INTERVENTIONAL

Thoracic duct embolization in treating postoperative chylothorax: does bail-out retrograde access improve outcomes?

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Abstract

Objectives To evaluate clinical outcomes of thoracic duct embolization (TDE) for the management of postoperative chylothorax with the aid of the bail-out retrograde approach for thoracic duct cannulation (TDC).

Materials and methods Forty-five patients with postoperative chylothorax underwent Lipiodol lymphangiography (LLG) between February 2016 and November 2019. If targetable central lymphatic vessels were identified in LLG, TDC, a prerequisite for TDE, was attempted. While the conventional antegrade transabdominal approach was the standard TDC method, the retrograde approach was applied as a bail-out method. Embolization, the last step of TDE, was performed after confirming leakages in the trans-TDC catheter lymphangiography. Technical and clinical success rates were determined retrospectively.

Results TDC was attempted in 40 among 45 patients based on LLG findings. The technical success rate of TDC with the conventional antegrade approach was 78% (31/40). In addition, six more patients were cannulated using the bail-out retrograde approach, which raised the technical success rate to 93% (37/40). While 35 patients underwent embolization (TDE group), ten patients did not (non-TDE group) for the following reasons: (1) lack of targetable lymphatics for TDC in LLG (n = 5), (2) technical failure of TDC (n = 3), and (3) lack of discernible leakages in the transcatheter lymphangiography (n = 2). The clinical success of the TDE group was 89% (31/35), compared with 50% (5/10) of the non-TDE group. One major procedure-related complication was bile peritonitis caused by the needle passage of the distended gallbladder.

Conclusions Bail-out retrograde approach for TDC could improve the overall technical success of TDC significantly.

Key Points

• *Bail-out retrograde thoracic duct access may improve the overall technical success of thoracic duct access, thus improving the clinical success of thoracic duct embolization.*

Abbreviations
LLG   Lipiodol lymphangiography
PACS Picture archiving and communication systems
TDC   Thoracic duct cannulation
TDE   Thoracic duct embolization

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Introduction

Postoperative chylothorax may occur as a complication after various thoracic, cardiac, and neck surgeries [1, 2]. Low-output chylothorax (< 1000 mL/day) is typically treated by conservative means, whereas high-output states call for thoracic duct ligation, carrying substantial morbidity and mortality risk [1, 3, 4]. Once introduced by Cope et al, thoracic duct

embolization (TDE) was accepted as the treatment of choice or at least as a viable alternative to surgical ligation in treating intractable postoperative chylothorax [3, 5–7].

Among three steps of TDE—Lipiodol lymphangiography (LLG), thoracic duct cannulation (TDC), and embolization—TDC is the major determining factor for the technical success of TDE due to its technical difficulty [3]. The previous studies reported the conventional antegrade TDC's technical success rate to be about 70% [5, 8, 9]. Hence, significant numbers of patients for whom TDC had failed were forced to settle for the unproven therapeutic effect of Lipiodol during the LLG or thoracic duct disruption, although neither procedure is as clinically efficient as TDE is [10, 11].

Recently, novel retrograde transvenous or percutaneous cervical TDC techniques have been instituted [12–16]. The present study was thus conducted to evaluate clinical outcomes of TDE for the management of postoperative chylothorax with the aid of a bail-out retrograde approach for TDC.

Materials and methods

Our Institutional Review Board approved this retrospective study. The requirement to obtain informed consent was waived per board protocol. All interventional procedures were conducted by one interventionalist (S.H.) with 10-year experience of interventional radiology. Radiological and clinical data were retrospectively reviewed by three radiologists (S.H., H.J., and H.L.) in consensus.

Study population

Patients with postoperative chylothorax undergoing LLG between February 2016 and November 2019 for intended TDC and TDE were included in this study. In each instance, typical "milky" chylous effusions > 110 mg/dL were recorded. Conservative measures, including a fat-free or low-fat diet or total parenteral nutrition, failed to stop the chylous leakage.

