure were 125.8 minutes +/- 49.0 and 152.8 minutes +/- 36.4.	2

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22. Kos S, Haueisen H, Lachmund U, Roeren T. Lymphangiography: forgotten tool or rising star in the diagnosis and therapy of postoperative lymphatic vessel leakage. <i>Cardiovasc Intervent Radiol.</i> 2007;30(5):968-973.	Observational-Tx	20 patients	To demonstrate the persisting diagnostic and therapeutic impact of LAG on the postoperative patient with known or suspected lymphatic vessel leakage.	In 20 patients who underwent mono- or bipedal LAG for lymphatic vessel injury, we were able to demonstrate the specific site of leakage in 15 cases (75%) and found signs of extravasation in 5 patients (25%). Furthermore, in 11 patients (55%) we were able to avoid surgery because of closure of the leak after LAG. As the conservative therapeutic approach usually takes 2–3 weeks to reveal its therapeutic effects, 73.3% (11/15) of the patients who were not reoperated before this hallmark was passed did not need any further operation.	3
23. Sachs PB, Zelch MG, Rice TW, Geisinger MA, Risius B, Lammert GK. Diagnosis and localization of laceration of the thoracic duct: usefulness of lymphangiography and CT. <i>AJR Am J Roentgenol.</i> 1991;157(4):703-705.	Review/Other-Dx	12 patients	To evaluate the usefulness of LAG and CT in the diagnosis and localization of laceration of the TD in patients with chylothorax or chylous ascites after surgery.	7 patients had abnormal findings on lymphangiograms; 5 with leaks from the TD, 1 with a lymphocele in a nephrectomy bed, and 1 with obstructed intestinal lymphatic vessels after thoracotomy. 5 patients had no evidence of lymphatic leakage. CT in 1 patient with evidence of a leak on LAG showed extravasation of contrast medium into the mediastinum and pleural space. CT in 3 patients with no abnormalities on LAG also showed no abnormalities. 4 of the 5 TD lacerations and the lymphocele were confirmed surgically. The diagnosis of obstructed intestinal lymphatic vessels was supported clinically. 4 of the 5 patients with normal findings on lymphangiograms had resolution of their pleural effusions and no evidence of recurrence during a follow-up period of 1–27 months. 1 patient with normal findings on LAG had an alternative diagnosis established at surgery. Laceration of the TD was accurately diagnosed and localized with LAG, which allowed definitive surgical repair. CT was of little additional value in diagnosing these injuries.	4

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24. Alejandre-Lafont E, Krompiec C, Rau WS, Krombach GA. Effectiveness of therapeutic lymphography on lymphatic leakage. <i>Acta Radiol.</i> 2011;52(3):305-311.	Observational-Tx	43 patients	To investigate if therapeutic lymphography is a reliable method to treat lymphatic leakage when conservative treatment fails and to investigate which parameters influence the success rate.	In nearly 79% of patients, the location of the leak could be detected, and surgical intervention could be planned when therapeutic lymphography failed. Due to the irrigating effect of the contrast medium (lipiodol), the lymphatic leak could be completely occluded in 70% of patients when the lymphatic drainage volume was <500 mL/day. Even when lymphatic drainage was higher than 500 mL/day, therapeutic lymphography was still successful in 35% of the patients. The overall success rate in patients with failed conservative treatment was 51%. Success did not depend on other factors such as age and sex, cause of lymph duct damage, or time elapsed between lymphatic injury and intervention.	3
25. Deso S, Ludwig B, Kabutey NK, Kim D, Guermazi A. Lymphangiography in the diagnosis and localization of various chyle leaks. <i>Cardiovasc Intervent Radiol.</i> 2012;35(1):117-126.	Observational-Dx	16 patients	To review the common types of chyle leaks, including chylothorax, chylous ascites, and chyluria, and demonstrate the use of LAG and post-LAG CT imaging in their diagnosis and localization.	In each case, the source of the chyle leak was identified and properly localized to guide further treatment. Of the 16 patients who underwent LAG and postprocedure CT imaging, the initial LAG alone provided the diagnosis and localized the chyle leak in 4 patients (25%); the postprocedure CT imaging provided the diagnosis and localized the chyle leak in 6 patients (37.5%); and the 2 modalities were equal in the diagnosing and localizing the chyle leak in the remaining 6 patients (37.5%).	4
26. Matsumoto T, Yamagami T, Kato T, et al. The effectiveness of lymphangiography as a treatment method for various chyle leakages. <i>Br J Radiol.</i> 2009;82(976):286-290.	Observational-Tx	9 patients	To assess the effectiveness of LAG as a treatment for various chyle leakages.	In 7 of these 9 patients (78%), we could detect the chyle leakage sites. In 8 of the 9 patients (89%), lymphatic leakage was stopped after LAG, and surgical re-intervention was avoided. No cases had a recurrence of chyle leakage during follow-up (range, 1–54 months). LAG is effective not only for diagnosis but also as treatment for various chyle leakages.	3

