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TECHNICAL NOTE

Intranodal Lymphangiogram: Technical Aspects and Findings

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Abstract
Purpose To report the technical results and imaging findings of intranodal lymphangiogram (INL).
Materials and Methods we studied four patients (three men, one woman) who had persistent chylous leakage despite conservative treatment after esophageal cancer surgery. Their mean age was 68 years (range 61–74 years). The inguinal or femoral lymph node was punctured under ultrasound guidance using a 60-mm-long, 23-gauge needle. If the lipiodol injected via the needle showed granular nodules on fluoroscopy, lipiodol injection was continued manually at a rate of 1 mL/3 min for INL. If the cisterna chyli was detectable on the lymphangiogram, it was punctured percutaneously via the abdomen by a needle under fluoroscopy, and thoracic duct embolization was performed.
Results INL was successful in all patients. Lymphaticovenous anastomoses at the femoral or pelvic region were confirmed in all four patients. In one case, a different ipsilateral lymph node was punctured because major flow of lipiodol into the veins through a lymphaticovenous anastomosis occurred. Catheter cannulation and embolization were successful for three of the four patients. In unsuccessful procedures, the cisterna chyli was not visualized, and puncture was not possible.
Conclusions INL succeeded in all patients. Lipiodol leaked into the vein through a lymphaticovenous anastomosis at the femoral or pelvic region in all patients.

Keywords Chylothorax · Intranodal lymphangiogram · Pulmonary embolization · Thoracic duct embolization

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Introduction

Percutaneous thoracic duct embolization (TDE) using bilateral pedal lymphangiogram for high-output chylothorax was first reported by Cope et al. [1] in 1999. The problem with TDE is that the bilateral pedal lymphangiogram required for this procedure has not been commonly performed in recent years. As a way to overcome this problem, Nadolski and Itkin [2] reported a method of performing TDE using intranodal lymphangiogram (INL). However, there is little information on the technical methods of INL. The objective of this study was to present our technique of INL for TDE.

Materials and Methods

The study protocols for this retrospective analysis were approved by our institutional review board. The requirement for informed consent was waived. Data were gathered

Table 1 Demographic data, treatment before TDE, and volume of effusion drainage

Patient no.	Sex	Age (years)	Conservative treatment			Surgical thoracic duct ligation after conservative treatment		Pre-TDE drainage (mL/day)
			Duration (days)	Pretreatment drainage (mL/day))	Posttreatment drainage (mL/day)	Performed	Postoperative drainage (mL/day)	
1	M	67	166	2,500	1,500	No	–	1,500
2	F	74	30	3,500	2,500	Yes	4,000	4,000
3	M	71	28	2,000	3,000	No	–	3,000
4	M	61	51	600	600	Yes	600	600

TDE thoracic duct embolization

retrospectively by reviewing clinical records, including images.

Patients

The subjects comprised four patients with esophageal cancer. In patients one, two, and three, esophagectomy was performed. In patient four, because cancer progression was confirmed after thoracotomy, esophagectomy was not performed. Three patients (patients one, two, and three) developed high-output chylothorax with daily chest drain output of $\geq$1,000 mL/day after the surgery. One patient (patient four) had chylous leakage of 600 mL/day at the incision site. In patients two and four, a second surgery of thoracic duct (TD) ligation was performed for the chylous leakage. Because chylous leakage persisted despite the second surgery or conservative treatment, TDE was performed in all patients. Table 1 shows the subjects' demographic data, TDE pretreatment, and amount of effusion drainage before and after conservative treatment and TD ligation.

