NATIONAL INSTITUTE FOR HEALTH AND CARE EXCELLENCE

INTERVENTIONAL PROCEDURES PROGRAMME

Interventional procedure overview of percutaneous thoracic duct embolisation for persistent chyle leak

Chyle is a fluid made in the intestines during digestion of fat. It flows around the body through a network of lymph vessels and ducts including the thoracic duct. If the thoracic duct is damaged during surgery or by trauma, chyle leaks out (persistent chyle leak) and builds up in the body. In this procedure, under general anaesthesia, ultrasound and X-rays are used to create an image of the thoracic duct and find the leak. Then, using a needle, a tube is inserted through the abdominal wall (percutaneous) and guided into the thoracic duct. Small metal coils and medical glue are inserted through the tube and used to plug the leak (embolisation). The aim is to stop the leak.

Contents

Appendix

Abbreviations

Word or phrase	Abbreviation
Confidence interval	CI
Common Terminology Criteria for Adverse Events	CTCAE
Intention to treat	ITT
Intranodal lymphangiography	INL
Lymphangiography	LAG
Not reported	NR
Thoracic duct catheterisation	TDC
Thoracic duct embolisation	TDE
Thoracic duct disruption	TDD
Thoracic duct ligation	TDL
Time to response	TTR

Introduction

The National Institute for Health and Care Excellence (NICE) prepared this interventional procedure overview to help members of the interventional procedures advisory committee (IPAC) make recommendations about the safety and efficacy of an interventional procedure. It is based on a rapid review of the medical literature and professional opinion. It should not be regarded as a definitive assessment of the procedure.

Date prepared

This overview was prepared in October 2022.

Procedure name

- Percutaneous thoracic duct embolisation for persistent chyle leak

Professional societies

- British Society of Interventional Radiology (BSIR)
- Royal College of Radiologists
- British Thoracic Society
- The Vascular Society for Great Britain and Ireland
- Society for Cardiothoracic Surgeons (SCTS).

Description of the procedure

Indications and current treatment

Chyle leak or discharge can occur as a result of thoracic duct injury (injury to the structure that returns lymph and chyle from the lower half of the body). Injury can happen during surgery, or from trauma or disease such as cancer. Chyle leak can cause delayed wound healing, dehydration, malnutrition, electrolyte imbalance, breathing problems and immunosuppression.

Small chyle leaks are usually treated with medicines and by managing nutrition (including by modifying diet or with total parenteral nutrition) to reduce chyle secretion and relieve symptoms. Persistent high-volume leaks may need drainage or surgical repair (such as thoracic duct ligation).

What the procedure involves

Thoracic duct embolisation (TDE) is a percutaneous image-guided closure of the thoracic duct and is done under general anaesthesia. It is a 3-step process consisting of intranodal inguinal lymphangiography followed by percutaneous transabdominal catheterisation of the thoracic duct or cisterna chyli and then embolisation of the thoracic duct.

Under fluoroscopic or ultrasound guidance, an oil-based contrast medium is injected into inguinal lymph nodes. This progresses slowly through the network of pelvic and retroperitoneal vessels and allows the thoracic duct and cisterna chyli to be visualised. Then through transabdominal access under imaging guidance, the target thoracic duct or cisterna chyli is accessed with a guidewire using a needle. A microcatheter is advanced over the guidewire into the thoracic duct, then the guidewire is removed. Contrast medium is injected through the catheter to define the source of the leak and the thoracic duct anatomy. The target thoracic duct and its branches are embolised proximally to the leak with a combination of micro-coils and cyanoacrylate glue.

Efficacy summary

Technical success

In a meta-analysis of 9 studies including chyle leakage of a variety of aetiologies, the pooled technical success rate of TDE (6 studies) was 63% (95% CI, 55.4% to 70.2%; p=0.157, I^2= 37.3%; Kim 2018). In a systematic review of 7 retrospective studies on percutaneous LAG with TDE or TDD for chyle leaks or chylothorax from multiple aetiologies (455 patients, including 180 after oesophageal resection), the median technical success rate for percutaneous TDE was 93% (range 48% to 100%) in 3 studies (Power 2021). In 1 study of chyle leak post oesophagectomy, the technical success rate was 86% (43/50; Pamarthi 2014).

In a retrospective case series of 99 patients with 113 procedures, the technical success rate of TDE (defined as the ability to access the thoracic duct and subsequent embolization of the duct) was 68% (72/106) with transabdominal antegrade access and 44% (15/34) with transcervical retrograde access. The overall technical success rate of TDE, including both the access methods, was 77% (87/113) (Crawford 2022).

Clinical success

In the meta-analysis of 9 studies including chyle leakage of a variety of aetiologies, the pooled clinical success rate of TDE for patients in whom technical success was achieved (6 studies), on a per-protocol basis, was 79% (95% CI, 64.8% to 89.0%; p=0.008, I^2= 68.1%). TDD was done in 25% (77/310) of the patients who had TDE because of technical (97%; 75/77) or clinical (3%; 2/77) failure of TDE. Clinical success of TDD was achieved in 61% (47/77) of these patients (Kim 2018). The pooled overall clinical success rate of lymphatic interventions on an ITT basis, based on 6 studies, was 60% (95% CI, 52.1% to 67.7%; p=0.025, I^2=54.3%; Kim 2018).

In the systematic review of 7 retrospective studies, the median clinical success rate (in 4 studies) was 57% (range: 38% to 98%). Four studies reported the outcome of TDE and TDD separately, with a median clinical success rate for TDE of 75% (range 57% to 98%) and a median clinical success rate for TDD of 72% (range 41.7% to 100%, Power 2021). Another study reported clinical success rates of 89% for TDE (n = 9), and 75% for TDD (n= 4) following oesophagectomy. Clinical success of TDE or TDD did not differ based on the type of operation (p=0.67, Yannes 2007).

In the retrospective case series of 45 patients, the clinical success rate in the TDE group was 89% (31/35), compared with 50% (5/10) in the non-TDE group. Patients in the non-TDE group did not undergo embolisation because of lack of targetable central lymphatics in LAG (n = 5), technical failures of TDC (n = 3),

and lack of discernible leakage in trans-TDC catheter lymphangiography (n = 2). The overall clinical success on an ITT basis was 80% (36/45, Jun 2022).

In a retrospective case series of 52 patients with non-traumatic chylothorax, resolution of chylothorax was reported in 93% (38/41) of patients who had TD and lymphatic network embolisation for abnormal pulmonary lymphatic flow (Gurevich 2022).

In the retrospective case series of 99 patients overall clinical success, defined as resolution of the chyle leak, was achieved in 83% (78/94) of the patients (Crawford 2022).

Safety summary

Major complications

In the meta-analysis of 9 studies including chyle leakage of a variety of aetiologies, the pooled major complication rate of TDE (based on 6 studies) was 2% (95% CI, 0.9 to 6.6%, p= 0.236; I^2=26.4%). Bile leak was reported in 2 patients (Kim 2018).

Access related complications

Biliary peritonitis caused by needle penetration of the distended gallbladder was reported in 1 patient in the retrospective case series of 45 patients who had TDE for post-operative chylothorax. This was treated by emergency percutaneous cholangiography (Jun 2022).