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27. Ruan Z, Zhou Y, Wang S, Zhang J, Wang Y, Xu W. Clinical use of lymphangiography for intractable spontaneous chylothorax. <i>Thorac Cardiovasc Surg.</i> 2011;59(7):430-435.	Review/Other-Dx	15 patients	To discuss the clinical value of LAG for intractable spontaneous chylothorax.	12 cases had successful LAG while LAG failed in the other 3 cases. No procedure-related complications occurred. LAG was useful for the diagnosis of lymphatic vessel disease and underlying disease in 6 (50 %) cases, but the etiology in the remaining 6 cases (50 %) remained uncertain. Signs of leakage or contrast extravasation were directly detected in 5 (42 %) patients. Based on the LAG findings, 5 cases underwent surgical intervention with satisfactory results, with 1 recurrence 5 years later. 2 patients had steatorrhea and chyluria after successful TD ligation. 7 cases were treated conservatively, 5 of whom were cured while the other 2 cases had temporary remission of symptoms.	4
28. Rajebi MR, Chaudry G, Padua HM, et al. Intranodal lymphangiography: feasibility and preliminary experience in children. <i>J Vasc Interv Radiol.</i> 2011;22(9):1300-1305.	Review/Other-Dx	5 pediatric patients	To review an initial experience studying the lymphatic system using direct injection of ethiodized oil contrast medium into lymph nodes (ie, intranodal LAG) in children with chylous disorders.	5 children (age range, 6 weeks to 17 years) with chylous vaginorrhea (n = 1), postoperative chylothorax (n = 2), or spontaneous chylothorax (n = 2) underwent intranodal LAG. The amount of ethiodized oil injected was 0.5–4.5 mL. Intranodal LAG was successfully completed in 4 patients. 1 procedure was terminated because of patient motion and extravasation of contrast medium. Lymphangiographic findings included a spectrum of lymphatic channel disorders including incompetence, obstruction, collateralization, chylous reflux, and chylous leak. There were no complications.	4
29. Kawasaki R, Sugimoto K, Fujii M, et al. Therapeutic effectiveness of diagnostic lymphangiography for refractory postoperative chylothorax and chylous ascites: correlation with radiologic findings and preceding medical treatment. <i>AJR Am J Roentgenol.</i> 2013;201(3):659-666.	Observational-Tx	14 patients	To assess the therapeutic effect of LAG for refractory postoperative chylothorax and chylous ascites and analyze the relation between the clinical outcomes and radiologic findings or response to the preceding medical treatment.	The leaks were healed in 9 of 14 patients (64.3%) by 3–29 days (median, 8 days) after LAG. Healing was achieved for 2 of 7 major leaks, and all of the minor leaks (n=4) and undetectable leaks (n=3) after LAG. The remaining 5 major leaks were not healed after a median follow-up of 15 days. The daily output decreased more than half after medical treatment in 7 of the 14 patients, and the leak was healed in 6 of these patients (85.7%) by 5–18 days (median, 10 days).	3