Intranodal Lymphangiogram

A high-frequency (13 MHz) superficial linear transducer and a diagnostic ultrasound device (Prosound 3500SX and UST-5413, Hitachi Aloka Medical, Tokyo, Japan) were used to visualize the lymph nodes. Local anesthesia of the puncture site was administered with 1 % lidocaine; then the inguinal or femoral lymph node was punctured under ultrasound guidance using a 60-mm-long, 23-gauge Cathelin needle (Terumo Europe, Leuven, Belgium). The puncture was made so that the tip of the needle was placed at the junction between the cortex and the hilum. Lipiodol was then injected manually, with the tip of the needle monitored under fluoroscopy (Axiom Artis dTA, Siemens Medical Solutions, Erlangen, Germany) when injection was started. If the injected lipiodol showed granular nodules on fluoroscopy at the start of injection and the lymphatic vessels continuous with them were visualized, the lymph node puncture was judged to be successful, and injection was continued (Fig. 1A). If enhancement of spreading lobulated nodular pooling with no visualization of lymphatic vessels indicated that the puncture was unsuccessful, injection was stopped, and the lymph node was repunctured (Fig. 1B). Lipiodol injection was continued manually at a rate of 1 mL/3 min and stopped at the point at which the lymphatic vessels at the level of the third lumbar vertebra were visualized. During injection, fluoroscopy was used intermittently to confirm that the injected lipiodol was entering the lymphatic vessels. Continuous fluoroscopy was not used to avoid excessive radiation exposure. Leakage of lipiodol from the puncture site was tolerated as long as it was also entering the lymphatic vessels. If there was no flow of lipiodol into the lymphatic vessels despite its injection, puncture was repeated at a different lymph node. The presence of lymphaticovenous anastomoses was confirmed by fluoroscopy. In the event of major flow of lipiodol into the veins through lymphaticovenous anastomoses, injection was halted, and a different ipsilateral lymph node was punctured or only the contralateral lymph node was used for injection.

Transabdominal TDE

Local anesthesia of the skin at the puncture site was achieved with 1 % lidocaine. Antibiotics were not provided. The cisterna chyli was punctured percutaneously via the abdomen by inserting the needle at an angle of approximately 10–20 degrees toward the head under fluoroscopy. A 22-gauge, 20-cm Chiba needle (Angiotech, Gainesville, FL) was used for the puncture. A 0.016-inch wire (Iris, Piolax Medical Devices, Kanagawa, Japan) was inserted and advanced into the TD. A 2.2F microcatheter (Sirabe, Piolax Medical Devices) was advanced into the TD over the wire. Iodinated contrast medium (iopamidol, Iopamiron 370, Bayer Schering Pharma, Berlin, Germany) was manually injected via the catheter for contrast enhancement of the TD. The site of leakage and the location of occlusion of the TD were confirmed. The tip of the

