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CLINICAL INVESTIGATION LYMPHATIC

# Transvenous Retrograde Thoracic Ductography: Initial Experience with 13 Consecutive Cases

**Shuji Kariya[1] · Miyuki Nakatani[1] · Yutaka Ueno[1] · Asami Yoshida[1] · Yasuyuki Ono[1] · Takuji Maruyama[1] · Atsushi Komemushi[1] · Noboru Tanigawa[1]**

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**Abstract**
*Purpose* To report the feasibility and findings of transvenous retrograde thoracic duct cannulation.
*Materials and Methods* The subjects were 13 patients who had undergone retrograde transvenous thoracic ductography. Despite conservative treatment, all required drainage for chylothorax, chylous ascites, or a chylous pericardial effusion. Lymphangiography was performed, and the junction of the thoracic duct with the vein was identified. A microcatheter was inserted into the thoracic duct retrogradely via the junction with the vein.
*Results* The catheter could be inserted to the cervical part, thoracic part, and cisterna chyli in 12 (92.3%), nine (69.2%), and six (46.2%) patients, respectively. Successful transvenous thoracic ductography was performed in eight patients (61.5%). The cervical part of the thoracic duct was branched into a plexiform configuration beyond which the microcatheter could not be advanced to reach the thoracic part in three unsuccessful cases. The success rate of transvenous thoracic ductography was significantly higher with the simple type (80%) than with the plexiform type (0%; $p = 0.035$). No extravasation of contrast agent was seen in the eight patients with successful thoracic ductography. Thoracic duct embolization was performed in one patient with a chylous pericardial effusion in whom myriad lymph ducts connecting to the hilar and pericardial regions from the thoracic duct were found, and drainage was unnecessary.
*Conclusion* Transvenous retrograde thoracic ductography was successful in only eight of 13 patients (61.5%), but when the cervical part was the simple type, it was successful in eight of 10 patients (80%).

**Keywords** Transvenous thoracic ductography · Lymphangiography · Thoracic duct · Leakage · Chylous effusion

The study protocols for this retrospective analysis were approved by our institutional review board.

✉ Shuji Kariya
kariyas@hirakata.kmu.ac.jp

Miyuki Nakatani
nakatanm@hirakata.kmu.ac.jp

Yutaka Ueno
uenoyut@hirakata.kmu.ac.jp

Asami Yoshida
yoshidaa@hirakata.kmu.ac.jp

Yasuyuki Ono
onoyasy@hirakata.kmu.ac.jp

Takuji Maruyama
maruytak@hirakata.kmu.ac.jp

Atsushi Komemushi
komemush@takii.kmu.ac.jp

Noboru Tanigawa
tanigano@hirakata.kmu.ac.jp

[1] Department of Radiology, Kansai Medical University, 2-5-1 Shinmachi, Hirakata, Osaka 5731010, Japan

## Introduction

Catheter cannulation to the thoracic duct is necessary for diagnosis of chylous leakage and transcatheter embolization. Since the report by Cope et al. [1] of percutaneous transabdominal catheterization to the thoracic duct, various approaches to the thoracic duct have been reported. However, most reports are of cases in which a percutaneous transabdominal puncture approach was used [2, 3]. There are some case reports where other approaches such as transvenous retrograde cannulation, direct puncture of the thoracic duct or leakage site, and lymphocele puncture are used [4–8]. With a transvenous approach, the thoracic duct is entered from a vein via the junction of the thoracic duct with the vein (JTV), and passage is through an existing vascular route. This approach without puncture is thought to be a less invasive procedure. Therefore, it might be useful to insert the catheter into the thoracic duct and the cisterna chyli by this approach for the diagnosis and embolization of chylous leakage. However, the only reports of transvenous approaches are three case reports, and technical information remains scarce [4, 5].

The purpose of this study was to report the feasibility and findings of thoracic ductography by transvenous retrograde cannulation.

## Materials and Methods

### Study Design and Patients

Data were gathered retrospectively by reviewing clinical records, including images. This retrospective study was approved by our institutional review board, and the requirement to obtain informed consent for inclusion in this study was waived. Informed consent for transvenous retrograde cannulation was obtained from all patients before the procedure.