Electronic medical records and picture archiving and communication systems (PACS) were accessed for the retrospective review of demographic data, etiologies of lymphatic leaks, initial triglyceride levels in leaked fluid, volumes of daily chest tube drainage, technical details, complications, follow-up periods, and clinical outcomes.

Interventional procedures

Intranodal Lipiodol lymphangiography

Lymph nodes of both inguinal regions were directly accessed under ultrasound guidance using a 26-gauge needle fitted with a short accessory tube and a 3-mL polycarbonate syringe. After positioning the needle tip at the transition between the nodal cortex and hilum, ethiodized oil (Lipiodol Ultra-Fluid; Guerbet) was injected manually under intermittent fluoroscopy until lymphatics along the upper lumbar region and cisterna chyli were opacified [17, 18]. If lymphatic opacification was inadequate or sluggish, iliac nodes at higher levels were accessed under fluoroscopy, as detailed in earlier reports [19].

Thoracic duct cannulation

Antegrade TDC Once upper lumbar lymphatics and cisterna chyli were opacified, antegrade percutaneous transabdominal TDC was attempted under fluoroscopic guidance, using a 22-gauge, 15-cm or 21-gauge, 20-cm needle (Cook Medical) to puncture cisterna chyli or a prominent retroperitoneal duct. Anteroposterior projections served for needle advancement upon skin entry (at ~45° angle), using orthogonal projections for location adjustments.

Next, a relatively stiff guidewire, 0.014 in. (Command ES; Abbott Vascular) or 0.018 in. (V18 Control; Boston Scientific), was passed through the needle to cisterna chyli and into the thoracic duct. A microcatheter (Progreat Alpha; Terumo Corp) was then inserted over the guidewire to the same position. If greater traceability was needed after a hostile course of the wire passage, a dedicated supporting catheter (CXI Support Catheter [Cook Medical] or Rubicon Support Catheter [Boston Scientific]) was first engaged and later replaced by an ordinary microcatheter.

Retrograde TDC If antegrade TDC failed, retrograde TDC was undertaken in either of two ways: direct puncture of the thoracic duct at neck level (n = 5) or transvenous access at the junction of the thoracic duct and subclavian vein (n = 6). Having the distal part of the thoracic duct immediately before entering the subclavian vein opacified by Lipiodol, a 21-gauge micropuncture needle (Micropuncture Access Set; Cook Medical) was introduced under fluoroscopic guidance for direct retrograde TDC, usually in the left supraclavicular fossa. If successful, a 0.016-in. guidewire (Asahi Meister; ASAHI INTECC Co.) and a microcatheter (Progreat Alpha; Terumo Corp) were advanced for further intervention. For transvenous retrograde access, a 5- or 6-Fr sheath was inserted into the left basilic or right common femoral vein, using a 5-F multipurpose, cobra-shaped or hook catheter; a microcatheter (Progreat Alpha, Terumo Corp); and a 0.016-in guidewire (Asahi Meister; ASAHI INTECC Co.) to reach and access the junction of the thoracic duct.

Embolization

After the successful antegrade or retrograde TDC, trans-TDC catheter lymphangiography using digital subtraction angiography function of the angiographic machine was performed while injecting 5–10 mL of iodinated water-soluble contrast

(0.3–1 mL/s) via a microcatheter to identify the point(s) of leakage from the thoracic duct or its tributaries. If the hallmarks of leakage, such as extravasated contrast or lymphopseudoaneurysm, were lacking in the transcatheter lymphangiography, the final embolization step was abandoned, even after strenuous TDC because there is a possibility of symptom aggravation by occluding the most important drainage route of lymphatic fluid back to the venous system.