Biliary peritonitis (grade 4 according to CTCAE version 5) was observed after gallbladder puncture, needing cholecystectomy in 1 of 2 transbiliary punctures in a retrospective analysis of 35 procedures in patients with refractory chylous effusions (Schild 2020).

Asymptomatic pulmonary embolism (as a result of glue migration during catheter pullback through the left renal vein) occurred in 1 patient in the retrospective analysis of 35 TDE procedures. Percutaneous removal of the embolus was unsuccessful and it was dislodged into a segmental pulmonary artery. Anticoagulation was given and the clinical course was uneventful in this patient (Schild 2020).

Pancreatitis after pancreatic transgression (CTCAE grade 2) was observed in 1 patient in the retrospective analysis of 35 TDE procedures. This was treated with antibiotics and parenteral nutrition for 4 days (Schild 2020).

Pulmonary embolism as a result of postoperative stress-induced cardiomyopathy (grade 5) 2 days after the procedure was reported in 1 patient who had

embolisation in the thoracic duct and lymphatic networks in the case series of 52 patients (Gurevich 2022).

The retrospective case series of 99 patients who had TDE reported 6 Society of Interventional Radiology (SIR) grade 1 adverse events (shearing off the tip of the micro-guide wire in the retroperitoneal structures in 5 and 1 microcatheter tip fracture), 5 SIR level 2 adverse events (1 non-occlusive thrombosis, 1 embolisation 2 new leaks needing intervention, 1 intervention to snare wire fragment from renal vein), and 2 SIR level 3 adverse events (postprocedural hypotension after TDE, needed transfer to the intensive care unit) (Crawford 2022).

Minor complications

The systematic review of 7 studies reported that minor complications ranged from 4% to 6% and included further chyle leak (in 1 patient), leg and pedal oedema resulting in wound infections (in 2 patients), asymptomatic pulmonary embolisation (in 1 patient), and inconsequential coil misplacement in 1 patient (Power 2021).

The meta-analysis of 9 studies reported minor complications in 4% (8/195) of patients who had TDE (based on 6 studies). These included non-target embolisation to lungs in 3 patients, non-target embolisation to the portal vein in 1 patient, guidewire fracture in 3 patients and perihepatic hematoma in 1 patient (Kim 2018).

Asymptomatic free abdominal air after transgression of the colon (grade 1) was reported in 1 patient in the retrospective analysis of 35 TDE procedures (Schild 2020).

A retrospective review of 106 patients who had TDE for symptomatic chylous effusions reported an overall 14% rate of ‘probably-related’ long-term complications after TDE. These included chronic leg swelling in 8% (4/46), abdominal swelling in 6% (3/46) and chronic diarrhoea in 12% (6/46) patients (Laslett 2012).

The retrospective case series of 52 patients who had TDE and lymphatic embolisation reported minor (grade 1) complications such as hypotension, hypoxemia, fluid overload and grade 2 complications such as systemic inflammatory response syndrome and atrial fibrillation with rapid ventricular response and acute pulmonary oedema in 1 patient each (Gurevich 2022).

Mortality

The systematic review of 7 studies reported a mortality rate in 2 studies and ranged from 2% to 3% (1 patient in each study) (Power 2021).

One patient (with clinical failure of TDE) died from the medical complication of persistent lymphatic leakage in the case series of 45 patients (Jun 2022).

Anecdotal and theoretical adverse events

In addition to safety outcomes reported in the literature, professional experts are asked about anecdotal adverse events (events that they have heard about) and about theoretical adverse events (events that they think might possibly occur, even if they have never happened).

For this procedure, professional experts listed no anecdotal adverse events. They considered that the following were theoretical adverse events: contrast allergy-either minor (self-limiting) or moderate (requiring drug treatment), and anaphylaxis.

The evidence assessed

Rapid review of literature

The medical literature was searched to identify studies and reviews relevant to percutaneous thoracic duct embolisation for persistent chyle leak. The following databases were searched, covering the period from their start to 13 October 2022: MEDLINE, PREMEDLINE, EMBASE, Cochrane Library and other databases. Trial registries and the internet were also searched. No language restriction was applied to the searches (see the literature search strategy). Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The inclusion criteria were applied to the abstracts identified by the literature search. If selection criteria could not be determined from the abstracts the full paper was retrieved.

Inclusion criteria for identification of relevant studies

Characteristic	Criteria
Publication type	Clinical studies were included. Emphasis was placed on identifying good quality studies. Abstracts were excluded if no clinical outcomes were reported, or if the paper was a review, editorial, or a laboratory or animal study. Conference abstracts were also excluded because of the difficulty of appraising study methodology, unless they reported specific adverse events that were not available in the published literature.
Patient	Patients with persistent chyle leak.
Intervention/test	Percutaneous thoracic duct embolisation.
Outcome	Articles were retrieved if the abstract contained information relevant to the safety and/or efficacy.
Language	Non-English-language articles were excluded unless they were thought to add substantively to the English-language evidence base.

List of studies included in the IP overview

This IP overview is based on 1,199 patients from 1 systematic review and meta-analysis, 1 systematic review and 5 retrospective case series. There is some overlap of primary studies between the 2 systematic reviews (Power 2021, Kim 2018).

Other studies that were considered to be relevant to the procedure but were not included in the main summary of the key evidence are listed in the appendix.

Summary of key evidence on percutaneous thoracic duct embolisation for persistent chyle leak

Study 1 Power R (2021)

Study details

Study type	Systematic review
Country	Ireland
Search details	Search period: up to December 2020; databases searched: Medline, Embase, and Web of Science. Hand searching of references from relevant systematic reviews was also done for additional studies.
Study population and number	n=7 retrospective case series (with 455 patients who had chyle leaks from multiple aetiologies [including 180 after oesophageal resection]).
Age and gender	Not reported
Study selection criteria	Inclusion criteria: randomized trials or retrospective studies that assessed management of chyle leaks after oesophageal resection; studies with chyle leaks of multiple aetiologies, interventions and comparators such as conservation management, surgical TDL, TDD, and TDE; reporting outcomes such as technical success rate, clinical success rate, time to resolution of chyle leak and complications; studies in English, and in humans. Exclusion criteria: case reports, small case series (n < 10), conference abstracts, commentaries, editorials, duplicate studies, and those reporting only incidence, risk factors, or prognosis.
Technique	Lymphangiography with thoracic duct embolisation or disruption.
Follow up	Varied across studies.
Conflict of interest/source of funding	The authors declared that they have no conflicts of interest.

Analysis

Study design issues: The protocol was registered on PROSPERO and study was done according to preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. Searches were comprehensive, 2 authors independently screened, extracted data and assessed the quality of studies (using Cochrane risk of bias tool or using the National Institute of Heart Lung and Blood (NHLBI) quality assessment tool for non-randomised case series). Studies were retrospective with significant risk of bias. Any disagreement was resolved by discussion and consensus. As studies were heterogenous (in patient groups, management regimens, treatment modalities and definitions used), a qualitative analysis was done.