The subjects were 13 consecutive patients from 2009 to 2016 in whom transvenous retrograde cannulation of the thoracic duct was indicated for the purposes of diagnosing the site of chylous leakage or embolization to stop the leakage. The patients included five men and eight women, with a mean age of 55 $\pm$ 20 years. Postoperatively, four patients had chylothorax, and two patients had chylous ascites. Seven of 13 patients had no history of surgery or trauma. Of these seven patients, chylothorax was seen in five patients, chylous ascites was seen in one patient, and a chylous pericardial effusion was seen in one patient. Despite conservative treatment, all cases required continuous drainage. The amount of drainage varied among cases, from temporary drainage done whenever symptoms worsened to drainage of 3000 ml/day (Table 1). Conservative treatment, including a low-fat diet, total parenteral nutrition, administration of a somatostatin analog, administration of etilefrine, and/or drainage, was performed in all cases, but this failed to reduce the chylous leakage. Transvenous retrograde cannulation of the thoracic duct was not indicated on lymphangiography when the cervical part of the thoracic duct could not be visualized, and the lipiodol could not be confirmed to discharge into the left venous angle. The reason that transvenous retrograde cannulation was judged to be impossible at the time of lymphangiography was that the JTV could not be identified. There were 12 such patients during this period, all of whom had undergone cannulation of the thoracic duct by a transabdominal approach. Figure 1 shows a flow diagram of the study patients. Patient demographics are shown in Table 1.

### Transvenous Retrograde Cannulation

Transvenous retrograde cannulation was performed by an interventional radiologist (S.K., with 15 years of experience). This procedure was performed with the patient under sedation using hydroxyzine and local anesthesia using lidocaine.

First, lymphangiography was performed. Bipedal lymphangiography was performed in one patient, and intranodal lymphangiography was performed in 12 patients. The mean amount of lipiodol injected was 14.7 $\pm$ 3.3 ml. After confirming that the lipiodol in the thoracic duct was discharged into a vein at the left venous angle following lymphangiography, a 6-F introducer sheath (Super Sheath; Medikit, Miyazaki, Japan) was placed in the left basilic vein of the upper arm, the left brachial vein, or the right femoral vein. In 12 patients, the initial approach to the vein was the left brachial vein or basilic vein approach; a change was made to a right femoral vein approach in two patients because of difficulty inserting the catheter into the thoracic duct. In one patient, a right femoral vein approach was used from the start considering the angle at which the thoracic duct joined the subclavian vein. In the approach from the brachial or basilic vein to the JTV, a 4- or 5-F hook, small J, multipurpose, or cobra-shaped catheter was used. In the approach from the femoral vein to the JTV, a 5-F multipurpose catheter was used.

A 2.2-F microcatheter (Sirabe, Piolax Medical Devices, Inc., Kanagawa, Japan) was used for insertion into the thoracic duct. A 0.016-in. wire (Iris, Piolax Medical Devices) was used to guide the microcatheter. Iodinated water-soluble contrast medium (iopamidol, Oypalomin® 370 Injection, Fuji Pharma Co., Ltd., Tokyo, Japan) was used in all transcatheter contrast radiography. In patients with insertion to the thoracic part, visualization was done using a power injector. The infusion rate was set at 2–3 ml/s, with an infusion amount of 10–15 ml.

In patients with chylous ascites, a 2.2-F microcatheter and 4- or 5-F catheter were changed to a 3-F microballoon catheter (Attendant; Terumo, Tokyo, Japan) with over-the-wire exchange using a 0.014-in. wire (Transend, Boston Scientific, Natick, MA). Microballoon-occluded retrograde thoracic ductography was then performed. The infusion rate was set at 2 ml/s, with an infusion amount of 10 ml.

**Table 1** Patients' demographic characteristics

| Pt. no. | Age (year) | Sex | Underlying condition | Duration of conservative treatment until the procedure (days) | Type of chylous leakage | Amount of leakage |
|---|---|---|---|---|---|---|
| 1 | 28 | F | Lymphangiectasis | 22 | Chylous pericardial effusion | 700 ml[a] |
| 2 | 77 | M | Past esophageal cancer chemoradiation | 270 | Chylothorax | 660 ml/day |
| 3 | 70 | M | Past esophageal cancer surgery | 28 | Chylothorax | 3000 ml/day |
| 4 | 50 | F | Thyroid cancer | 7 | Chylothorax | 200 ml/day |
| 5 | 51 | M | Past gastric cancer surgery | 27 | Chylous ascites | 3000 ml/week |
| 6 | 65 | M | Past lung cancer surgery | 18 | Chylothorax | 150 ml/day |
| 7 | 69 | F | Systemic lupus erythematosus | 240 | Chylothorax | 1200 ml/day |
| 8 | 71 | F | Past gastric cancer surgery | 328 | Chylous ascites | 2000 ml/week |
| 9 | 44 | M | Acquired immunodeficiency syndrome | 62 | Chylous ascites | 1000 ml/week |
| 10 | 41 | F | Lymphangiectasis | 60 | Chylothorax | 1000 ml[a] |
| 11 | 55 | F | Past cervical cancer surgery | 95 | Chylothorax | 800 ml/day |
| 12 | 84 | F | None | 180 | Chylothorax | 1000 ml/week |
| 13 | 15 | F | Lymphangiectasis | 35 | Chylothorax | 1000 ml/day |