On the other hand, if the leakage was confirmed in the lymphangiography, Microcoils (Interlock [Boston Scientific] or Concerto [Covidien]) were deployed at the cervical portion of the thoracic duct via the established access catheter (Progreat Alpha; Terumo Corp) to prevent overflow of the glue material into the systemic vein. Then, minimal amount (less than 1 mL) of 5% dextrose water was flushed through the microcatheter system to prevent premature glue polymerization during the embolization. The whole segment of the thoracic duct was embolized by casting it with n-butyl-2-cyanoacrylate (NBCA, Histoacryl; B. Braun Medical Inc.) mixed with Lipiodol (Lipiodol Ultra-Fluid; Guerbet) at a ratio of 1:1.5 to 1:3 (mostly 1:2). The latter was added to opacify the glue and prevent premature microcatheter blockage. Injection of the NBCA/Lipiodol mixture took place while withdrawing the catheter. In the cases of retrograde TDC, the basic principle of the embolization was the same as antegrade TDC: placing Microcoils at the cervical portion of the thoracic duct, and then glue embolization of the whole segment of the thoracic duct from the lower part of the injured segment.

In selected cases, superselective embolization (rather than occlusion of the entire thoracic duct) was carried out using NBCA/Lipiodol mixture alone, when the culprit lymphatic vessel was visualized, and further superselection of the vessel with microcatheter was feasible.

Assessment of the clinical outcomes and complications

The clinical outcome was analyzed, and any medical records indicating the possible complications after the procedures were reviewed. The technical success rates of TDC procedures (overall, antegrade, and retrograde) were determined. Patients were classified as TDE group if they underwent all three steps of TDE, which are LLG, TDC, and embolization. Otherwise, they were classified as non-TDE group. The clinical success was defined as resolving the lymphatic leakages within 2 weeks after the final TDE attempts, regardless of its technical success. The clinical success rates of TDE and non-TDE groups were compared, respectively.

Results

Overall, 45 patients (men, 28; women, 17; mean age, 62 years) were referred for treatment during the study period (Fig. 1). In
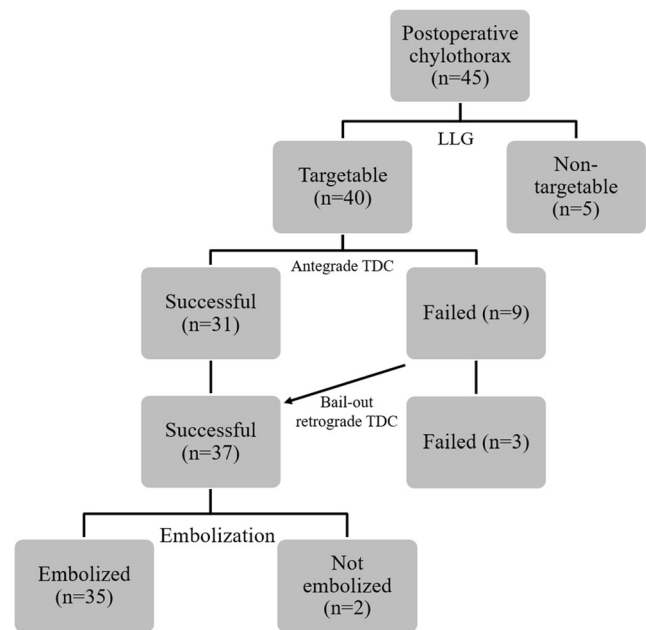

Fig. 1 Flowchart of the therapeutic process. Lipiodol lymphangiography was performed in all 45 referred patients who suffered from high-output postoperative chylothorax. Thoracic duct cannulation (TDC), which is the prerequisite step before the embolization, was pursued only when the targetable central lymphatic structure such as cisterna chyli or thoracic duct is seen in the Lipiodol lymphangiography (n = 40). The antegrade approach through the transabdominal route was the standard method. The retrograde approach was applied if the antegrade approach was unsuccessful. This bail-out procedure increased the overall technical success rate of TDC from 78 to 93% by salvaging six failed patients