Other issues: 18 studies that described the conservative management of chyle leaks, 17 by surgical ligation of the thoracic duct, 5 by pleurodesis, were not considered in this overview as they are out of the remit of this guidance.

There is some overlap of primary studies between study 1 and 2.

Key efficacy findings

Number of patients analysed: 455

Outcomes

Study	Patient aetiology	Intervention	Technical success %	Clinical success %	Hospital stay (mean)
Boffa 2008	Unknown indications/referrals	TDE (n=21)	93	57	8 days
		TDD (n=4)		50	19 days
Itkin 2010	Unknown indication/referrals	TDE (73)	97	74.6	NR
		TDD (n=18)		72	NR
Nadolski 2018	Failed TDL/referral	TDE (n=49)	98	98	NR
		TDD (N=1)	100	100	NR
Pamarthi 2014	Unknown indication/referrals	TDE/TDD (n=50)	86 (n=43 post oesophagectomy)	56	NR
Reisenauer 2018	1.1 litre daily output	Surgical TDL (n=48)	-	85	NR
		TDE (n=40)^	48	38 50 post oesophagectomy (n=22)	NR
Yannes 2017*	Presence of post-operative chyle leak and failed conservative management	INL alone (n=7)	100	71.4	Median TTR 14 days
		INL+TDE for leak<500 L/day(n=21)		90.5 88.6 (post esophagectomy [n=9])	Median TTR 3 days
		INL+TDD (n=12)		41.7 75 (n=4 post esophagectomy)	Median TTR 7 days

*no difference in clinical success rates between the groups was reported (p=0.19).

^inability to cannulate the cisterna chyli in 48% patients.

Reoperations were not needed in patients who had TDE.

In 4 studies the median clinician success rate was 57% (ranged 38-98%); 4 studies reported TDE and TDD separately, with a median clinical success rate for TDE of 75% (range 57% to 98%) and a median clinical success rate for TDD of 72% (range 41.7% to 100%).

Key safety findings

Complications	**% (n)**
Minor complications	Range 4-6%
Further chyle leak (managed by endoscopic cholangiography and bile duct stenting)	1 (Boffa 2008)
Leg and pedal oedema (resulting in wound infections)	2 (Itkin 2010)
Asymptomatic pulmonary embolisation	1 (Itkin 2010)
Inconsequential coil misplacement	1 (Itkin 2010)
Mortality	3% (1/40) (Reisenauer 2018) 2% (1/57) (Yannes 2017)

Study 2 Kim PH 2018

Study details

Study type	Systematic review and meta-analysis
Country	Republic of Korea, China
Search details	Databases searched: MEDLINE, EMBASE, and Cochrane databases were searched until March 2017. Hand searching of references from relevant systematic reviews was also done for additional studies including Google Scholar. Authors of studies contacted for further individual patient data.
Study population and number	9 retrospective case series (n=407 patients) chylothorax aetiology: iatrogenic (82.6%; 336/407), malignancy (5.4%; 22/407). High-output chylothorax in 76.9% (70/91) Previous unsuccessful surgery 17.6% (40/228)
Age and gender	Mean 60 years; 43% (177/407) male
Patient selection criteria	Inclusion criteria: studies regarding patients with chylothorax treated with lymphangiography, TDE, or TDD, in English language. Exclusion criteria: studies with less than 10 patients, case reports, review articles, letters, and conference abstracts, with no extractable data, or data included in subsequent articles or duplicate reports.
Technique	Percutaneous lymphatic interventions for chylothorax (LAG, TDE, TDD)
Follow up	Varied across studies.
Conflict of interest/source of funding	None

Analysis

Follow-up issues: overall 6 patients were lost to follow-up (1 after LAG and 5 after TDE).

Study design issues: the review was conducted according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines. Searches were comprehensive, 2 authors independently screened, extracted data using standardised form. All studies included were retrospective case series and quality of studies were fair to good according to the U.S. National Institutes of Health Quality Assessment of Case Series studies tool. Any disagreement between the authors was resolved by discussion and consensus. Meta-analysis was done using random effect model and heterogeneity across studies was also assessed. There is significant heterogeneity in sample size, patient groups, definition of outcomes.

Other issues: there is some overlap of primary studies between study 1 and 2.

Key efficacy findings

- Number of patients analysed: 407

Technical and clinical outcomes
Technical success of LAG was defined as successful injection of contrast agent into the lymphatic system; technical success of TDE was defined as total occlusion of the target lymphatic duct.

Clinical success was defined as complete resolution of chylothorax without further surgical treatment.

	% (n)
LAG	**n=407**
Pedal LAG	88.7% (361/407)
Intranodal LAG	11.3% (46/407)
Technical success	95.1% (387/407)
Technical failure^	4.9 (20/407)
Clinical success (n=89)	56.2% (50/89)
TDE	**80.1% (310/387)**
Technical success	62.9% (195/310)
Technical failure^^	37.1 (115/310)
Clinical success	79.5% (151/190)
TDD (in those with TDE technical/clinical failure)	24.8 (77/310)
Clinical success	61 (47/77)

^ data available for 16 patients show that they were due to unsuccessful cannulation of the pedal lymphatic vessels in 87.5% (14/16), over-sedation in 6.3% (1/16), and injector malfunction in 6.3% (1/16) of the patients. ^^data available for 68 patients show that the causes included unsuccessful cannulation of the cisterna chyli or thoracic duct in 86.8% (59/68) and unsuccessful negotiation of the guidewire into the thoracic duct in 13.2% (9/68).

Pooled technical and clinical success rates (on a per-protocol basis)

Outcome	**Number of studies**	**% (95% CI)**	**P value, I^2**
Technical success rate of LAG	6 studies	94.2 (88.4–97.2)	p=0.059, I^2=46.7%
Clinical success rate of LAG	6 studies	56.6 (45.4–67.2)	p= 0.382; I^2=5.4%
Technical success rate of TDE	6 studies	63.1 (55.4–70.2)	p=0.157, I^2=37.3%
Clinical success rate of TDE	6 studies	79.4 (64.8–89.0)	p=0.008, I^2=68.1%
Clinical success rate of TDD*	5 studies	60.8 (49.4–71.2)	p=0.830, I^2=0%
Overall clinical success rate of lymphatic interventions (LAG, TDE, TDD)	6 studies	60.1 (52.1–67.7)	p=0.025, I^2=54.3%

* TDD was done in 25% (77/310) of the patients who had TDE because of technical (97%; 75/77) or clinical (3%; 2/77) failure of TDE.

Meta-regression analysis showed that aetiology of chylothorax was identified as a significant source of heterogeneity for the pooled clinical success rate of TDE (p=0.012) and overall clinical success rate (p=0.002).

Key safety findings

Complications of LAG	**% (n)**
Major- aspiration	**0.3 (1/407)**
Minor	**1.3 (8/407)**
Over-sedation	5
Pedal incision site injury	2
Oedema in leg	1
Complications of TDE	
Major (bile leak)	1.0 (2/195)
Minor (in 6 studies)	4.1 (8/195)
Non-target embolisation to lungs	3
Non-target embolisation to the portal vein	1
Guidewire fracture	3
Perihepatic hematoma	1
Complications of TDD	**0**

Complications were categorized as major or minor according to the Society of Interventional Radiology clinical practice guidelines.