[a]Amount of drainage done temporarily to relieve symptoms

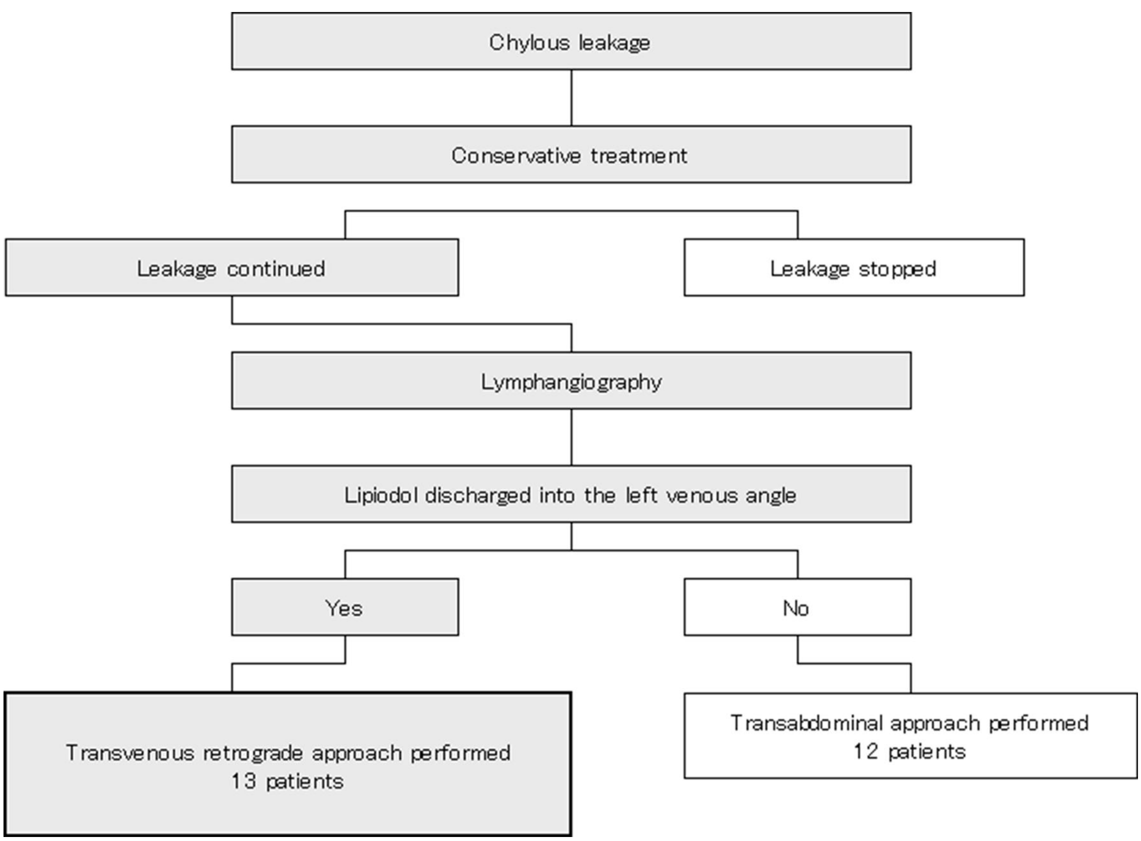



**Fig. 1** Flow diagram of the study patients

### Definition

The thoracic duct was divided into a thoracic part, the section that runs in the caudal thoracic cavity from the level of the intersection with the left brachiocephalic vein, and the cervical part, the section that runs from the same level to the vein on the cranial side in the cervical area [9] (Fig. 2). With respect to the shape of the cervical part, "simple type" was defined as the presence of at least one prominent thoracic duct, and "plexiform type" was defined as the cervical part having a plexiform configuration without a prominent main duct. Successful transvenous thoracic ductography was defined as a case in which the entire thoracic duct region and cisterna chyli were visualized by injecting iodinated water-soluble contrast media via the microcatheter.

