Management of Unremitting Chylothorax by Percutaneous Embolization and Blockage of Retroperitoneal Lymphatic Vessels in 42 Patients

Constantin Cope, MD, and Larry R. Kaiser, MD

PURPOSE: To demonstrate the applicability, technique, and efficacy of percutaneous transabdominal catheter embolization or needle disruption of retroperitoneal lymphatic vessels in the treatment of high-output or unremitting chylothorax.

MATERIALS AND METHODS: Forty-two patients (21 men, 21 women; mean age, 56 y; range, 19–80 y) who had chylothorax with various etiologies were referred from the thoracic surgery department for treatment as soon as chylothorax was documented. The thoracic duct was punctured and catheterized via a peritoneal cannula to facilitate embolization with use of microcoils, particles, or glue; if there were no lymph trunks that could be catheterized, attempts were made to disrupt lymph collaterals with use of needles.

RESULTS: The thoracic duct was catheterized in 29 patients and embolized in 26 patients. In patients with lymph trunks that could be catheterized, treatment resulted in cure within 7 days in 16 patients and partial response with cure within 3 weeks in six patients. In the patients with lymph trunks that could not be catheterized (n = 16), disruption with use of needles resulted in cure in five patients and partial response in two patients. Cure and partial response rates after thoracic duct embolization and needle disruption were 73.8%, with no morbidity. Surgical thoracic duct ligation was performed in seven patients. The nonprocedural mortality rate was 19%. Follow-up was 3 months or longer.

CONCLUSIONS: Effective percutaneous treatment of high-output or medically uncontrollable chylothorax was performed promptly and safely in more than 70% of referred cases. This procedure should be attempted, especially if patients are very ill, before riskier surgical thoracic duct ligation is considered.

Index terms: Chylothorax • Lymphatic system, embolization • Thoracic duct

Abbreviation: TD = thoracic duct

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<thead>
<tr>
<th>Groupings</th>
<th>No. of Patients (Sex Ratio, M:F)</th>
<th>TD Embolization Fluid Output (N)</th>
<th>Chylothorax Cure and Partial Response, N</th>
<th>Follow-up (N)</th>
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<tr>
<td>A Esophagectomy, N = 9</td>
<td>10 (8:2)</td>
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<td>Ligation (2)</td>
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<td>B Aortic surgery</td>
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<td>C Cardiac surgery</td>
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<td>CABG, N = 3</td>
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<td>Total</td>
<td>42</td>
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Note.—Two patients had only TD ligation examinations.
of this study was to demonstrate the safety and efficacy of these procedures in a larger prospective series of patients with acute high-output chylothorax or chronic chylous pleural effusions unresponsive to medical therapy.

MATERIALS AND METHODS

Study Group

Forty-two patients were treated during a period of 4 years for the management of symptomatic chylothorax (Table 1). All patients were referred from our institution’s cardio-thoracic department because of high-output chylothorax or from outside institutions because of recurrent bouts of chylous pleural effusions, which could not be cured by diet, repeated thoracentesis, pleurodesis, or surgical TD ligation. These interventional procedures were performed immediately after the chylous effusion was diagnosed after chest surgery or within a few days after the patient was admitted from a referring hospital. Four patients arrived by ambulance, underwent treatment, and returned to their referring hospitals the same day. The same operator performed all procedures.

Table 2

<table>
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<tr>
<th>Interventions</th>
<th>N</th>
<th>Cure, N</th>
<th>Partial Response, N</th>
<th>No Response, N</th>
<th>Morbidity, N</th>
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<td>16</td>
<td>6</td>
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<td>0</td>
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<tr>
<td>Needle disruption of lymphatic vessels</td>
<td>16</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>0</td>
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<tr>
<td>Pleurodesis</td>
<td>4</td>
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<td>1</td>
<td>1</td>
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<td>7</td>
<td>5</td>
<td>2</td>
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<td></td>
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</tbody>
</table>

Note.—* Includes three repeat TD embolizations and three TD catheterizations without embolization.