Table 1 Underlying pathologic conditions and operations performed

	Total
Pathologic conditions	
Lung cancer	16
Esophageal cancer	10
Thymic neoplasm	7
Thyroid cancer	3
Breast cancer	2
Oral cavity cancer	2
Aortic disease	1
Mediastinal lymphadenopathy	1
Mesothelioma	1
Necrotizing pneumonitis	1
Pulmonary metastasis	1
Operations	
Lung resection	18
Esophagectomy	10
Thymectomy	7
Neck dissection	5
Mediastinal node dissection	1
Thoracic aortic surgery	1
Other	3

Table 1, underlying pathologic conditions and original operations performed are listed. Four patients demonstrated secondary chylous leakage into surgical neck wounds, and three showed coexisting chylous ascites.

Technical success of TDC

Antegrade TDC

Intranodal lymphangiography was successful in all patients (45/45, 100%), but TDC was attempted in 40 among 45 patients based on LLG findings; TDC was attempted in five patients due to a lack of targetable lymphatics (i.e., cisterna chyli or thoracic duct). One patient had a history of prior pelvic node dissection and was devoid of opacified inguinal lymph nodes; three patients showed interruptions of the thoracic duct; and another harbored a lymphopseudoaneurysm below cisterna chyli, without any points of thoracic duct leakage.

The technical success rate of antegrade TDC was 78%, succeeding in 31 of 40 patients. TDE was then performed in 30 of these 31 patients (96%).

Retrograde TDC

Retrograde TDC was attempted in 11 patients as bail-out procedures (n = 8) after difficult or failed standard antegrade TDC efforts or as adjunctive measures (n = 3) (Fig. 2). The bail-out procedures were successful in 6 of 8 cases. The technical success rate of retrograde TDC was 82% (9/11). In one patient for whom retrograde TDC failed, repeat antegrade TDC led to successful TDE during a subsequent separate session.

Overall TDC

As a result of bail-out retrograde TDC, the overall technical success rate of TDC improved to 93% (37/40) in the subgroup

of patients subjected to TDC by achieving success in additional six patients. On an intention-to-treat basis, regarding non-attempts as failures, the success rate was 82% (37/45) (Table 2).

Clinical success of TDE

In 37 patients with successful TDC, 35 proceeded to embolization (TDE group) either in the form of extensive embolization of thoracic duct (n = 27) or superselective (n = 8) embolization of culprit lymphatic channels (Fig. 3). TDE was abandoned even after the successful TDC in two patients, who showed no evidence of leakage in LLG or trans-TDC catheter lymphangiography.

Clinical success was 89% (31/35) in the TDE group. Among the four patients regarded as clinical failures, three patients were able to remove chest drains more than 2 weeks after the final TDE attempts. However, the other patient died from the medical complication of persistent lymphatic leakage.

Ten patients did not undergo TDE (non-TDE group) due to (1) lack of targetable central lymphatics in LLG (n = 5), (2) technical failures of TDC (n = 3), or (3) lack of discernible leakage in trans-TDC catheter lymphangiography (n = 2). The clinical success rate in this group was 50% (5/10).

Based on intention-to-treat, the overall clinical success was 80% (36/45).

Procedural complications

Only one major procedural complication was encountered during the follow-up period (average 434 days). The patient complained of extreme right upper quadrant pain immediately after successful TDE, likely due to bile peritonitis. Emergency computed tomography revealed a dilated gallbladder with scant surrounding fluid at the midsection. Following cholecystostomy performed on the next day, the abdominal