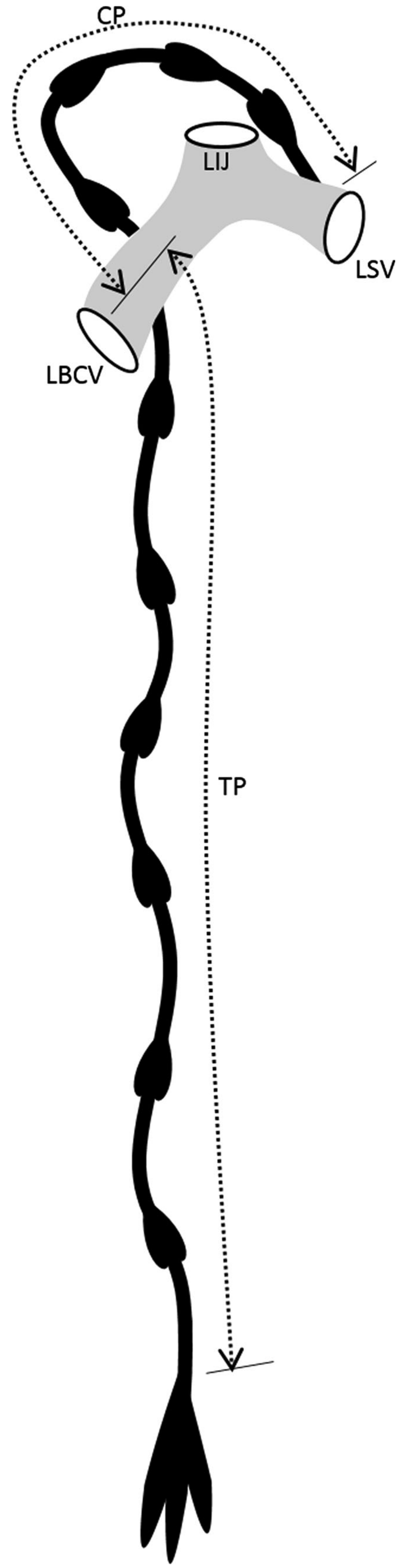
### Evaluation

The following three issues were evaluated in this study.

1. How far a microcatheter could be advanced retrogradely toward the cisterna chyli was evaluated in 13 patients. The part of the thoracic duct reached was taken to be the cervical part, thoracic part, or cisterna chyli.
2. The success rate of transvenous thoracic ductography in the 13 patients was evaluated. The success rates of transvenous thoracic ductography in the simple type and plexiform type were compared using Fisher's exact probability test. In cases where transvenous thoracic ductography was successful, the procedure time was investigated. The procedure time was taken to be the time from the start of the sheath placement procedure in the upper arm or thigh until the sheath was removed at the end of the procedure. The time for lymphangiography was not included.
3. Extravasation of lipiodol from lymphangiography and extravasation of iodinated contrast medium from transvenous thoracic ductography were examined.

## Results

The results are shown in Table 2. In one patient (7.7%), transvenous cannulation could not be done, because of lack of identification of the JTV by lymphangiography due to the presence of a large thyroid tumor. Consequently, the catheter could not be inserted into the thoracic duct. Lipiodol also flowed into the right subclavian vein via a collateral pathway. For all of the remaining 12 patients (92.3%) in whom the JTV was identified, microcatheter



◀ **Fig. 2** Diagram of the thoracic duct. The thoracic duct is divided into a thoracic part that runs from the level of the intersection with the left brachiocephalic vein caudally in the thoracic cavity, and a cervical part that runs in the cervical area from the same level to the junction with a vein on the cranial side. *CP* cervical part, *TP* thoracic part, *LIJ* left internal jugular vein, *LSV* left subclavian vein, *LBCV* left brachiocephalic vein

passage through the JTV and visualization of the cervical part of the thoracic duct were achieved.

Insertion into the thoracic part through the cervical part was performed in nine patients. In these nine patients, the cervical part was simple type, and the catheter could be retrogradely passed through the prominent thoracic duct (Fig. 3A–D). In three patients (23.1%) who had a plexiform configuration in the cervical part of the thoracic duct, no catheter could be passed through the plexiform segment (Fig. 4A–D). The microcatheter could not be passed retrogradely through the plexiform thoracic duct to reach the thoracic part.

Insertion into the cisterna chyli through the thoracic part was achieved in six patients. In three patients, the catheter could not be advanced retrogradely in the thoracic part to reach the cisterna chyli. In the first of these three patients, the thoracic duct was interrupted, and the catheter could not be advanced beyond that point. In the second patient, it was difficult to advance the catheter retrogradely beyond the thoracic duct valve in the thoracic part. The valve was damaged by the micro guidewire, and the attempt to advance it further was discontinued. There was no extravasation from the damage, and the lumen was maintained; thus, visualization up to the cisterna chyli could be done with retrograde injection of the contrast agent through the microcatheter using a power injector. This patient had esophageal cancer, and the region including the thoracic duct had been exposed to radiation of 60 Gy. In the third patient, the thoracic part of the thoracic duct had a plexiform configuration at the level of thoracic vertebrae 10–12. It was impossible to advance the catheter retrogradely beyond the plexiform configuration. However, visualization up to the cisterna chyli could be done with retrograde injection of the contrast agent through the microcatheter using a power injector.

Thus, in eight of 13 patients (61.5%), transvenous thoracic ductography was successful. The success rate of transvenous thoracic ductography was 80% with the simple type and 0% with the plexiform type. Thus, the success rate was higher with the simple type ($p = 0.035$, Fisher's exact test).