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30. Liu DY, Shao Y, Shi JX. Unilateral pedal lymphangiography with non-contrast computerized tomography is valuable in the location and treatment decision of idiopathic chylothorax. <i>J Cardiothorac Surg.</i> 2014;9:8.	Observational-Tx	24 patients	To analyze the results of unilateral LAG with post-LAG noncontrast CT scan in idiopathic chylothorax patients after failure of right supradiaphragmatic TD ligation, aiming to identify its value in proper location and treatment guidance of these refractory cases.	The amount of iodized oil used was 6–14 mL with no related complications. LAG demonstrated 8 patients with TD leaks and 10 patients with leaks elsewhere, but no visible chylous leak in 6 patients. Ligation of TD was performed as the primary treatment in all 8 cases as having TD leakage and cured 7(87.5%) patients. For 8 patients not having TD lesion under LAG, the successful rate of TD ligation was 25% (2 out of 8 patients), which was significantly lower than patients due to TD lesions ( $P=0.02$ ). Meanwhile, nonoperative therapy had significantly higher successful rate (87.5% vs 25%, $P=0.02$ ).	2
31. Pui MH, Yueh TC. Lymphoscintigraphy in chyluria, chyloperitoneum and chylothorax. <i>J Nucl Med.</i> 1998;39(7):1292-1296.	Review/Other-Dx	18 patients	To analyze lymphoscintigraphic studies to determine their efficacy in the investigation of chyluria, chyloperitoneum and chylothorax.	Lymphoscintigraphy was normal (5/11 patients) or showed lymphatic obstruction (6/11 patients) in chyluria associated with filariasis. Lymphatic obstruction was demonstrated in chyloperitoneum and/or chylothorax associated with liver cirrhosis (2 patients), postoperative (1 patient) or congenital (1 patient) lymphatic dysplasia, inferior vena cava obstruction (1 patient) and nephrotic syndrome (1 patient). Enhanced lymph flow was seen in systemic lupus erythematosus (1 patient). Follow-up lymphoscintigrams showed patency of lymphovenous anastomosis (1 patient), improvement (1 patient) or no change (1 patient) in lymphatic drainage after treatment.	4
32. Takanami K, Ichikawa H, Fukuda H, Takahashi S. Three-dimensional lymphoscintigraphy using SPECT/CT and 123I-BMIPP for the preoperative detection of anatomical anomalies of the thoracic duct. <i>Clin Nucl Med.</i> 2012;37(11):1047-1051.	Observational-Dx	35 patients	To evaluate the clinical feasibility of 3D TD scintigraphy using SPECT/CT and BMIPP for the detection of anatomical anomalies of TD.	The TD visualization grades for the cervical, upper, middle, and lower thoracic segments were 4.4 +/- 0.6, 3.7 +/- 1.0, 3.1 +/- 0.8, and 2.1 +/- 0.9, respectively. The TD scintigraphy demonstrated an uncommon accumulation including that in the right- or bilateral-sided mediastinum or venous angle in 6 (17%) of the 35 patients. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 3D TD scintigraphy for the detection of anatomical anomalies of TD were 0.75, 0.90, 0.5, 0.97, and 0.89, respectively.	2