Pooled major complications

LAG (6 studies)	1.9% (95% CI, 0.8%–4.3%), p= 0.940; I^2 = 0%
TDE (6 studies)	2.4% (95% CI, 0.9%–6.6%), p= 0.236; I^2= 26.4%)

Study 3 Jun H 2022

Study details

Study type	Retrospective case series
Country	Republic of Korea
Study details	2016-2019
Study population and number	N=45 patients with postoperative chylothorax
Age and gender	Mean 62 years; 62% (28/45) male
Patient selection criteria	Patients with postoperative chylothorax undergoing lipiodol LAG for intended TDC and TDE, with milky" chylous effusions > 110 mg/Dl, fat-free or low-fat diet or total parenteral nutrition, failed to stop the chylous leakage were included.
Technique	First patients underwent intranodal lipiodol LAG under ultrasound guidance. If targetable central lymphatic vessels were identified, standard TDC (antegrade transabdominal approach) was attempted. The retrograde approach was applied as a bail-out method for TDC in few failed cases. TDE (embolisation), was performed after confirming leakages in the trans-TDC catheter lymphangiography. Micro-coils or Concrerto were deployed at the cervical position of the thoracic duct and then glue embolisation of the segment of the duct was done. Extensive embolisation of thoracic duct or super-selective embolisation of culprit lymphatic channels were done.
Follow up	Average 434 days
Conflict of interest/source of funding	No conflicts of interest. Study funded by the Ministry of Science, ICT and Future Planning of Korea.

Analysis

Follow-up issues: 2 patients were lost to follow-up. Follow-up data was highly variable.

Study design issues: all procedures were conducted by 1 interventional radiologist. Radiological and clinical data were retrospectively reviewed by 3 radiologists. Electronic medical records and picture archiving and communication systems were accessed for review. Technical success and clinical success of TDE group (with all 3 steps of LAG, TDC and embolisation) and non-TDE group were compared.

Key efficacy findings

- Number of patients analysed: 45

Technical and clinical outcomes

	Per protocol % (n)	**ITT % (n)**
LAG	100 (45/45)	
Technical success rate of TDC (antegrade approach)	78 (31/40)	69 (31/45)
Failure of TDC	22 (9/40)	
Technical success rate of TDC (antegrade + bail-out retrograde approach in 8)	93 (37/40)	82 (37/45)
Failure	7 (3/40)	
Clinical success of TDE* (n=35)	89 (31/35)	80 (36/45)
Non-TDE^ (n=10)	50 (5/10)	

^ the reasons for non-TDE: lack of targetable lymphatics for TDC in LAG (n = 5), technical failure of TDC (n = 3), and lack of visible leakages in the transcatheter lymphangiography (n = 2).
* defined as resolving the lymphatic leakages within 2 weeks after final TDE, regardless of its technical success. TDE was in the form of extensive embolisation of thoracic duct (n = 27) or super selective (n = 8) embolisation of culprit lymphatic channels.

Key safety findings

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Procedure related major complication	
Bile peritonitis (caused by needle penetration of the distended gallbladder at average 434 days, triggered extreme abdominal pain after TDE, needed emergency percutaneous cholecystectomy).	1
Death (due to persistent lymph leak in TDE failure patient)	1
Minor complications	
Fever (treated conservatively)	4
Asymptomatic non-target glue embolisation of the pulmonary artery	1

Study 4 Schild HH 2020

Study details

Study type	Retrospective case series
Country	Germany
Study details	2014-18
Study population and number	N=35 patients with chylous effusions refractory to conservative therapy who had TDE. Aetiology of the chylothorax: traumatic/postoperative in 25 patients, idiopathic in 9, and leukaemia-related in 1.
Age and gender	Mean 57 years; 63% (22/35) male
Patient selection criteria	Patients with TDE and post-procedural CT data were included.
Technique	Transabdominal TDE: first, conventional oily lymphangiography was performed. For initial duct obstruction, coils were placed into the thoracic duct to act as a scaffold, followed by injection of liquid embolic mixture (mix of tissue adhesive agent and Lipiodol) under fluoroscopic guidance. During embolisation, the microcatheter was slowly pulled back until the point of entry into the lymphatic system was sealed. A thin line of radiopaque embolisation material outlined the access route on postprocedural imaging. CT studies were obtained 30–60 minutes after TDE.
Follow up	Mean follow-up, 678 days (range, 44–2,619 days)
Conflict of interest/source of funding	One author is a paid consultant for Philips Healthcare.

Analysis

Follow up issues: complete follow-up.

Study design issues: all procedures were performed by 2 interventional radiologists. Data were gathered from electronic medical records. Procedures with post intervention CT data were retrospectively analysed by 2 experienced radiologists for abdominal structures and organs transgressed by the access route, signs of complications, and distribution of embolic material. Findings were correlated with clinical course. Adverse events were graded according to CTCAE version 5.

Other issues: only the final access route and its related complications were analysed. Other previous unsuccessful punctures and long term complications of TDE were not assessed in this study.

- Number of patients analysed: 35

Key safety findings

	n
Intra-abdominal organs transgressed by access route	
Liver	28
Crus of the diaphragm	25
Pancreas	14
Portal vein	10
Duodenum	7
Inferior vena cava	5
Colon	3
Left renal vein	2
Pericardium	2
Pleura	2
Gastric sleeve	2
Other adverse events	
Periprocedural abdominal pain (decreased over time)	35
Pancreatitis after pancreatic transgression (grade 2, treated with antibiotics and parenteral nutrition for 4 days).	1
Biliary peritonitis (grade 4) was observed after gallbladder puncture, needing cholecystectomy in 1 of 2 transbiliary punctures	1
Asymptomatic pulmonary embolism (as a result of glue migration on catheter pullback through the left renal vein); percutaneous removal was unsuccessful and dislodged into a segmental pulmonary artery. Anticoagulation was given and clinical course was uneventful.	1
Asymptomatic free abdominal air after transgression of the colon (grade 1)	1

Study 5 Gurevich 2022

Study details

Study type	Retrospective case series
Country	USA
Study details	2014-20
Study population and number	N=52 patients with nontraumatic chylous pleural effusions and/or chylopericardium. Aetiologies: idiopathic 58% (30/52), malignancy 40.3% (21/52), genetic 1. Previously failed conservative treatments: non-fat diets, total parenteral nutrition, and octreotide. Patients were symptomatic for an average of 283 days before referral.
Age and sex	Mean 54 years (range 11-89 years); sex not reported
Patient selection criteria	Patients with various abnormalities that led to chylothorax are identified using pre-intervention dynamic contrast-enhanced magnetic resonance lymphangiography (DCMRL).
Technique	Using DCMRL 3 lymphatic patterns were identified (abnormal perfusion from thoracic duct needing TDE [n= 31], abnormal perfusion from retroperitoneal networks needing interstitial lymphatic embolisation [n=10], and presence of ascites with a normal/absent thoracic duct, similar fluid characteristics within ascites and chylothorax, extravasation of contrast in the abdomen and requires treatment for chylous ascites [n=11]). All embolisation procedures done under general anaesthesia or moderate sedation. Thoracic duct embolisation (TDE): intranodal lymphangiography was followed by transabdominal thoracic duct catheterization and thoracic duct embolisation. Embolisation was performed using mixture of endovascular coils and/or n-butyl cyanoacrylate n-BCA glue or autologous blood and oil-based contrast material (Lipiodol). Interstitial lymphatic embolisation delivers an embolisation agent (n-BCA glue or lipiodol directly into cystic or cavernous retroperitoneal lymphatic patterns.
Follow up	Median 396 days (range 824)
Conflict of interest/source of funding	None

Analysis

Follow up issues: long term follow-up was available in 87% (27/31) patients in the TDE only group.