Microballoon-occluded retrograde thoracic ductography and non-occluded retrograde thoracic ductography were performed in two patients with chylous ascites. In both patients, thoracic ductography was successful. In one of these two patients, the contrast agent reached the hepatic

**Table 2** Results

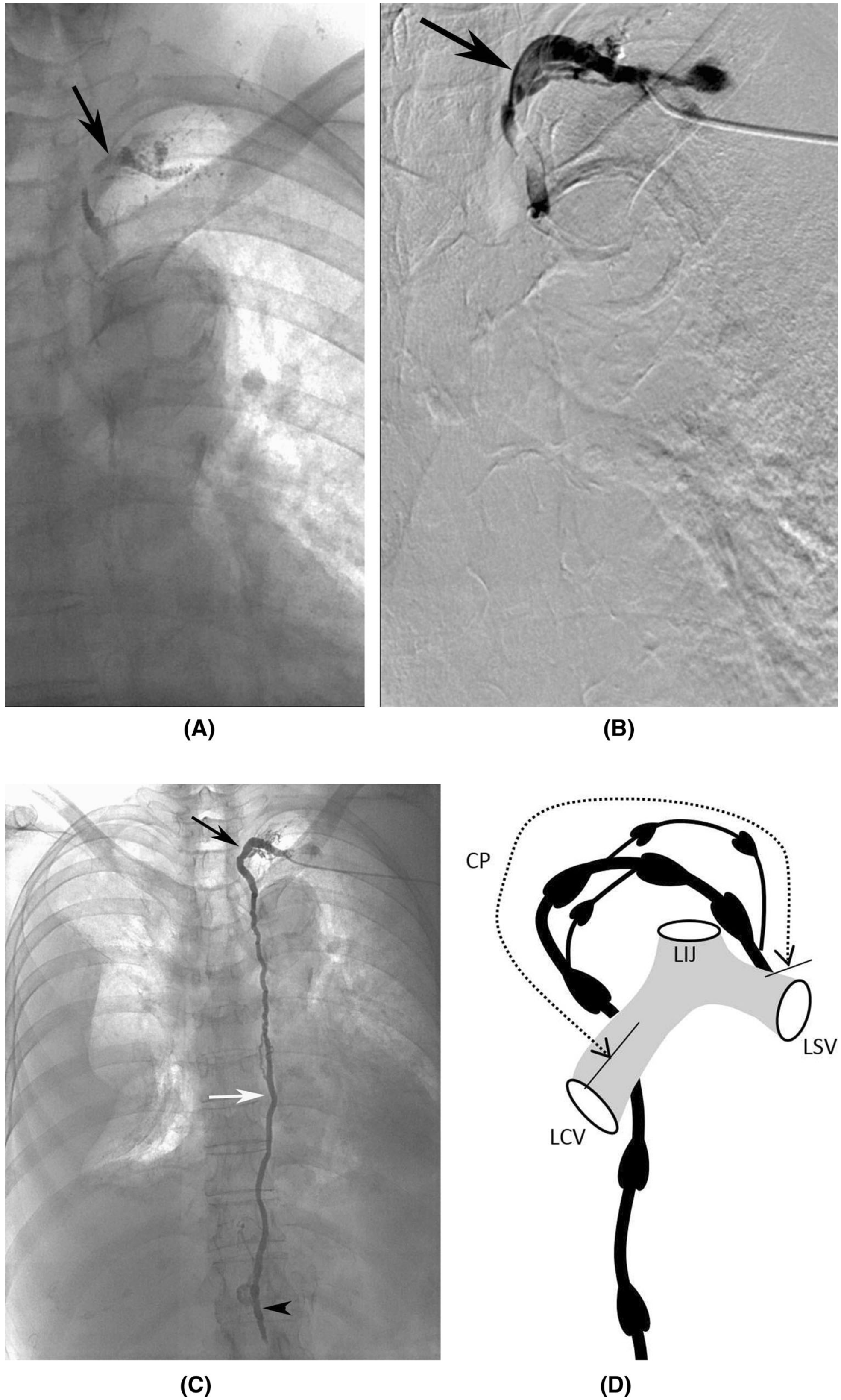
| Pt. no. | Type of the cervical part of the thoracic duct[a] | Arrival position of the tip of the microcatheter by transvenous retrograde cannulation[b] | Transvenous thoracic ductography[c] | Procedure time (min) |
|---|---|---|---|---|
| 1 | Simple | Cisterna chyli | Successful | 140 |
| 2 | Simple | Thoracic part | Successful | 235 |
| 3 | Simple | Thoracic part | Unsuccessful | 73 |
| 4 | Simple | None[d] | Unsuccessful | 244 |
| 5 | Plexiform | Cervical part | Unsuccessful | 69 |
| 6 | Plexiform | Cervical part | Unsuccessful | 165 |
| 7 | Simple | Cisterna chyli | Successful | 50 |
| 8 | Simple | Cisterna chyli | Successful | 87 |
| 9 | Simple | Cisterna chyli | Successful | 128 |
| 10 | Simple | Cisterna chyli | Successful | 42 |
| 11 | Plexiform | Cervical part | Unsuccessful | 112 |
| 12 | Simple | Cisterna chyli | Successful | 30 |
| 13 | Simple | Thoracic part | Successful | 151 |