Table 3

<table>
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<th>Procedure</th>
<th>N</th>
<th>TD Ligation (Cure), N</th>
<th>Medical Therapy, N</th>
<th>Death, N</th>
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<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Needle disruption of lymphatic vessels</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>3</td>
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</table>

Techniques

The patients underwent normalized coagulography; a steroid preparation was administered if the patient was allergic to contrast medium. When possible, 1–2 cups of barium preparation were administered the night before the procedure to opacify the transverse colon and a barium milkshake was administered just before the procedure to stimulate lymphatic flow. A wide-spectrum antibiotic was administered intravenously at the start of the procedure.

Patient consent to TD embolization was obtained. Pedal lymphography was performed; to prevent possible pulmonary complications, no more than 20 mL of Ethiodol (Savage Laboratories, Melville, NY) was used (6). Because the purpose of lymphography was to assess the presence of cisternae chyle or large retroperitoneal lymph trunks that could be catheterized in the upper abdomen dextral to the aorta, most studies were performed in the right foot with 8–12 mL of contrast material; bipedal lymphography was performed only if there was inadequate opacification of paraaortic lymphatic vessels. The flow of iodinated oil was followed fluoroscopically until retroperitoneal lymph trunks were opacified to the level of the diaphragm.

The technique for transabdominal TD occlusion (Fig 1) has been described in detail (5). Institutional review board approval was obtained.
After local anesthesia was administered, a midline puncture was made 5–10 cm below the xiphoid cephalad to the transverse colon and, with the patient consciously sedated, a 0.035-inch J-tip guide wire was threaded into the peritoneal cavity through the sheath of a micropuncture set to allow insertion of a 10-F peel-away sheath. A 13-cm-long bulbous-tip stiff 8-F malleable cannula (Cook, Bloomington, IN) was introduced through the sheath to the peritoneal cavity to provide accurate guidance of a coaxial 20–25-cm-long flexible 21–22-gauge skinny needle, which was used to puncture the lymphatic trunk and prevent the microcatheter and guide wire from looping in the peritoneal cavity. In three patients, a short 6-F introduction sheath was used instead of a directional cannula.

After localized anesthesia of the opacified cisterna chyli (Fig 2a) or a retroperitoneal lymph trunk, usually at the level of the first lumbar vertebra, a 0.018-inch hydromer-coated microguide wire (Gold-tip or V18; Boston Scientific/Medi-tech, Watertown, MA) was threaded through the needle into the TD (Fig 2b) and a 3-F microcatheter was inserted and advanced to the chest (Fig 2c). In some cases, a short 3-F homemade Teflon dilator with a long, tapered tip was used to facilitate entry of the microcatheter to the lymphatic trunk. Care was taken not to puncture the aorta by advancing the skinny needle slightly to the right of its expected location. Nonionic contrast medium (5–10 mL) was injected to opacify the complete length of the TD and assess branch pattern, including parallel lymph ducts and the site of duct leakage.

Three to eight overlapping complex platinum microcoils, 5 cm long and 3–6 mm in diameter (Target Vascular; Boston Scientific/Medi-tech), were packed in a row to form a dam within the proximal TD above the diaphragm and below the suspected leak (Fig 2d). If the coils were not completely occlusive after injection of the contrast medium (5–10 mL) was injected to opacify the complete length of the TD and assess branch pattern, including parallel lymph ducts and the site of duct leakage.

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Figure 3. Lymphatic needle disruption in a patient who had undergone coronary artery bypass graft placement and developed high-output left-sided chylothorax. The patient was cured and the chest tube was removed after 8 days. (a) After bipedal lymphography, most retroperitoneal lymphatic vessels beyond the second lumbar vertebral level were occluded; a few remaining small lymphatic collaterals were disrupted with a 21-gauge needle through the metal cannula. (b) The TD was not opacified; lymphatic collaterals (arrows) are seen in the mediastinum.

Endpoints and Definitions

Results of interventions were classified as “cure,” “partial response,” or “no response” (Tables 1 and 2). “Chylothorax cure” was defined as a prompt reduction of daily chest fluid output from a baseline value of 0.3–17 L to a range of 50–100 mL within 3–7 days and removal of the thoracostomy tube within a few days thereafter, when the patient had resumed a normal diet with no increase in pleural effusion. “Partial response” was defined as a prompt postprocedural decrease in chyle output but persistence or recurrence of chylothorax with a fluid output of 100–200 mL/d, which required continued management with a low-fat diet, repeat thoracentesis, pleurodesis, or surgical TD ligation. The majority of the patients in this group were cured within 2–3 weeks. “Nonresponse” (Table 3) was defined as no change in postprocedural chyle output. The majority of patients in this group who had a high fluid output (class A) required TD ligation and/or pleurodesis but some were too debilitated to undergo surgery and died of medical or surgical complications.