**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
33. Yang J, Codreanu I, Zhuang H. Minimal lymphatic leakage in an infant with chylothorax detected by lymphoscintigraphy SPECT/CT. <i>Pediatrics</i> . 2014;134(2):e606-610.	Review/Other-Dx	1 patient	To review a pediatric case using lymphoscintigraphy SPECT/CT to detect minimal lymphatic leakage.	The case demonstrates that lymphoscintigraphy SPECT/CT can be a useful modality for detecting the chyle leakage site in children with chylothorax even when the amount of leakage is minimal.	4
34. Hayashi S, Miyazaki M. Thoracic duct: visualization at nonenhanced MR lymphography--initial experience. <i>Radiology</i> . 1999;212(2):598-600.	Review/Other-Dx	6 patients	To evaluate depiction of the TD along the thoracic aorta at electrocardiography-gated MRI with a short echo spacing, 3D, half-Fourier fast spin-echo sequence. No contrast was used.	The images clearly depicted the main duct in the region of the thoracic aorta in all 6 volunteers, drainage into the left subclavian region in 4, and the cisterna chyli in 1.	4
35. Erden A, Fitoz S, Yagmurlu B, Erden I. Abdominal confluence of lymph trunks: detectability and morphology on heavily T2-weighted images. <i>AJR Am J Roentgenol</i> . 2005;184(1):35-40.	Review/Other-Dx	125 patients	To evaluate the detectability, configuration, location, and dimensions of the cisterna chyli on heavily T2-weighted images obtained with a single-shot fast spin-echo technique and to determine whether the disorders that have the potential to affect the abdominal lymphatic drainage could change the cisternal dimensions.	Abdominal confluence of the lymphatics was shown in 96% of patients. The most common configuration of the cisterna chyli was tubular (42.5%). It was located at the level of L1-2 in 33% of cases and at the midline in 70%. Mean longitudinal, anteroposterior, and transverse diameters of the duct were 33.45 +/- 1.74 (SD) mm, 5.23 +/- 0.13 mm, and 5.23 +/- 0.15 mm, respectively. No significant difference was found in the mean values of antero-posterior, transverse, and longitudinal diameters of the cisterna chyli in the control group and in the groups expected to have an increased flow into the cisterna chyli.	4
36. Kato T, Takase K, Ichikawa H, Satomi S, Takahashi S. Thoracic duct visualization: combined use of multidetector-row computed tomography and magnetic resonance imaging. <i>J Comput Assist Tomogr</i> . 2011;35(2):260-265.	Observational-Dx	60 patients	To assess the ability of MRI and MDCT to visualize the TD in esophageal cancer patients.	In the cervical, middle, and lower segments, MRI provided significantly higher visualization grades than MDCT. In all segments, combined MDCT and MRI resulted in higher grades than MDCT alone. In addition, combined MDCT and MRI successfully allowed visualization of the cervical, upper, middle, and lower segments of the TD in 46 (76.7%), 50 (83.3%), 58 (96.7%), and 60 (100%) patients, respectively.	3
37. Matsushima S, Ichiba N, Hayashi D, Fukuda K. Nonenhanced magnetic resonance lymphoductography: visualization of lymphatic system of the trunk on 3-dimensional heavily T2-weighted image with 2-dimensional prospective acquisition and correction. <i>J Comput Assist Tomogr</i> . 2007;31(2):299-302.	Review/Other-Dx	9 healthy volunteers	To evaluate the usefulness of the nonenhanced 3D heavily T2-weighted images obtained with 2D prospective acquisition and correction in visualization of the lymphatic system of the trunk.	The TD, cisterna chyli, and lumbar lymphatics were well shown in 9 healthy volunteers. This nonenhanced MR lymphoductography is thought to be a suitable method in visualization of the lymphatic system of the trunk.	4