[a]With respect to the shape of the cervical part, "simple type" was defined as the presence of at least one prominent thoracic duct, and "plexiform type" was defined as the cervical part took the form of a plexus

[b]The catheter was inserted to the cervical part, thoracic part, and cisterna chyli in 12, nine, and six patients, respectively (92.3, 69.2, and 46.2%)

[c]In eight of 13 patients (61.5%), transvenous thoracic ductography was successful

[d]The catheter could not be inserted into the thoracic duct


(A)
(B)
CP
LIJ
LSV
LCV
(C)
(D)

◀**Fig. 3** 69-year-old woman in whom bilateral chylothorax appeared during treatment for systemic lupus erythematosus. **A** Captured fluoroscopic image. Bipedal lymphangiography was done. One prominent thoracic duct is seen in the cervical part (black arrow). **B** Transcatheter thoracic ductography using iodinated water-soluble contrast media. The approach is from a brachial vein, and the tip of a 5-F multipurpose catheter is placed facing the junction of the thoracic duct with the vein (JTV). A 2.2-F microcatheter was inserted into the thoracic duct and advanced retrogradely to the cervical part. Iodinated water-soluble contrast media was injected from the microcatheter. One prominent thoracic duct is seen in the cervical part (black arrow). **C** Thoracic ductography. A microcatheter was advanced retrogradely to the cisterna chyli, and 10 ml of iodinated water-soluble contrast media was injected at a rate of 2 ml/s. One prominent thoracic duct is seen in the cervical part (black arrow). Thoracic part of the thoracic duct (white arrow). Position of the microcatheter tip inserted in the cisterna chyli (black arrowhead). **D** Diagram of the cervical part of the thoracic duct in this patient. *CP* cervical part, *LIJ* left internal jugular vein, *LSV* left subclavian vein, *LBCV* left brachiocephalic vein

hilar lymphatic ducts on microballoon-occluded retrograde thoracic ductography (Fig. 5A, B).

In the eight patients with successful transvenous thoracic ductography, the mean time from placement of the sheath to sheath removal was 117 ± 69 min (30–235 min).

Extravasation of lipiodol was seen on lymphangiography in only two cases, but transvenous thoracic ductography was unsuccessful in both. No extravasation of lipiodol on lymphangiography or extravasation of iodinated contrast medium on transvenous thoracic ductography was seen in any of the eight patients with successful transvenous thoracic ductography. In the patient with a chylous pericardial effusion, thoracic duct embolization using *n*-butyl cyanoacrylate was performed because myriad lymph ducts connecting to the hilar and pericardial regions from the thoracic duct were seen. Pericardial drainage was then unnecessary. There were no cases in which transcatheter embolization was done for chylothorax or chylous ascites.

Damage to a thoracic duct valve occurred in one patient. There were no other complications.

## Discussion

In the cervical part of the thoracic duct, there are many branches that join from the cervical region or arms. While injection was done in the cervical part, the contrast agent did not reach the thoracic part retrogradely even with pressure injection, instead spreading into the branches. In imaging of the entire thoracic duct region from the cisterna chyli, it is thought to be necessary to at least pass through the cervical part and reach the thoracic part. However, it might be difficult to insert the microcatheter to the thoracic part. Cannulation with the microcatheter tip advancing beyond the JTV to the thoracic duct could be done in 12 of the 13 patients (92.3%), but in three of these patients, it could not be advanced retrogradely in the cervical part, and cannulation could not be done because of the plexiform configuration of the cervical part. When the plexiform type was present in the cervical part, the respective thoracic ducts were narrow, and retrograde advancement could not be done because of the presence of valves and complex branching. In one report, the cervical part of the thoracic duct was plexiform type in 26% [9]. In the present patients, the cervical part of the thoracic duct was plexiform type in 23.1%, similar to that report. In the present study, no retrograde advancement of the catheter was achieved through the plexiform segment in cases of plexiform type (three of three cases).

The success rate for transvenous retrograde thoracic ductography was low, at 61.5%. One cause of this may have been that the catheter could not be cannulated to the thoracic part in any of the patients with the plexiform type. Excluding this method in such patients is thought to be one choice. The present results show that this can be determined by lymphangiography using lipiodol prior to cannulation. Looking only at the cases in which the cervical part was the simple type, the success rate was 80%.