Fig. 2 Obtained images during retrograde transvenous access: (**a**) digital subtraction angiography after transvenous approach confirming contrast leakage (arrowheads) by a branch of the thoracic duct; and (**b**) fluoroscopic spot image after selective embolization of the culprit branch (arrow)
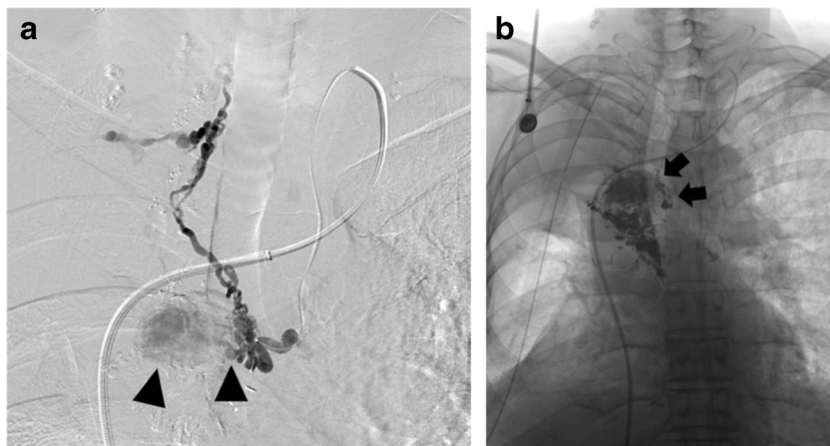
Table 2 Outcomes of TDC/TDE procedures

Outcome measure	Intention-to-treat group	Attempt-to-treat group
Technical success, antegrade TDC	31/45 (69%)	31/39 (79%)
Technical success, overall TDC	37/45 (82%)	37/40 (93%)
Clinical success, TDE	36/45 (80%)	31/35 (89%)

pain resolved. There were also five minor procedure-related complications. Four patients developed fever that responded to conservative treatment, and one experienced asymptomatic non-target glue embolization of the pulmonary artery, which was asymptomatic.

Discussion

Wire insertion and catheterization of central lymphatic channels during TDC are the most technically challenging aspects of the three-step (LLG → TDC → embolization) process of TDE. Failure at this juncture accounts for the majority of technical failures [9]. Even after the failure of TDC, LLG alone is known to have some degree of potential therapeutic effects on lymphatic leakage in one meta-analysis data [9]. Furthermore, thoracic duct disruption was performed as a bail-out procedure to overcome the technical failure of TDC in some previous studies [3, 10, 11, 20]. Its pooled clinical success rate was 60.8% in the meta-analysis, but this is considerably lower than that of TDE (79.4%) and only slightly higher than that of LLG (56.6%) in the same analysis [5, 9, 10]. Thus, the clinical outcomes of TDE can be significantly enhanced only by bolstering the technical success of TDC.

According to previous reports, antegrade TDC's technical success rates range from 60 to 80% [5, 8, 9]. Herein, we achieved a comparable rate (78%) that may have edged higher through repeated antegrade TDC attempts. The main issue with antegrade TDC is poor opacification of lymphatic targets (i.e., cisterna chyli or thoracic duct) due to insufficient Lipiodol injection or washout of cisternal Lipiodol by a rapid inflow of non-opacified intestinal lymphatic fluid. Large body habitus is yet another obstacle that reduces fluoroscopic image quality. Once initial wire insertion fails, the punctured Lipiodol-filled lymphatics also begin to leak, further impeding the visualization and lymphatic targeting.

Retrograde TDC may be a welcome alternative in these problematic situations because it is unaffected by washout of Lipiodol or large body habitus. Despite the dearth of information on this relatively new technique, our data indicate a viable approach with a fair (82%) technical success rate. Nevertheless, antegrade TDC remains the first choice, reserving retrograde TDC for alternate or bail-out use. This convention is based on flow considerations and valvular hurdles when passing a wire through cervical thoracic duct segments via retrograde direction. In our study, 93% of overall TDC technical success could be achieved by combining antegrade transabdominal access and bail-out retrograde approach.