The authors included only procedural complications associated with pedal lymphography, such as pedal incisional infection, dye allergy, and pulmonary dysfunction caused by oil embolization, and complications associated with transabdominal puncture and catheterization of retroperitoneal lymphatic ducts, such as intraperitoneal hemorrhage, peritonitis, chylous ascites, thoracic duct rupture, and microcoil misplacements.

During the 3-month period after the patients were discharged, information on the patients’ health status and possible recurrence of chylothorax was obtained by telephone from the patients, their families, or the referring physicians.

RESULTS

The ability to catheterize the TD after lymphography was completely dependent on the availability of suitably sized cisterna chyli or retroperitoneal lymphatic trunks; it was possible to successfully catheterize all uninterrupted lymphatic channels that were more than 2 mm in diameter. In 26 patients, the TD was catheterized via recognizable cisterna chyli in 22 procedures and retroperitoneal lymphatic trunks in seven procedures (Table 2).

In the 16 patients in whom lymphatic trunks could not be catheterized and in whom opacification was performed via a lymphatic plexus comprising a variable number of small retroperitoneal channels approximately 1 mm in diameter or interrupted segments of ducts, some channels and ducts coursed cephalad to fill the mediastinum whereas others deviated lateral to the lumbar spine to connect with ducts or collaterals in the chest (Table 2). In all these patients, an attempt was made to interrupt the flow of lymph by repeated needling of one or more of the lymphatic channels that were most likely to feed the chyle fistula (Fig 4).

The time interval between the start of pedal lymphography and the opacification of suitable retroperitoneal...
in one patient who had a malignant rather than a chylous effusion. A patient who had undergone cardiac transplantation underwent repeat embolization twice and another patient with a pleura-pericardial effusion of unknown etiology underwent repeat embolization once; cure was achieved in both these patients. Three patients who had undergone esophagectomy underwent catheterization but not embolization; two patients had undergone TD ligation that had been performed intraoperatively and was completely occlusive and one patient had primarily chylous ascites.

The patients in group A and the postsurgical/traumatic chylothorax category were the most ill and at highest risk for development of sepsis and irreversible metabolic imbalance because of high T-cell, protein, and fluid losses (7). Of the 29 patients in group A, 75% (n = 21) were cured as a result of percutaneous interventions in 16 patients, TD ligation in five patients, and complementary pleurodesis in one patient, with no procedural mortality (Table 1). Of the 29 patients with traumatic chylothorax (penetrating and nonpenetrating, groupings A, B, C, D, and G), 76% (n = 22) were cured or had partial response as a result of percutaneous interventions, whereas of the 13 patients with nontraumatic chylothorax (groupings E and F), 84% (n = 11) were cured or had partial response. Three of five patients in groupings E and F who had partial response had unusually prolonged or recurrent effusions beyond 3 weeks despite the complementary use of TD ligation in one patient and pleurodesis in two patients. There were six non-procedure-related deaths in the traumatic chylothorax group compared with two in the nontraumatic chylothorax group during 3-month follow-up.

In summary (Table 2), TD embolization and needling-disruption of lymphatic vessels in 29 patients led to immediate chylothorax cure in 21 patients (72.6%), with no long-term recurrence. There was a partial response in eight patients (27.4%). If the two post-TD-ligation studies that were shown to be secure are added, the procedural success rate for TD catheter procedures increases to 78.6%. The sum of the rates of complete and partial response to percutaneous inter-

trunks was often delayed from a normal period of approximately 45–60 minutes to more than 2 hours in some patients who had extensive occlusive lymphatic vascular patterns. The average duration of transabdominal catheterization and embolization and/or needle disruption procedures after pedal lymphography was 30 minutes.

An intrathoracic chyle leak was identified in 14 patients in the group A and in two patients in group B. Except for the major leaks, which could be visualized early in the procedure by lymphography, most were seen only by selective TD opacification with aequous contrast media.