Transvenous retrograde thoracic ductography was followed by embolization in only one patient, who had a chylous pericardial effusion. Since extravasation of contrast media in thoracic ductography was not seen in other patients, embolization was not done. This is only conjecture on our part, but since the pressure in the thoracic duct is thought to be low in patients in whom the thoracic duct discharges into the venous angle, conservative treatment may be successful. In cases when leakage continues despite long-term conservative treatment, there may be failure in a lymph duct whose connection with the venous angle is cut off. Thus, such a lymph duct may be beyond the range that a catheter could reach by transvenous retrograde cannulation. All of the thoracic duct embolizations that we have done to date for refractory chylothorax in which conservative treatment was unsuccessful were done with a transabdominal approach. In all of these cases, the thoracic duct was interrupted and did not discharge into the venous angle, and a transvenous retrograde approach was not indicated.

No extravasation of lipiodol in lymphangiography with lipiodol was seen in any of the patients in this study in whom transvenous retrograde thoracic ductography was successful. For the time being, therefore, it may be that transvenous retrograde thoracic ductography should not be done in these patients.

This technique is safe and does not require any special devices or instruments, and it is already being tried at a number of institutions for the diagnosis of chylous leakage and as a means of embolization; nevertheless, the number

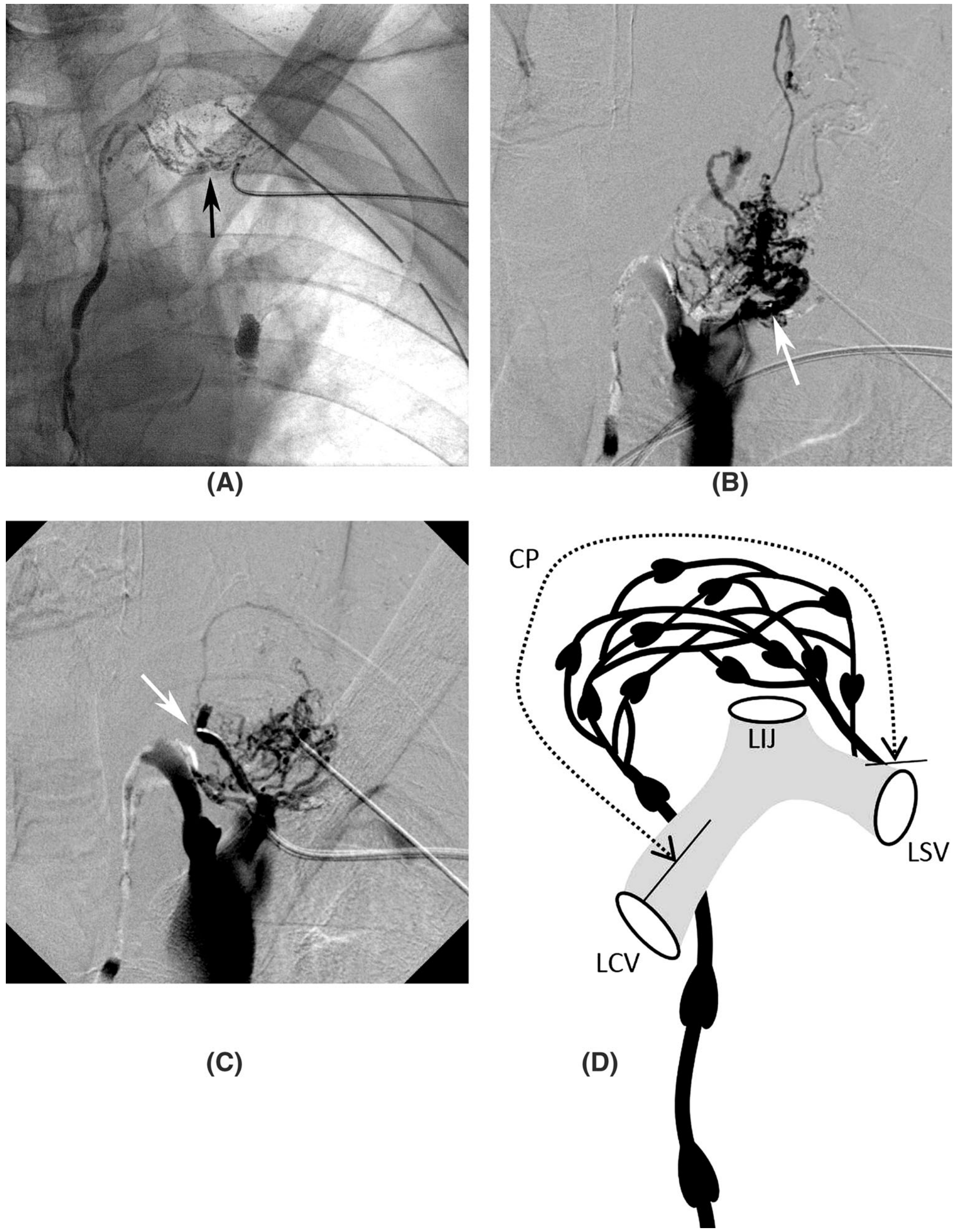



**Fig. 4** 65-year-old man who underwent left upper lobectomy for lung cancer, after which left chylothorax appeared. **A** Radiograph following intranodal lymphangiography. The cervical part has a plexiform configuration (black arrow). **B**, **C** Transcatheter thoracic ductography using iodinated water-soluble contrast media. Cannulation of the microcatheter tip beyond the junction of the thoracic duct and vein to the thoracic duct could be done, but it could not be advanced retrogradely beyond the cervical part because of the many duct junctions. Microcatheter tip (white arrow). **D** Diagram of the cervical part. The cervical part has a plexiform configuration. *CP* cervical part, *LIJ* left internal jugular vein, *LSV* left subclavian vein, *LBCV* left brachiocephalic vein

of reports was small. We consider that this is because extravasation is not seen, even when transvenous retrograde thoracic ductography is performed (e.g., this study), and few patients become candidates for embolization. However, in one published case report, extravasation was confirmed with retrograde transvenous thoracic ductography for chylothorax, and embolization was