\* See Last Page for Key

**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
38. Pinto PS, Sirlin CB, Andrade-Barreto OA, Brown MA, Mindelzun RE, Mattrey RF. Cisterna chyli at routine abdominal MR imaging: a normal anatomic structure in the retrocrural space. <i>Radiographics</i> . 2004;24(3):809-817.	Observational-Dx	200 patients	To review variations in normal anatomy of the retrocrural space, with emphasis on the MRI appearance of the lymphatic system in this region and, particularly, the cisterna chyli.	The cisterna chyli was evident on abdominal MRIs acquired in 30 (15%) of 200 consecutive patients who underwent MRI at the authors' institution between February and June 2002. Its appearance varied from that of a thick tube to that of a thin tube, parallel or converging tubes, tortuous tubes, a sausage-shaped fluid collection, a focal collection, or a focal plexus.	4
39. Takahashi H, Kuboyama S, Abe H, Aoki T, Miyazaki M, Nakata H. Clinical feasibility of noncontrast-enhanced magnetic resonance lymphography of the thoracic duct. <i>Chest</i> . 2003;124(6):2136-2142.	Experimental-Dx	23 healthy volunteers and 113 patients	To determine which combination of posture and breathing phase during noncontrast-enhanced MR lymphography provided the clearest images, and to evaluate the morphologic changes in the TD in healthy volunteers and patients with liver disease and malignancy.	MR lymphography with respiratory gating in the supine position depicted the TD well and was the most comfortable for the subjects. In 82/113 patients (72.6%), the TDs were entirely visualized from the diaphragm level to the subclavian region. The remaining 31 patients had ducts that could not be entirely visualized due to sections or short lengths that were obscured. The maximum diameter was 3.74 +/- 0.81 mm in all healthy volunteers, 6.98 +/- 2.77 mm in alcoholic cirrhosis, 4.12 +/- 1.51 mm in nonalcoholic cirrhosis, 3.76 +/- 1.10 mm in malignancy, and 3.60 +/- 0.80 mm in chronic hepatitis (mean +/- SD). The diameter in alcoholic cirrhosis was significantly greater than in other groups ( $P < 0.01$ ).	2
40. Okuda I, Udagawa H, Hirata K, Nakajima Y. Depiction of the thoracic duct by magnetic resonance imaging: comparison between magnetic resonance imaging and the anatomical literature. <i>Jpn J Radiol</i> . 2011;29(1):39-45.	Review/Other-Dx	63 patients	To compare TD configuration depicted by MRI with TD configuration described in the anatomical literature.	On MRI scans the TD was often located to the left of the mid-vertebral line compared to the location reported in the anatomical literature ( $P < 0.001$ ). 9 patients had marked leftward TD displacement, a configuration similar to that of the descending aorta ( $W = 1$ ); however, no association with age was established.	4

**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
41. Okuda I, Udagawa H, Takahashi J, Yamase H, Kohno T, Nakajima Y. Magnetic resonance-thoracic ductography: imaging aid for thoracic surgery and thoracic duct depiction based on embryological considerations. <i>Gen Thorac Cardiovasc Surg.</i> 2009;57(12):640-646.	Observational-Dx	78 patients	To assess the performance of our MRI technique for TD visualization and analyzed the depicted TD patterns to determine the morphological variations to be considered during thoracic surgery.	MRI TD was conducted in 78 patients, and the 3D reconstruction was considered to provide excellent view of the TD in 69 patients, segmentalization of TD in 4, and a poor view of the TD in 5. MRI TD achieved a visualization rate of 94%. Most of the patients had a right-side TD that flowed into the left venous angle. Major configuration variations were noted in 14% of cases. Minor anomalies, such as divergence and meandering, were frequently seen.	4
42. Yu DX, Ma XX, Wang Q, Zhang Y, Li CF. Morphological changes of the thoracic duct and accessory lymphatic channels in patients with chylothorax: detection with unenhanced magnetic resonance imaging. <i>Eur Radiol.</i> 2013;23(3):702-711.	Observational-Dx	7 patients and 30 healthy individuals	To characterize the imaging findings of patients with chylothorax and to identify the leak site using unenhanced MRI.	The patients had a higher display rate of the entire TD and some accessory lymphatic channels, enlarged diameters and tortuous configuration of the TD, and existence of chylomas compared with the control group ( $P<0.05$ ). 7 leaks of the TD in 5 patients and 5 leaks of the parietal pleura in 4 patients were identified. Close relationships between the leak of TD and the chylomas or the meshworks of tiny lymphatics were found ( $P<0.05$ ).	2
43. Yu DX, Ma XX, Zhang XM, Wang Q, Li CF. Morphological features and clinical feasibility of thoracic duct: detection with nonenhanced magnetic resonance imaging at 3.0 T. <i>J Magn Reson Imaging.</i> 2010;32(1):94-100.	Observational-Dx	139 cases	To evaluate the detection of the TD using nonenhanced MRI and to determine the influence of some related disorders on the lymphatic duct.	The cisterna chyli was shown in 91% of cases on fat-suppressed T2-weighted imaging, while the TD appeared in 70% of the maximum intensity projection images. The common configuration of the cisterna chyli was tubular or saccular in 73%. 80 TDs had a slight turn declining to the left at the level of T8-10. There was a significant difference in the transverse diameter of the TD between the portal hypertension group and other groups ( $F = 5.638, P=0.005$ ).	3