Study design issues: small single centre study, data was collected retrospectively from electronic medical records and/or health system medical records. In a few cases data was supplemented by calling patients.

Other issues: DCMRL was not performed for 3 patients in thoracic duct group because of contraindications to MR imaging. They underwent intranodal lymphangiography.

Number of patients analysed: 52

Key efficacy findings

Technical and clinical outcomes

	TD only (n=31)	Retroperitoneal lymphatic networks (n=10)	TD and lymphatic networks (n=41)	Ascites (n=11)
Mean number of procedures	1.3	2.4	1.5	
Embolisation technical success (ability to access and embolise the duct), %	97(30/31)	80 (8/10)	93 (38/41)	(6/11)
Clinical success (output reduced by 85% within 2 weeks or eliminated within 2 months), %	97(30/31)	80 (8/10)	93 (38/41)	(4/6)
Time to resolution (mean, range) days	8 (1–30)	15.4 (5-53)	9.5 (1-53)	NR
Follow-up (median, range) days	275 (640)	751 (573.5)	396 (824)	NR

Key safety findings

Complications were scored according to the National Institutes of Health common terminology grading system (CTCAE version 5.0)

Complications in TDE and lymphatic embolisation groups only	**14.6 (6/41)**
Hypotension (grade 1)	n=1
Hypoxemia (grade 1)	n=1
Fluid overload (grade 1)	n=1
Systemic inflammatory response syndrome (grade 2)	n=1
Atrial fibrillation with rapid ventricular response and acute pulmonary oedema (grade 2)	n=1
pulmonary embolism due to stress-induced cardiomyopathy 2 days after procedure (grade 5)	n=1
Complications in ascites group (n=11)	**0**

Study 6 Laslett D2012

Study details

Study type	Retrospective case series
Country	USA
Study details	1994-2010
Study population and number	N= 106 patients with technically successful TDE for symptomatic chylous effusions.
Age and sex	Average age 58 years; 50% women
Patient selection criteria	patients' multiple medical conditions who underwent TDE for symptomatic chylous effusion.
Technique	Thoracic duct embolisation.
Follow up	Mean 34 months (range 2-134 months)
Conflict of interest/source of funding	None

Analysis

Follow up issues: long term follow-up was available in 74% (78/106) patients.

Study design issues: data was collected retrospectively from electronic medical records and hospital databases. Patients who were alive and 3 family members were surveyed and interviewed to determine the post-operative status and rate of long-term complications.

Number of patients analysed: 106

Clinical success of TDE (chylous effusions resolved): 93% (99/106)

Key safety findings

	% (n)
Overall long-term complication rate	14.3 (26/46)
Death unrelated to TDE	41 (32/78)
Chronic leg swelling in patients alive (probably related to the procedure)	8 (4/46)
Abdominal swelling (unrelated to the procedure)	6 (3/46)
Chronic diarrhoea (4 probably related to the procedure as onset was after the procedure and needed medication)	12 (6/46)

Study 7 Crawford D 2022

Study details

Study type	Retrospective case series
Country	
Study details	2015-2021
Study population and number	N= 99 patients with technically successful TDE for symptomatic chylous effusions.
Age and sex	Mean age 61 years; 59 women
Patient selection criteria	Patients aged 18 years or older, with iatrogenic or spontaneous persistent chyle leaks (>200ml) after conservate therapy, who underwent lymphangiography with TDE.
Technique	intranodal lymphangiography with attempted thoracic duct embolisation (113 procedures) using transabdominal antegrade and/or transcervical retrograde access. 14 were done under moderate sedation and remaining under general anaesthesia. 85 patients had 1 procedure and 14 needed 2 procedures (7 for persistent chyle leaks despite TDE, 5 for unsuccessful TDE, and 2 for new chyle leaks after TDE). Different materials are used for embolisation (n Butyl cyanoacrylate, microcoils, gelatin sponge slurry).
Follow up	Median 259 days (range 0-6.3 years)
Conflict of interest/source of funding	None

Analysis

Follow up issues: 5 patients were lost to follow-up.

Study design issues: data was collected retrospectively from electronic medical records. Adverse events assessed using Society of Interventional Radiology (SIR) classification system.

Population issues: causes of chyle leaks were esophageal surgery (n = 28), lung cancer resection (n = 15), thoracic outlet decompression surgery (n = 13), and head and neck surgery (n = 13). The locations of chyle leaks were mainly chest (n = 75) and neck (n =16).

Number of patients analysed: 99

Technical success (ability to access thoracic duct and subsequent embolization of the thoracic duct)

	% (n)
TDE with transabdominal antegrade access	68% (72/106)
Technical failure with transabdominal antegrade access	32% (34/106)
Overall TDE with transcervical retrograde access	44% (15/34)
Overall (including both access methods)	77% (87/113)

Clinical success of TDE (resolution of the chyle leak), (n= 94/99)

	% (n)
Overall clinical success	83% (78/94)
Clinical failure	28% (28/99)
Second procedures after clinical failure	N=12
Clinical success in those who had a second procedure	83% (10/12)

Key safety findings

	% (n)
Total adverse events (12 occurred immediately after the procedure)	12% (13/113)
Shearing off the tip of the micro-guide wire in the retroperitoneum (1 needed an additional intervention to snare the wire fragment from the left renal vein during TDE (SIR adverse event grade 2), 5 needed no intervention (grade 1).	5% (6/113)
Microcatheter tip (adhered to the thoracic duct with glue) fractured on catheter retrieval, but fragment was left in place without sequalae (SIR grade 1 adverse event)	n=1
New leaks leading to chylothoraces (1 needed additional TDE 6 days after the initial procedure, and the other required surgical ligation 4 days later (SIR grade 2 adverse event)	n=2
Postprocedural hypotension after TDE, treated in intensive care unit (SIR grade 3 adverse event).	n=2
Nonocclusive thrombosis of the left internal jugular vein needing anticoagulation (in a patient with transabdominal antegrade access and TDE with coils and oil mixture) (SIR grade 2 adverse event).	n=1
Embolization of a portion of glue to the pulmonary artery, during procedure (SIR grade 2 adverse event), The patient was asymptomatic.	n=1

Validity and generalisability of the studies

- There are no prospective studies comparing percutaneous TDE with other treatments for managing chyle leaks. Studies were mainly retrospective analyses, heterogenous in terms of patient cohorts (with no clear definitions of chyle leak), aetiologies, and outcomes.
- In 1 study retrograde thoracic duct access was used as a bail out approach in very few cases.
- Quality of life was not assessed in any of the studies.