The treatment regimens and long-term follow-up of the 42 patients in this study are summarized in Table 1. In the 26 patients who underwent TD embolization (Table 2), a cure was achieved in 16 patients, partial response in six patients, and no response for the 42 patients in this study is 73.8%. There was no discernible morbidity or mortality as a result of these procedures, despite the transgression of fine needles and catheters through interposed viscera and vessels. There were no sequelae after accidental puncture of the aorta in two patients. In the group of patients for whom percutaneous treatment failed (Table 3), five patients underwent TD ligation whereas four died of surgical complications or their primary disease.

Patients who had partial response or no response as a result of percutaneous treatment underwent secondary treatments. Talc pleurodesis was performed in five patients who had partial response to percutaneous treatment and resulted in cure in two patients. Surgical TD ligation resulted in a complete cure in five of seven patients; one patient had a partial response with eventual cure whereas a nonresponder who was found to have advanced cirrhosis probably did not have chylothorax. There was no mortality associated with pleurodesis or TD ligation. All deaths (n = 8), which occurred over a follow-up of 3 months, were associated with complications from the patient's primary disease, inability to control the pleural effusion, pulmonary emboli, or surgical complications (Table 1).

DISCUSSION

The TD is a 2–4-mm-wide duct with multiple valves, which arises from the cisterna chylī in the upper abdomen to empty either directly or through multiple branches into the left jugular or subclavian veins. The flow of chyle in the TD varies from 2 to 4 L/d. In the presence of an untreated chylothorax, the major loss of chyle, which contains 2%–6% protein and 80% T-cells and electrolytes, can lead patients to experience life-threatening weakness, dehydration, edema, emaciation, and hemodynamic distress as a result of hypoproteinemia, hyponatremia, lymphopenia, and lung compression (8). Minor TD lacerations can heal experimentally without developing a chyle fistula (9). For symptomatic chylothorax to develop, there must be laceration of the TD or one or more of its lymphatic branches that is severe enough to allow persistent leakage of
chyle into the mediastinum. Then, chyloma will form that, with continued growth, will burst into the pleural cavity through the parietal pleura to form a persistent fistula. This scenario may explain why chylous thoracostomy is often does not manifest until several weeks after the inciting traumatic event (8).

The diagnosis of a chyloous effusion in patients on a normal diet is made by the whitish creamy appearance of the fluid with a triglyceride level of more than 110 mg and the presence of chylomicrons. None of these criteria may be present in some patients who are on total parenteral nutrition after chest surgery. A difficult differential diagnosis must then be made between chylorrhoea, reactive pleurisy, and malignant effusion, singly or in combination. Immediate decisions about the management of massive postoperative pleural effusions are difficult to make in such cases and may result in the overdiagnosis of chylorrhoea. We studied three such patients who were found not to have a chyloous effusion. One patient had pleural metastases from esophageal carcinoma and did not respond to TD embolization. Two patients who had undergone esophagectomy had potentially incomplete TD ligations that were found to be totally occluded; the use of percutaneous interventions promptly clarified the diagnosis.

The current surgical trend is to use TD ligation to treat high-output chylothorax or chyle pleural effusions if there is no improvement after 1–2 weeks of conservative management. This open-chest operation has a potential mortality rate of 2.1% and a morbidity rate of 38.8% (7); however, the mortality rate may be more than 16% in patients who are very ill and in whom duct ligations is delayed for more than 1 month (2). Surgical TD ligation is considered to be only 90% effective because the operator may fail to securely ligate the duct, inadequately oversew the duct leak, or miss tying an anomalous accessory duct. In this study, TD ligation resulted in a 9.5% failure rate and a 7% partial response rate. Two patients underwent failed TD ligation before admission; one underwent subsequent repeat ligations with incomplete response. In four patients who experienced in-hospital TD ligation failure, two patients were successfully treated by embolization and needle disruption (Fig 4), respectively, and two patients had partial response. TD catheterization proved that the duct had been securely ligated in two patients who had persistent postoperative high-output pleural effusions suspected of being chylous.