**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
44. Verma SK, Mitchell DG, Bergin D, Mehta R, Chopra S, Choi D. The cisterna chyli: enhancement on delayed phase MR images after intravenous administration of gadolinium chelate. <i>Radiology</i> . 2007;244(3):791-796.	Observational-Dx	59 patients	To retrospectively evaluate cisterna chyli (CC) enhancement on MRIs obtained after intravenous administration of a gadolinium-based contrast agent.	Mean cisterna chyli-spinal canal signal intensity ratios on nonenhanced, arterial phase, venous phase, and delayed phase images were 0.92, 0.98, 0.99, and 2.13, respectively. The cisterna chyli had low signal intensity on all 3D gradient-echo images obtained during the nonenhanced, arterial, and venous phases and high signal intensity, similar to the azygos vein signal intensity, on all delayed phase images. The cisterna chyli-spinal canal signal intensity ratio during the delayed phase was significantly higher than that during the other phases ( $P < .001$ ).	3
45. Krishnamurthy R, Hernandez A, Kavuk S, Annam A, Pimpalwar S. Imaging the central conducting lymphatics: initial experience with dynamic MR lymphangiography. <i>Radiology</i> . 2015;274(3):871-878.	Review/Other-Dx	6 patients	To describe a dynamic MR LAG technique after intranodal injection of gadolinium-based contrast agent and to assess its feasibility for evaluation of the central conducting lymphatics in patients with pathologic disorders that involve the central conducting lymphatics.	The procedure was technically successful in all 6 patients. The dynamic MR LAG findings confirmed the presence of normal central conducting lymphatics morphologic structure in 2 patients and provided a possible explanation for clinical manifestations in the remaining 4 patients. The dynamic MR LAG procedure led to a change in management in 2 patients, continuation of conservative treatment in 3 patients, and confirmation of an alternative nonlymphatic diagnosis in 1 patient. Image quality for visualization of the central conducting lymphatics was considered good in all cases by the 2 readers. There were no known adverse effects related to the procedure.	4

**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
46. Liu NF, Lu Q, Jiang ZH, Wang CG, Zhou JG. Anatomic and functional evaluation of the lymphatics and lymph nodes in diagnosis of lymphatic circulation disorders with contrast magnetic resonance lymphangiography. <i>J Vasc Surg.</i> 2009;49(4):980-987.	Observational-Dx	27 patients	To evaluate the anatomic and functional images of contrast MR LAG in the diagnosis of limb lymphatic circulation disorders.	Examination of the MRIs after injection of the contrast agent showed enhanced lymphatic channels consistently visualized in all clinical lymphedematous limbs and in 5 contralateral limbs of unilateral lymphedema patients. The speed of flow within the lymphatics of lymphedematous limbs was 0.3 to 1.48 cm/min. Contrast enhancement in inguinal nodes of edematous limbs was significantly less than that of contralateral limbs ( $P<.01$ ). Dynamic measurement of contrast enhancement showed a remarkable lowering of peak time ( $P<.01$ ) and peak enhancement ( $P<.01$ ), and a delay in outflow in inguinal nodes of affected limbs compared with that of control limbs. Postcontrast MRI also depicted varied distribution patterns of lymphatics and abnormal lymph flow pathways within lymph nodes in the limbs with lymphatic circulation disorders.	3
47. Smith TR, Grigoropoulos J. The cisterna chyli: incidence and characteristics on CT. <i>Clin Imaging.</i> 2002;26(1):18-22.	Observational-Dx	403 CT cases	To determine the incidence of the cisterna chyli on CT. Intravenous contrast used.	There were 7 cases of demonstrated cisterna chyli (1.7%). It was variably located at the L2 to T11 levels; average attenuation was 4 H and average size was 7.4 mm AP by 7.0 mm in transverse diameter with rounded to elliptical shape. Average length of cisterna chyli was 1.5 mm. Malignant primary was present in 4 of the 7 cases, and none of the 7 had adenopathy. There were 3 males and 4 females; average age of the CC group was 55.5 years.	4