successful [10]. Even for chylous ascites, extravasation was seen, and embolization was successful [11]. In another report, the causative site for chylous ascites was identified with microballoon-occluded retrograde thoracic ductography, and embolization was successful [12]. According to published case reports, there seem to be patients in whom transvenous retrograde cannulation technology is useful for identifying the site of leakage and embolization.

Considering both the present results and the past literature, lymphangiography findings seem to be a useful reference prior to catheter cannulation in judging indications for embolization with a transvenous retrograde approach. Those are cases in which (1) the thoracic duct discharges into the venous angle, (2) the cervical part of the thoracic duct is the simple type, and (3) lipiodol leakage is confirmed to be in a range that the catheter can reach through retrograde cannulation.

Even in patients who can be cured with conservative treatment, performing transvenous retrograde thoracic

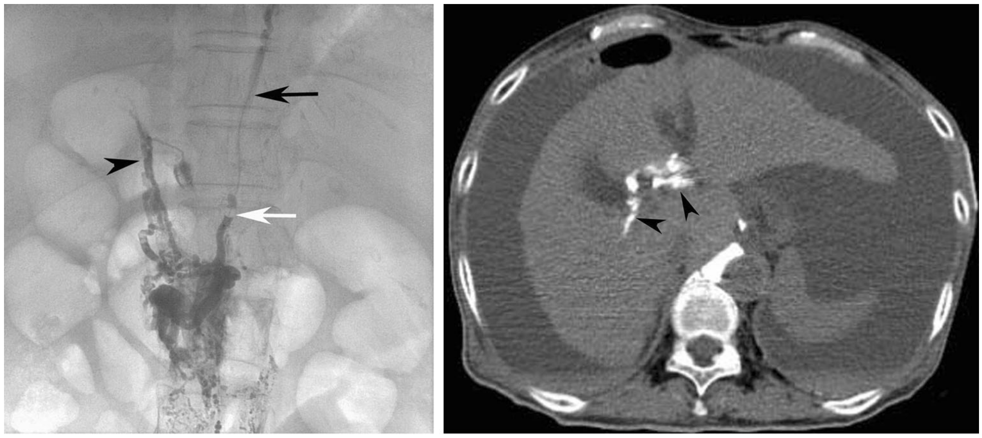



**Fig. 5** 71-year-old woman with chylous ascites following gastrectomy for gastric cancer. **A** Balloon-occluded retrograde thoracic ductography. A microballoon catheter reached the cisterna chyli, and iodinated water-soluble contrast media was injected retrogradely under balloon occlusion. The iodinated water-soluble contrast media flows retrogradely to the hepatic hilar lymphatic ducts duct. Thoracic duct (black arrow), balloon (white arrow), and hepatic hilar lymphatic ducts (black arrowhead). **B** CT scan immediately after contrast. Visualized hepatic hilar lymphatic ducts (black arrowhead). Extravasation of iodinated water-soluble contrast media or lipiodol is not seen

ductography, which is safe and does not require special devices, is thought to be acceptable before conservative treatment. If it can be followed by embolization, it may be possible to achieve a shorter treatment period than reported in the current literature [10–12].

The limitations of the present study include the small number of patients.

## Conclusion

Transvenous retrograde thoracic ductography was successful in only eight of 13 patients (61.5%), but when the cervical part was the simple type, it was successful in eight of 10 patients (80%). Whether it is the simple type can be understood from lymphangiography prior to cannulation of a catheter. This technique is safe and minimally invasive, and so if the thoracic duct discharges into the venous angle and the cervical part is the simple type, it may be actively selected as an approach for diagnosis and embolization.

**Compliance with Ethical Standards**

**Conflict of interest** The authors declare that they have no conflict of interests.

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