Existing assessments of this procedure

There were no published assessments from other organisations identified at the time of the literature search.

Related NICE guidance

There is currently no NICE guidance related to this procedure.

Additional information considered by IPAC

Professional experts' opinions

Expert advice was sought from consultants who have been nominated or ratified by their professional Society or Royal College. The advice received is their individual opinion and is not intended to represent the view of the society. The advice provided by professional experts, in the form of the completed questionnaires, is normally published in full on the NICE website during public consultation, except in circumstances but not limited to, when comments are considered voluminous, or publication would be unlawful or inappropriate. Two Professional expert questionnaires for percutaneous thoracic duct embolisation for persistent chyle leak were submitted and can be found on the NICE website.

Patient commentators' opinions

NICE received 1 questionnaire from patients who had the procedure. Patient's views on the procedure were consistent with the published evidence and the opinions of the professional experts. [See the patient commentary summary for more information].

Company engagement

There is no specific device used for this procedure. Therefore, no structured information requests were sent to companies.

Issues for consideration by IPAC

- None

References

1. Power R, Smyth P, Donlon NE et al. (2021) Management of chyle leaks following oesophageal resection: a systematic review. Diseases of the Esophagus. 34,1–10.
2. Kim PH, Tsauo J, Shin JH et al. (2018) Lymphatic interventions for chylothorax: A systematic review and meta-analysis. J Vasc Interv Radiol; 29:194–202.
3. Jun H, Hur S, Jeong YS et al. (2022) Thoracic duct embolization in treating postoperative chylothorax: does bail-out retrograde access improve outcomes? Eur Radiol, 32:377–383.
4. Schild HH, Pieper CC (2021) Where have all the punctures gone? An analysis of thoracic duct embolizations. J Vasc Interv Radiol; 31:74–79.
5. Gurevich A, Hur S, Singhal S et al. (2022) Nontraumatic Chylothorax and Chylopericardium: Diagnosis and Treatment Using an Algorithmic Approach Based on Novel Lymphatic Imaging. Ann Am Thorac Soc, 19(5). 756–762.
6. Laslett D, Trerotola SO, Itkin M. (2012) Delayed complications following technically successful thoracic duct embolization. J Vasc Interv Radiol; 23:76 –79.
7. Crawford D, Guevera CJ, Kim SK. (2022) Thoracic duct embolization using transabdominal antegrade and transcervical retrograde accesses. J Vasc Interv Radiol; 33:1536–1541.

Literature search strategy

Databases	Date searched	Version/files
MEDLINE (Ovid)	13/10/2022	1946 to October 12, 2022
MEDLINE In-Process (Ovid)	13/10/2022	1946 to October 12, 2022
MEDLINE Epubs ahead of print (Ovid)	13/10/2022	October 12, 2022
EMBASE (Ovid)	13/10/2022	1974 to 2022 October 12
EMBASE Conference (Ovid)	13/10/2022	1974 to 2022 October 12
Cochrane Database of Systematic Reviews – CDSR (Cochrane Library)	13/10/2022	Issue 10 of 12, October 2022
Cochrane Central Database of Controlled Trials – CENTRAL (Cochrane Library)	13/10/2022	Issue 10 of 12, October 2022
International HTA database (INAHTA)	13/10/2022	-

Trial sources searched

- Clinicaltrials.gov
- ISRCTN
- WHO International Clinical Trials Registry

Websites searched

- National Institute for Health and Care Excellence (NICE)
- NHS England
- Food and Drug Administration (FDA) – MAUDE database
- Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP – S)
- Australia and New Zealand Horizon Scanning Network (ANZHSN)
- General internet search

The following search strategy was used to identify papers in MEDLINE. A similar strategy was used to identify papers in other databases.

MEDLINE search strategy

Ovid MEDLINEI <1946 to November 23, 2021>

1 Chylothorax/ 3138
2 (Chylothoraces or chylothorax or chylopleura or cholothorax or chylopneumothora).tw. 3228
3 Chyle/ 1424
4 (chyle* or chylous).tw. 3154
5 or/1-4 6820
6 Thoracic Duct/ 4231

7 ((((thoracic or lymph*) adj4 duct*) or Cisterna Chyli or Cisterna Chylus or intesin* lymph*) adj4 (leak* or lacerat* or injur* or 29ymphangi*)).tw. 371
8 (leak* or lacerat* or injur* or 29ymphangi*).tw. 1085212
9 6 and 8 493
10 5 or 7 or 9 7023
11 Embolization, Therapeutic/ 34273
12 (emboli?ation or sclero-emboli?ation or scleroemboli?ation or embolotherap*).tw. 44177
13 11 or 12 55164
14 10 and 13 196
15 Animals/ not Humans/4885087
16 14 not 15 187
17 limit 16 to ed-20221031

Appendix

The following table outlines the studies that are considered potentially relevant to the IP overview but were not included in the summary of the key evidence. It is by no means an exhaustive list of potentially relevant studies.

Additional papers identified

Article	Number of patients/follow-up	Direction of conclusions	Reasons for non-inclusion in summary of key evidence section
Alejandre-Lafont E, Krompiec C, Rau WS et al. (2011) Effectiveness of therapeutic lymphography on lymphatic leakage. Acta Radiol; 52: 305–311.	Case series N=34 patients with lymphatic leaks (due to traumatic/malignant issues)	Lymphangiography was technically successful in 88% (30/34) and clinical success in 55% (16/29).	Included in systematic review added to the summary of evidence.
Bazancir LA, Jensen RJ, Frevert SC et al (2021) Embolization of the thoracic duct in patients with iatrogenic chylothorax. Diseases of the Esophagus, 34,1–8	Retrospective case series N=17 patients with iatrogenic chylothorax treated with TDE.	.Lymphography was done in all and visualization of cisterna chyli was achieved in 83% (14/17) patients. Of the 17 patients included, 15 patients were successfully embolized and cured of chylothorax (88.2%). Median	Larger studies included in the overview summary.