Video-assisted thoracoscopic surgery for clipping or ligating the TD is safer and less invasive than open-chest repair, but is not widely used because of the risk that open thoracotomy may be necessary if the TD leak cannot be localized or there are thick pleural adhesions (10). Ligation causes increased TD back pressure, which is quickly normalized by the opening of multiple lymphaticovenous communications to lumbar, intercostal, andazygos, and other veins (8); chylous ascites is rarely seen as a complication of TD ligation. Pleurodesis is generally not very effective by itself in controlling a chylothorax. In this study, it failed in four patients before admission and in one patient after admission and provided only a partial response in two patients.

High-output chylothorax is a rare but serious complication of thoracic and neck surgery. In a single-institution study, its incidence was found to be 0.42% in 11,314 thoracic surgical procedures and, of these, 2.9% occurred after esophagectomy (7). Of the 26 patients who had thoracotomy in groupings A, B, C, and D, chylorrhoea was also most commonly seen after esophagectomy (n = 9). Although chylorrhoea is rarely seen after median sternotomy for intracardiac and coronary artery bypass graft surgery (11), there was a high incidence of chyle fistula in this group (Table 1), which may have been a result of surgical complications in two patients (eg, repeat operation for mediastinal bleed and cardiac arrest) and the use of a left internal mammary artery as part of a quadruple coronary bypass procedure in one patient.

Patients with low-output chylothorax seek medical help because of increased dyspnea and chest discomfort and are commonly found to have previously unsuspected malignancies or systemic benign diseases, lymphangioleiomyomatosis, and a history of questionable blunt trauma, but frequently no etiology can be found. Many of these patients are cured after 2–6 weeks by a diet high in protein and carbohydrates, with small- and medium-chain triglycerides and repeated thoracentesis or tube chest drainage. Pleurodesis may be successful in some patients. In this study, patients who did not respond to this regimen (eg, some patients in groupings A and F) had a lower cure rate of interventions because of the lack of suitable retroperitoneal lymphatic vessels and coexisting occlusion of the proximal thoracic duct. There was a high incidence of only partial responses, despite the complementary use of pleurodesis in four patients and TD ligation in one patient.

The TD is a single duct at the level of the eighth dorsal vertebra that frequently splits above this level into 2–3 parallel branches, which rejoin the main duct more cephalad (12). One of the main causes of failure in TD ligation is neglecting to tie a parallel branch that is feeding a chyle fistula. Selective percutaneous TD opacification is very useful in preventing this because it demonstrates anomalous vessels better than lymphography (13). Accessory branches can then be embolized directly or proximal to their origin as demonstrated in two patients in this study (Fig 5).

The cisterna chyli is a sac of variable shape and length that ranges from 2 to 16 mm in diameter. It is present in 50%–94% of necropsy dissections and on 64.5%–80% of pedal lymphograms (14). In this study, cisterna chyli, which constitute the most favorable target for percutaneous puncture and catheterization, were found in only 19 patients (45.2%); however, it was possible to locate retroperitoneal ducts in the diameter range of 2 mm for successful catheterization in seven patients.

The replacement of normal large retroperitoneal lymphatic trunks by small collateral vessels constituted a pattern that was present in 38% of patients in this study. Although this pattern could constitute a developmental variant in some instances, the authors believe it was mostly related to lymphatic vessel occlusion or disruption by diseased lymph nodes, lymphoma, or previous retroperitoneal trauma or surgery.

In 26 patients, the TD was safely catheterized in 29 procedures and embolized in 26 procedures. Other au-
thors have also reported single cases of successful TD embolization (15,16). Based on animal work (9) and reports (17) indicating that chyle clotted as well as blood but more slowly, the authors initially inserted microcoil emboli in the TD to form an occlusive thrombus. Because this did not achieve good lymph stasis in some patients, microemboli were added to completely occlude the duct. In two subsequent patients, one patient with a spontaneous pleuropericardial effusion and the other with a heart transplant, in whom leakage continued, although at a reduced rate, despite efficacious initial embolizations. After repeat embolization with the same technique, cure was achieved in the first patient whereas the second continued to require thoracentesis every 3–6 weeks. When the second patient returned after 6 months to undergo repeat catheterization, the TD was again partially patent because of re-.