Superselective embolization of damaged lymphatics, rather than complete occlusion of the thoracic duct, was performed in eight of our patients. All of them recovered without any complications or recurrence of symptoms. Unlike arterial bleeding, in which such practice is routinely pursued, the standard approach to TDE entails extensive segmental blockade of the thoracic duct. Although proven safe in most traumatic chylothorax cases, the potential complications of TDE, such as chylous ascites, lower extremity lymphedema, and protein-losing enteropathy, are well-known. These complications largely result from related pressure increases, because the thoracic duct is the primary lymphatic conduit to the venous system [8, 21–24]. In theory, selective embolization of the thoracic duct may be preferable to conventional TDE in that

Fig. 3 Obtained images during superselective embolization: (**a**) digital subtraction angiography showing contrast leakage (arrowhead) with lymphopseudoaneurysm by a branch of the thoracic duct; and (**b**) fluoroscopic spot image after selective embolization of the culprit branch with NBCA/Lipiodol mixture alone (arrow) while preserving main thoracic duct (white arrow)
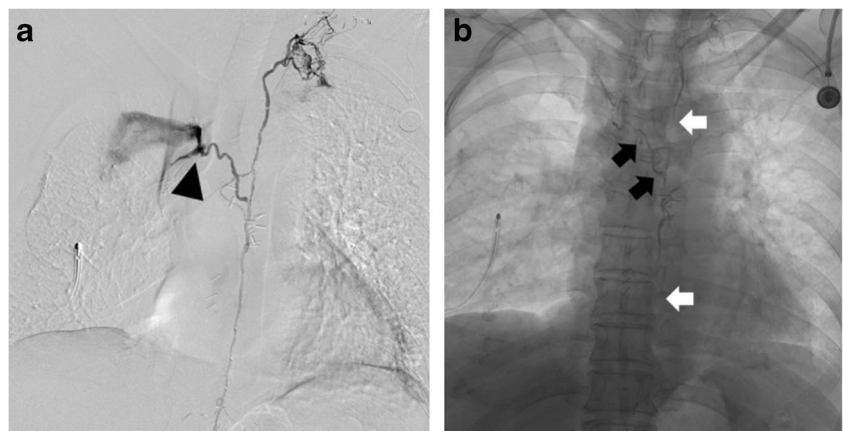
thoracic duct flow is sustained, causing no temporary pressure elevations. Further investigation is warranted to identify the actual benefits and the future role of this particular strategy.

Because the conventional antegrade approach for TDC involves the penetration of a long needle through the intervening abdominal organs before it reaches the deeply seated thoracic duct, cisterna chyli, or their tributaries, some practitioners still do not feel comfortable with this conventional route of access [25–27], regardless of the existing published reports on its safety. However, one major complication in our series warranted special attention. Bile peritonitis triggered extreme abdominal pain immediately after successful TDE, requiring emergency percutaneous cholecystostomy. Even though needle penetration of various abdominal organs during TDC is generally innocuous, the gallbladder is undoubtedly the one organ to avoid [28]. Therefore, pre-procedural computed tomography or ultrasound screening for anomalous central location or dilation of the gallbladder is advised.

A limitation of this study is its retrospective design. Some patients were transferred to our institute expressly only for TDE procedure and have returned to outside hospitals for clinical follow-up. We lost two patients to follow-up and could not retrieve sufficient post-procedural information. Also, the availability of comprehensive follow-up data was highly variable, so long-term complications, such as lower extremity edema, could not be assessed in terms of prevalence.

Conclusion

Bail-out retrograde approach for TDC could improve the overall technical success of TDC significantly. Successful TDE resulted in a quick resolution of postoperative chylothorax in the majority of patients.

Declarations

Guarantor The scientific guarantor of this publication is Saebeom Hur.

Conflict of interest The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article.

Statistics and biometry No complex statistical methods were necessary for this paper.

Informed consent Written informed consent was waived by the Institutional Review Board (IRB number: 1711-080-900).

Ethical approval Institutional Review Board approval was obtained.

Methodology
• retrospective
• observational
• performed at one institution

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