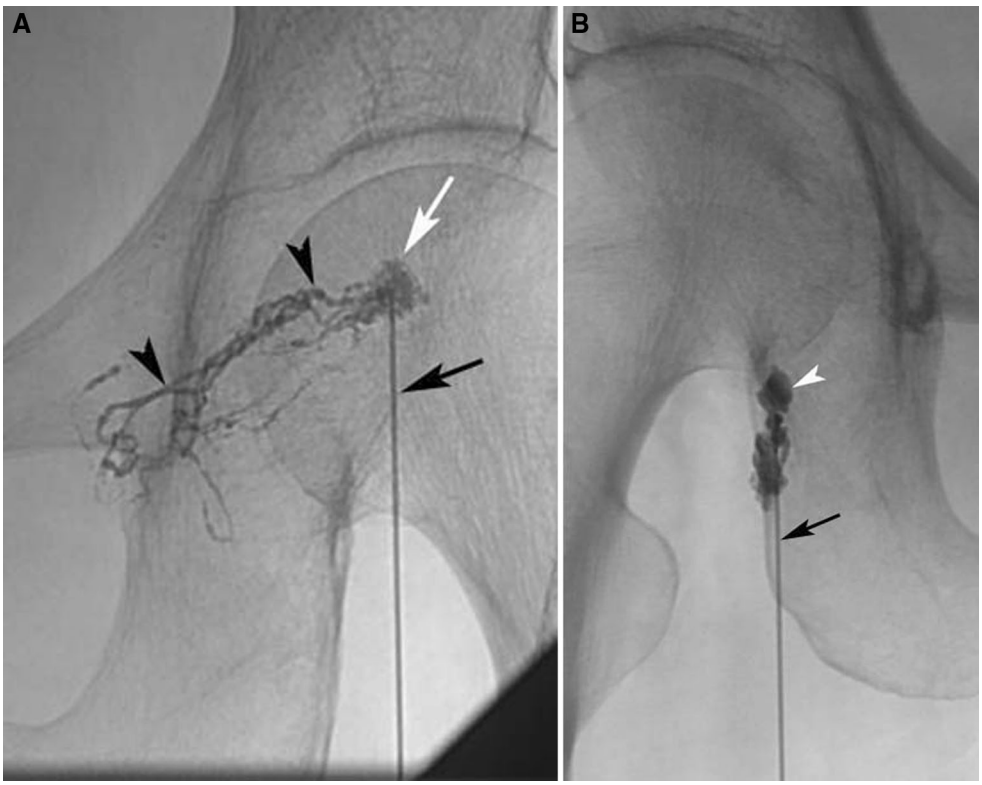

Fig. 1 A 74-year-old woman underwent thoracic duct embolization (TDE) after developing high-output chylothorax after esophagectomy for esophageal cancer. Intranodal lymphangiogram was performed for TDE. **A** Lipiodol is manually injected via the Cathelin needle. The lymph node shows enhancement of the granular nodule (*white arrow*), and the lymphatic vessels continuous with it are detected (*black arrowheads*). Lymph node puncture is successful. Cathelin needle (*black arrow*). **B** A spreading lobulated nodular pooling (*white arrowhead*) with no visualization of lymphatic vessels indicates that lymph node puncture is unsuccessful. Cathelin needle (*black arrow*)

microcatheter was advanced to a position as close as possible to the site of leakage. *N*-Butyl cyanoacrylate (NBCA) mixed with lipiodol was used as the embolization material. Once the NBCA had reached the site of leakage, the TD, cisterna chyli, and puncture route were all embolized with NBCA while the catheter was being withdrawn.

Results

Table 2 shows the results of lymphangiogram. INL was successful in all patients. In patients two and three, the numbers of failed punctures were one and two, respectively. Lymphaticovenous anastomoses at the femoral or pelvic region were confirmed in all four patients. In patient four, a different ipsilateral lymph node was punctured because major flow of lipiodol into the veins through a lymphaticovenous anastomosis occurred (Fig. 2). There were no clinical findings of pulmonary embolization in all four patients. In all patients, continuity between the TD and veins was interrupted as a result of surgical ligation of the TD.

Catheter cannulation and embolization were successful for three of the four patients. In patient three, in whom the cisterna chyli was not visualized, cannulation of the TD was not possible, and TDE was not achieved. In this case, lipiodol drained into the TD via a collateral channel from the lumbar lymphatic vessels.

Discussion

Although over a decade has passed since the first report of TDE, the number of reported TDEs remains relatively low, and the largest series have been reported from a small number of institutions [3, 4]. It has been suggested that this may be due to the technical difficulty involved in lymphangiogram and cannulation of the TD. Bilateral pedal lymphangiogram has been performed with decreasing frequency over the past 20 years, with fewer doctors now able to carry out this procedure, and lymphangiogram pumps are difficult to obtain [5]. INL, which was first reported in 1967, requires neither special equipment nor incisions [6]. There have been few subsequent reports of its use, however, and it has not been generally used for diagnostic lymphangiogram. This may be because of the difficulty of lymph node puncture. This problem may have been solved

Table 2 Results of lymphangiogram

Patient no.	Bilateral lymph node injection	No. of failed lymph node punctures	Total volume of lipiodol injected (mL)	Presence of LVA	Lymphangiography	Complications
1	Successful	0	14	Yes	Successful	No
2	Successful	1	17	Yes	Successful	No
3	Successful	2	10	Yes	Successful	No
4	Successful	0	16	Yes	Successful	No