		discharge time 7 days. Most patients reported post-procedural pain, which was treated with medications.	
Boffa DJ, Sands MJ, Rice TW, et al. (2008) A critical evaluation of a percutaneous diagnostic and treatment strategy for chylothorax after thoracic surgery. Eur J Cardiothorac Surg; 33:435–439.	N=37 patients with thoracic duct injuries had TDE (in 25) and TDD (9).	Lymphangiography was successful in 97%. In patients who had TDE, technical success was 48% (12/25) and clinical success was 100%. In those who had TDD, clinical success was 56% (5/9). The median time to discharge was 8 days with TDE and 19 days with TDD.	Included in systematic review added to the summary of evidence.
Bundy JJ, Chick JFB, Cline JMR et al. (2019) Percutaneous fluroscopically guided trans cervical retrograde access facilitates successful thoracic duct embolisation after failed antegrade transabdominal access. Lymphology (52), 52-60.	Case series N=5 patients had TDE after failed transabdominal cisterna chyli cannulation for chylothorax. Median follow-up 372 days.	Transcervical retrograde thoracic duct access and treatment was technically successful in all. No major or minor adverse events occurred. Clinical success was achieved in all.	Larger studies included in the overview summary.
Chen E, Itkin M. (2011) Thoracic duct embolization for chylous leaks. Semin Intervent Radiol;28:63–74.	Review describes the aetiologies of chylothorax, patient population, outcomes, and long-term follow-up of TDE patients.	Lymphatic anatomy physiology, and the formation of the duct by tributaries at the cisterna chyli are reviewed. The technique of TDE, including bilateral pedal lymphangiography, TD cannulation, and embolic agents used are outlined.	Review
Chen CS, Kim JW, Shin JH et al. (2020) Lymphatic imaging and	Case series N=9 patients who had chylothorax	The technical success rate of lymphangiography	Larger studies included in the

intervention for chylothorax following thoracic aortic surgery. Medicine;99:34(e21725) .	interventions after thoracic aortic surgery.	was 89% (8/9).The technical success rates of antegrade and retrograde TDE were 75% (6/8) and 100% (3/3). Clinical outcomes after embolisation were similar between low and high output chylothorax patients. The drainage amount decreased significantly. Clinical success rate of TDE was 88% (7/8).	overview summary.
Cope C, Salem R, Kaiser LR. (1999) Management of chylothorax by percutaneous catheterization and embolization of the thoracic duct: Prospective trial. J Vasc Interv Radiol; 10:1248–1254. 32.	Case series N=11 patients with high output chylothoracic effusions had 31 lymphangiography and TDE with platinum coils.	The thoracic duct was successfully catheterized in 5 patients who had major retroperitoneal lymphatic trunks, (45% technical success rate), embolisation was done in 4 patients and curative in 2. Previous abdominal surgery, aortic dissection, and lymph-angioleiomyomatosis can lead to silent occlusion of retroperitoneal lymphatic trunks.	Data included in Itkin 2011 and Nadolski 2013 added to systematic review.
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; 13:1139–1148.	Case series N=42 patients who had chylothorax with various aetiologies and TDE with micro-coils particles or glue. Follow up 3 months	The thoracic duct was catheterized in 29 patients and embolized in 26 patients. 16 patients were cured within 7 days and partial response was seen within 3 weeks in 6 patients. In the patients who could	Data included in Itkin 2011 and Nadolski 2013 added to systematic review.

		not be catheterized (n= 16), TDD resulted in cure in 5 patients and partial response in 2 patients. TDL was performed in 7 patients. The nonprocedural mortality rate was 19%.	
Dong, Y, Bing, J, Lingling, L et al. (2022) Retrograde thoracic duct approach via left venous angle in the treatment of chylothorax. Chinese Journal of Radiology; vol. 56 (no. 6); 656-660	Retrospective case series N=16 patients with chylothorax had LAG, TDC and thoracic ductography and embolized with microcoils and glue.	LAG and TDCs were successful in 10 patients, 6 **case**s showed contrast agent overflow in thoracic ductography, and the thoracic ducts were embolized using microcoils combined with glue. Chylothorax was improved in all patients, and 6 **case**s were completely cured. All patients had no serious complications.	Larger studies included in the summary of evidence.
Fukumoto, A; Terao, T; Kuzume, A et al. (2022) Management of lymphoma-associated chylothorax by interventional radiology and chemotherapy: a report of five cases. International journal of hematology; vol. 116 (no. 4); 579-585	Case series N=5 patients with lymphoma-associated chylothorax treated with lymphangiography (LAG) and thoracic duct embolization.	Complete resolution of chylothorax was achieved in all patients. No patients experienced serious adverse events related to LAG/TDE. Treatment of chylous effusion required 0.2-4.8 months for most patients. Our data suggest that a combination of chemotherapy and LAG/TDE is effective for refractory	Larger studies included in the summary of evidence.

		lymphoma-related chylous effusion.	
Guevara CJ, Rialon KL, Ramaswamy RS et al. (2016) US-guided, direct puncture retrograde thoracic duct access, lymphangiography, and embolization: feasibility and efficacy. J Vasc Interv Radiol; 27:1890–1896.	Case series N=10 patients with thoracic duct leaks had thoracic duct embolisation (TDE) via US-guided retrograde TD access. Mean follow-up 5.4 months (range, 3-10 months).	All attempts at TD access via the neck were successful. Technical and clinical success of TDE was 60%. There were no complications. Mean TD access time was 17 minutes and mean total procedure time was 49 minutes.	Larger studies included in table 2.
Itkin M, Kucharczuk JC, Kwak A et al. (2010) Nonoperative thoracic duct embolization for traumatic thoracic duct leak: experience in 109 patients. J Thorac Cardiovasc Surg; 139:584–590	Case series N=109 patients 106 with traumatic thoracic duct leak had INL, TDE (with coils or embolic agent) or TDD	Lymphangiography was technically successful in 99%, and TDE in 66% (69/105). Clinical success was achieved in 87% (57/66) in those who had TDE and 71% (12/17) who had TDD.	Included in systematic review added to the summary of evidence.
Itkin M, Chen EH (2011) Thoracic duct embolization. How I do it. Semin Intervent Radiol;28:261–266.	Description of technique.		No extractable data.
Jayasinghe SA, Srinivasa RN, Hage AN et al. (2018) Thoracic duct embolization: analysis of practice patterns. Ann Vasc Surg; 52: 168–175	Survey of practice patterns of TDE N=47 interventional radiologists.	TDE is performed by practitioners in both academic and private practice settings. Treatment techniques were similar for a majority of operators. Technical success rates were higher in private practice. Most referrals were from thoracic surgery.	Survey
Jeon YJ, Cho JH, Hyun D et al. (2021)Management of	Retrospective case series	5 patients (16.7%) received TDE after lung surgery and 5	More comprehensiv e studies

chyle leakage after general thoracic surgery: Impact of thoracic duct embolization. Thorac Cancer;12:1382–1386.	N=105 patients who developed chyle leakage after surgery (49 due to lung surgery, 30 due to pulmonary resection, 8 after esophagectomy) Only 10 had TDE procedures and 9 patients underwent TDL. .	patients (27.7%) after esophageal surgery. Also, the hospital stay of patients who underwent pulmonary resection was shorter than patients who had lung surgery (12.6 days versus. 16.3 days; p = 0.026).	added to the overview summary.
Kim SK, Thompson RE, Guevara CJ et al. (2020) Intranodal Lymphangiography with Thoracic Duct Embolization for Treatment of Chyle Leak after Thoracic Outlet Decompression Surgery. Journal of vascular and interventional radiology, 31 (5), 795-800.	Case series N= 9 patients had ultrasound-guided intranodal lymphangiography for chyle leak following thoracic outlet decompression surgery. Mean follow-up 304 days	The technical success rate of TDE was 67% (6/9), fluoroscopic transabdominal antegrade access (n =4) and ultrasound-guided retrograde access (n = 2). Clinical success was achieved in 89% patients (8/9). The mean interval from lymphangiography to drain removal was 6.6 days (range, 4–18 d). No patients had a chyle leak recurrence.	Larger studies included in the overview summary.
Pamarthi V, Stecker MS, Schenker MP et al. (2014) Thoracic duct embolization and disruption for treatment of chylous effusions: experience with 105 patients. J Vasc Interv Radiol; 25:1398–1404.	N=105 patients with chylous effusions (traumatic in 97, malignancy in 4 and other reasons in 4) had TDE/TDD.	INL technical success 89.5% (94/105), TDE technical success in 57% (53/94), clinical success 72% (38/53). TDD clinical success in 62% (23/37).	Included in systematic review added to the summary of evidence.
Nadolski DJ, Itkin M. (2013) Thoracic duct embolization for nontraumatic chylous effusion experience in 34 patients. original	Retrospective case series N=34 patients with nontraumatic chylous effusions	TDE was successful in 50% cases of thoracic duct occlusion and extravasation. Lymphangiography	Included in systematic review added to the overview.