Figure 5. Images from a patient who had undergone left rib resection for thoracic outlet syndrome and developed high-output chylothorax. The chyle fistula was fed by the TD and a left paraspinal branch. (a) Catheter opacification of the TD demonstrates a left-sided parallel vessel being filled through a lymphatic plexus (curved arrow) at the T10–11 vertebral interspace. (b) The chyle fistula (curved arrow) was controlled with intraduct particles and four coils placed low enough to occlude the source of the accessory duct (arrow head). Chyle output stopped within 3 days.

lymphatic collaterals that coursed toward the mediastinal leak by needle disruption to cause a decrease in chylothorax output; surprisingly, this led to complete cure in five patients and partial response in two patients (Table 2). Although it can be argued that the fistula output may have decreased spontaneously without needle disruption, this is probably unlikely because the five patients who were cured were undergoing optimal medical support for periods of 1 week (n = 2), 1 month (n = 1), 2 months (n = 1), and 9 months (n = 1), with daily outputs ranging from 300 to 1,000 mL. Chest fluid output in the two patients who had a partial response was 400 mL/d for periods of 8 and 2 weeks, respectively. The first patient, who previously underwent coronary artery bypass graft placement, had a prompt response to needle disruption 4 days after the procedure but the fluid recurred at 9 days with an output of 80–160 mL/d and he eventually died 3 weeks later of pulmonary embolus or pneumonia. The second patient, who previously had an intracardiac tumor removed, also had recurrent fluid output of 120 mL/d after a prompt initial response, but the leak gradually subsided and the thoracostomy tube was removed 3 weeks later. Although lymphatic needle disruption should be attempted because it may result in a good response in some patients, this technique is generally unsuitable for occluding the many lymphatic collaterals that are too close to the aorta, out of reach, or poorly opacified. Better techniques need to be investigated for this purpose, such as electrocoagulation, laser disruption of lymphatic vessels, or retroperitoneal injections of agents that will cause fibrosis of lymphatic vessels.

Most of the 42 patients in this prospective study were initially considered candidates for open-chest TD ligation because of unremitting chylothorax output; but this was required only in the seven patients who did not respond to percutaneous interventions because of unfavorable retroperitoneal lymphatic vessel anatomy. TD embolization and lymphatic vessel needle disruption resulted in cure and partial response rates of 73.8% with no morbidity. The long-term cure rate increased to 81% with the use of TD ligation, pleurodesis, or further medi-

In the patients in whom no lymphatic ducts could be catheterized, attempts were made to occlude small
The death rate of 19% in these patients, many of whom presented with severe cachexia, dehydration, and hypoproteinemia, was a result of the patients' severe illnesses, disease progression, and operative surgical complications.

The limitations of the results of this study are related to the well-known fact that spontaneous sealing of chyle fistulas can be very unpredictable and therefore difficult to resolve in some cases, especially in those with a low pleural fluid output, whether the chylothorax was cured by interventional therapy, simple healing, or a combination of both. This was especially true in the partial-response group. With future improvements in techniques for percutaneous lymphatic vessel occlusion, there should be a higher rate of cures.

In summary, the main advantages of the use of percutaneous versus surgical techniques in the treatment of chylothorax include: (i) the percutaneous procedure is performed with use of local anesthesia and conscious sedation instead of general endotracheal anesthesia and lung decompression; (ii) percutaneous interventions have been associated with no morbidity or mortality; (iii) because of its safety, it can be performed immediately after the chylothorax is diagnosed, without waiting 1–2 weeks to determine whether effusion will subside with medical management; (iv) lymphography and selective TD catheter opacification can be used to identify sites of leakage and TD branch anomalies; (v) TD catheterization can be used to check for possible patency of previously performed surgical TD ligation; and (vi) these percutaneous procedures can be performed without any complications on an inpatient and outpatient basis with the use of ambulance transportation from other hospitals.

Interventional radiologists are especially qualified and encouraged to perform these potentially life-saving procedures. The percutaneous treatment of chylothorax, when successfully performed, can replace more hazardous surgical operations and thereby reduce patient morbidity and mortality as well as the long-term hospitalization costs associated with management. In conclusion, early aggressive use of percutaneous retroperitoneal lymphatic vessel blockage should be strongly considered before allowing surgical TD ligation to be
performed, especially in patients who are very ill or debilitated.

References