**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Liu ME, Branstetter BF, Whetstone J, Escott EJ. Normal CT appearance of the distal thoracic duct. <i>AJR Am J Roentgenol.</i> 2006;187(6):1615-1620.	Observational-Dx	301 patients	To determine how often the distal TD can be identified on neck CT and to characterize the CT appearance of the duct.	The left side of the neck was unevaluable in 26 (9%) of 301 patients because of streak artifact. In the other 275 patients, the distal TD was identified in the left side of the necks of 150 (55%) of the patients. 11 of these patients (4%) also had a visible duct in the right side of the neck, but a right-sided duct was never identified without a left-sided counterpart. The distal TD had a tubular configuration in 70 (43%), a flared configuration in 72 (45%), and a long segmental fusiform dilation in 19 (12%) of 161 patients. Patient sex had no significant effect on the appearance of the distal TD. Older patient age had a slight positive effect on the size of the duct.	4
49. Kiyonaga M, Mori H, Matsumoto S, Yamada Y, Sai M, Okada F. Thoracic duct and cisterna chyli: evaluation with multidetector row CT. <i>Br J Radiol.</i> 2012;85(1016):1052-1058.	Observational-Dx	50 patients	To evaluate the normal anatomy of the thoracic duct and cisterna chyli obtained by axial and multiplanar reformation images of 1 mm slice thickness using MDCT with contrast.	Visualization of the thoracic duct and cisterna chyli was almost 100% on axial and coronal images. The lower section of the thoracic duct was most clearly visualized among the 3 sections. There was little difference in the maximum size of the thoracic duct among the 3 sections. The cisterna chyli was most frequently located at the Th12 or L1 level, and the most common type was the "straight thin tube type".	4
50. American College of Radiology. ACR Appropriateness Criteria®: Acute Respiratory Illness in Immunocompromised Patients. Available at: <a href="https://acsearch.acr.org/docs/69447/Narrative/">https://acsearch.acr.org/docs/69447/Narrative/</a> .	Review/Other-Dx	N/A	Evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for acute respiratory illness in immunocompromised patients.	N/A	4
51. American College of Radiology. ACR Appropriateness Criteria®: Acute Respiratory Illness in Immunocompetent Patients. Available at: <a href="https://acsearch.acr.org/docs/69446/Narrative/">https://acsearch.acr.org/docs/69446/Narrative/</a> .	Review/Other-Dx	N/A	Evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for acute respiratory illness in immunocompetent patients.	N/A	4

**Chylothorax Treatment Planning  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
52. Hooper C, Lee YC, Maskell N. Investigation of a unilateral pleural effusion in adults: British Thoracic Society Pleural Disease Guideline 2010. <i>Thorax</i> . 2010;65 Suppl 2:ii4-17.	Review/Other-Dx	N/A	To present new recommendations regarding image guidance of pleural procedures with clear benefits to patient comfort and safety, optimum pleural fluid sampling and processing and the particular value of thoroscopic pleural biopsies and to review recent evidence for the use of new biomarkers including N-terminal pro-brain natriuretic peptide, mesothelin and surrogate markers of tuberculous pleuritis.	No abstract available.	4

## Evidence Table Key

### Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
  - *Category 2* The study is moderately well-designed and accounts for most common biases.
  - *Category 3* There are important study design limitations.
  - *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
    - a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
    - b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
    - c) the study is an expert opinion or consensus document.
  - M = Meta-analysis
- 

Dx = Diagnostic

Tx = Treatment

## Abbreviations Key

CT = Computed tomography

LAG = Lymphangiography

MDCT = Multidetector computed tomography

MRI = Magnetic resonance imaging

SD = Standard deviation

SPECT = Single-photon-emission computed tomography

TD = Thoracic duct

TDE = Thoracic duct embolization