Research Disorders of the Pleura. 143 (1),158-163.	underwent TDE (n=31).	is important for identifying the cause of chylous effusions and selecting patients who benefit most from TDE. Complication was reported in 1 patient.	
Nadolski G, Itkin M. (2012) Feasibility of ultrasound guided intranodal lymphangiogram for thoracic duct embolization. J Vasc Interv Radiol; 23: S103–S104	Case series N=6 patients had Intranodal lymphangiography and TDE for chylothorax.	Opacification, catheterization, and embolisation of the thoracic duct was successful in all cases. Using IL, the thoracic duct may be more quickly visualized and catheterized for TDE than with PL.	Larger studies included in the overview summary.
Marthaller KJ, Johnson SP, Pride RM et al. (2015) Percutaneous embolization of thoracic duct injury post-esophagectomy should be considered initial treatment for chylothorax before proceeding with open re-exploration. The American Journal of Surgery. 209, 235-239	Case series N=5 patients with refractory chylous fistula post-esophagectomy were treated with percutaneous embolisation.	Successful ablation of the chylous fistula was achieved in 80% (4/5) patients. Pre-treatment chylous output averaged 1,756 mL/day. A modified technique is detailed, which utilizes direct puncture of groin lymph nodes to facilitate opacification of the thoracic duct.	Larger studies included in the overview.
Majdalany BS, Saad WA, Beecham chick JF et al. (2018) Pediatric lymphangiography, thoracic duct embolization and thoracic duct disruption: a single-institution experience in 11 children with chylothorax. Pediatr Radiol. 48:235–240	Case series N=11 paediatric patients who underwent lymphangiography and thoracic duct embolisation.	Lymphangiography was technically successful in all patients. In 37% (3/8) procedures, disruption was performed when the central lymphatics could not be accessed. Clinical success was achieved in 7/11 (64%) children. 3	Paediatric study.

		minor complications were reported.	
Moussa AM, Maybody M, Gonzalez Aguirre AJ et al. (2020) Thoracic duct embolization in post-neck dissection chylous leakage: A case series of 6 patients and review of the literature. Cardiovasc Intervent Radiol; 43(6): 931–937.	Case series N=6 patients with chylous leaks following neck dissection who have failed conservative management.	Clinical success was achieved in all patients, with one patient requiring repeat TDE. No minor or major complications were reported.	Larger studies included in the overview.
Reisenauer J S, Puig C A, Reisenauer C J et al. (2018) Treatment of postsurgical chylothorax. Ann Thorac Surg; 105: 254–62.	N=48 patients with 1.1 litre daily output. Surgical TDL (in 8), TDE (in 40)	TDE was technically successful in 48% patients. Clinical success in 85% patients who had TDL and 38% in patients who had TDE. 8% mortality was reported in patients with TDE.	Included in systematic review added to the overview.
Ruan Z, Zhou Y, Wang S et al. (2011) Clinical use of lymphangiography for intractable spontaneous chylothorax. Thorac Cardiovasc Surg; 59:430–435.	Case series N=15 patients with chylothorax had lymphangiography alone.	80% technical success 58% clinical success.	Included in systematic review added to the overview.
Nadolski G J, Itkin M. (2018) Lymphangiography and thoracic duct embolization following unsuccessful thoracic duct ligation: imaging findings and outcomes. J Thorac Cardiovasc Surg; 156: 838–43.	N=50 patients with failed TDL/referrals had TDE (n=49) /TDD (n=1)	Technical and clinical success was 98% in patients with TDE and 100% in the 1 patient who had TDD.	Included in systematic review added to the overview.
Schild HH, Naehle CP, Wilhelm KE, et al. (2015) Lymphatic interventions for treatment of chylothorax. Rofo; 187:584–588.	Case series N= 21 patients with therapy resistant chylothorax a lymphatic had TDE in 17 (3 with prior failed TDL) and percutaneous	82% (14/17) successful embolisations were clinically successful including ethanol injection. Complications were a bile peritonitis	Included in systematic review added to the overview.

	destructions of lymphatic vessels in 2, CT-guided injection of ethanol next to a duplicated thoracic duct in 1.	requiring operation, and one clinical deterioration of unknown cause.	
Stecker MS, Pamarthi V, Steigner ML et al. (2020). Utility of planning MRI in percutaneous thoracic duct embolization for chylothorax. Clinical Imaging; 64: 43-49.	Retrospective case series N=96 MRI and conventional lymphangiograms reviewed.	Identification of a cisterna chyli and/or 4 mm or greater target on pre-procedural MRI indicated higher likelihood of technically successful TDE. MRI did not help predict unsuccessful TDE procedures. Better target level concordance was not associated with improved technical outcomes.	More comprehensive studies included.
Ushinsky A, Guevara CJ, Kim SK. (2021) Intranodal lymphangiography with thoracic duct embolization for the treatment of chyle leaks after head and neck cancer surgery. Head & Neck; 43:1823–1829.	Retrospective case series N=12 patients had lymphangiography and 11 TDE for a chyle leak after head and neck surgery	3 patients had repeat TDE. Technical success of TDE was 86% (12/14). Clinical success of TDE was 90% (9/10). Median time until drain removal was 2.1 days in 9 patients. Two had chylothorax after initial TDE, requiring additional TDE and one needed surgical TD ligation.	Larger studies added to the overview summary.
Yannes M, Shin D, McCluskey K et al. (2017) Comparative analysis of intranodal lymphangiography with percutaneous intervention for postsurgical chylous	Retrospective comparative case series N=46/57 patients with chyle leaks postoperatively and failed medical conservative	In patients who had TDE, clinical success was 91% (21/22) and median time to response was 3 days. In those who had TDD, clinical success was 50% (6/12) and	Included in systematic review added to the overview.

effusions. J Vasc Interv Radiol; 28:704–711.	treatment had intranodal lymphangiography (INL) alone (n=12), INL +TDE (n=22). and INL+TDD (n=12).	median time to response was 7 days. In 7 patients who had INL alone, clinical success was 58% (7/12) and median time to response was 14 days. 1 patient died in INL+CTE group died.	