LVA lymphaticovenous anastomosis

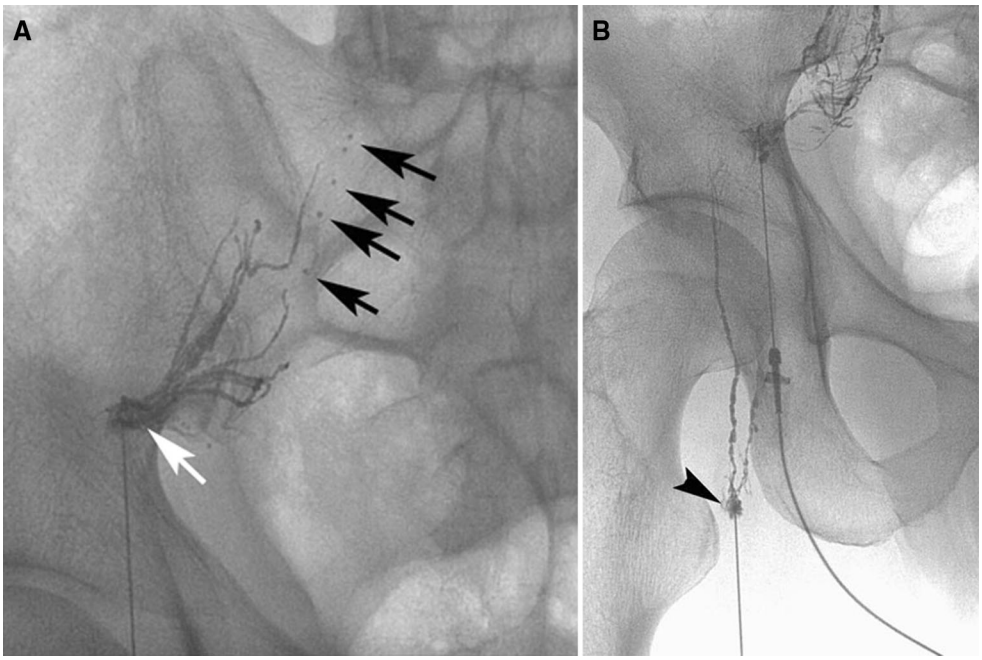

Fig. 2 A 61-year-old man with chylous effusion leakage of 600 mL/day at the incision site after surgery for esophageal cancer. Intranodal lymphangiogram for thoracic duct embolization is performed. **A** The inguinal node (*white arrows*) is punctured, and then lipiodol is injected. Lymphatic vessels are visualized. However, injection is halted because major flow of lipiodol into the veins through lymphaticovenous anastomosis has occurred. *Dots* are lipiodol in the vein (*black arrow*). **B** Another ipsilateral lymph node is punctured (*black arrowhead*)

by the improved performance of the latest ultrasound devices, which enable even impalpable lymph nodes to be punctured under ultrasound guidance. Compared with bilateral pedal lymphangiogram, INL shortens the time required and does not require a lymphangiogram pump [2].

In the present cases, lymphaticovenous anastomoses in the femoral or pelvic region were confirmed in all four patients under fluoroscopy. Peripheral lymphaticovenous anastomoses have also been reported in bilateral pedal lymphangiogram, as has the rare complication of pulmonary embolization [7, 8]. When bilateral pedal lymphangiogram was performed in the past, it is probable that plain X-rays were normally obtained after injection, meaning that lymphaticovenous anastomoses could not be confirmed because still images were obtained. We do not know how much inflow of lipiodol into the veins through lymphaticovenous anastomoses was tolerated, and to our knowledge, it has yet to be reported. With both bilateral pedal lymphangiogram and INL, most of the lipiodol that passes through the TD flows into the veins, and pulmonary oil embolization occurs. When lipiodol leaks into the vein through lymphaticovenous anastomoses, pulmonary oil embolization also occurs. If a lymphaticovenous anastomosis is confirmed, injection of lipiodol might have to be stopped at once to prevent severe pulmonary embolization. However, we did not stop injection. Because some of the injected lipiodol remains in lymph nodes and lymphatic vessels, the amount that actually flows into the veins is unknown. Even so, with lymphangiogram that is normally conducted with $\leq$20 mL of lipiodol, pulmonary oil embolization does not cause symptoms unless respiratory function is severely impaired. We therefore considered the

lipiodol that flowed into veins through lymphaticovenous anastomoses to also be acceptable. However, the safety and tolerance of the leakage of lipiodol into the veins are still unclear. The purpose of INL is to visualize the lymphatic vessels, cisterna chyli, and TD, and this cannot be achieved if much of the lipiodol injected via lymphaticovenous anastomoses flows into the veins. Therefore, injection was stopped when a large amount of lipiodol entered the veins. However, whether to discontinue injection was determined by the operator on the basis of fluoroscopic findings, without any clear criteria.

When lipiodol is injected until the lymphatic vessels at the L3 level are visualized, the amount is sufficient to enable visualization of the cisterna chyli and TD, which is necessary to perform TDE. When lymphatic vessels at the level of L3 are visualized, the cisterna chyli will soon be visualized, and this is a good time to start the TDE procedure. If injection is continued until the cisterna chyli is visualized, lipiodol will pass through the TD before the next TDE, and lipiodol that is not needed to perform the TDE procedure will have been injected.

Lymph node puncture failed three times and was redone. Ultimately, the lymph node puncture was successful in all cases, and INL could be obtained. When puncture fails and a large amount of lipiodol leaks into the area surrounding the lymph nodes, repeat puncture of a lymph node in the same area becomes difficult. It is important to stop injection when fluoroscopic images at the start of lipiodol injection reveal spreading lobulated nodular pooling with no visualization of lymphatic vessels.

Limitation

This study had the limitation that it was a retrospective study involving a small number of patients.

Conclusions

INL succeeded in all patients. Lipiodol leaked into the vein through a lymphaticovenous anastomosis at the femoral or pelvic region in all patients. In 3 of the 4 patients, the cisterna chyli was detected by INL and could be punctured, and TDE was achieved.

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

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