A critical evaluation of a percutaneous diagnostic and treatment strategy for chylothorax after thoracic surgery

Daniel J. Boffa, Mark J. Sands, Thomas W. Rice, Sudish C. Murthy, David P. Mason, Michael A. Geisinger, Eugene H. Blackstone

Department of Thoracic and Cardiovascular Surgery, Cleveland Clinic, Cleveland, OH, USA
Department of Diagnostic Radiology, Cleveland Clinic, Cleveland, OH, USA
Department of Quantitative Health Sciences, Cleveland Clinic, Cleveland, OH, USA

Received 31 May 2007; received in revised form 29 October 2007; accepted 2 November 2007; Available online 22 January 2008

Abstract

Objective: Because chylothorax complicating thoracic surgery is difficult to diagnose and failure of nonoperative management necessitates further surgery, we critically evaluated an evolving percutaneous strategy for diagnosing and treating chylothorax. Methods: After thoracic surgery, 37 patients with a clinical diagnosis of chylothorax were referred for lymphangiography for definitive diagnosis and percutaneous treatment. Successful localization of the cisterna chyli by lymphangiogram facilitated percutaneous cannulation of the thoracic duct and its embolization. In patients in whom cannulation was not possible, the thoracic duct was percutaneously disrupted. Results: Diagnosis: Lymphangiography was successful in 36 of the 37 patients (97%). Contrast extravasation, confirming clinical diagnosis, was present in 21 of the 36 (58%). Management: Twenty-one of 36 patients underwent 22 lymphangiographically directed percutaneous interventions: 12 embolizations and 10 disruptions. Mortality was zero, with two manageable complications. Patients without percutaneous intervention were discharged a median of 7 days (range 4–58) after first lymphangiography, 8 days (range 2–19) after percutaneous embolization, and 19 days (range 6–48) after first disruption. Eight patients had nine subsequent reoperations for chylothorax, two with negative lymphangiograms; no embolization patient required reoperation. Conclusions: There is a discrepancy between the clinical diagnosis of chylothorax after thoracic surgery and the presumed gold standard of diagnosis, contrast extravasation at lymphangiogram. Percutaneous treatment by thoracic duct embolization or disruption is safe and may obviate reoperation, but embolization of the thoracic duct is preferable to its disruption.

Keywords: Lymphangiogram; Contrast extravasation; Thoracic duct embolization; Thoracic duct disruption

1. Introduction

Large-volume chest tube drainage complicating thoracic surgery, suspicious for chylothorax, typically responds to nonoperative management. However, biochemical analysis of chest tube output may not be diagnostic of chylothorax because of the transitory postoperative state. Nonoperative management may not be successful, necessitating reoperation. Technological advances now permit percutaneous treatment of chylothorax, which has resurrected diagnostic lymphangiography in our institution. This study critically evaluates this evolving percutaneous strategy for diagnosing and treating chylothorax.
The second patient had lymphangiography and percutaneous disruption of the retroperitoneal lymphatics at the cisterna chyli—thoracic duct junction (hereafter called thoracic duct disruption); 15 days later he had thoracotomy with thoracic duct ligation and decortication, and 3 days later he underwent repeat lymphangiogram and repeat disruption of the thoracic duct. Eventually, a pleuro-peritoneal shunt was required for resolution of this recalcitrant chylothorax.

The third patient underwent an unsuccessful attempt to cannulate the thoracic duct; 3 days later he had repeat lymphangiography and thoracic duct disruption.

2.2. Lymphangiography

Isosulfan blue dye (1% Lymphazurin, US Surgical, Norwalk CT) was injected intradermally into the dorsal aspect of the web spaces between toes of both feet (Fig. 2A). After approximately 30 min, lymphatic channels on the dorsal surfaces of the feet were identified by green subcutaneous paths. The foot with larger caliber lymphatic channels was sterilely prepared, and a pedal lymphatic was isolated by superficial dissection and cannulation with a 30-gauge catheter (Cook, Inc., Bloomington, IN) (Fig. 2 middle, right). Ethiodized oil (Ethiodol, Savage Laboratories, Melville, NY) was infused into the lymphatic by a flow-limited pump (0.5 ml min^{-1}; total volume 12 ml). Spot fluoroscopy was obtained periodically to confirm adequate antegrade progression of contrast. Following completion of ethiodized oil injection, normal saline was infused at the same rate. The cisterna chyli and thoracic duct were usually opacified within 1–2 h (Fig. 3 left). Large thoracic duct leaks were identified by frank extravasation of ethiodized oil into the mediastinum or pleural space (Fig. 3 middle). In patients without contrast extravasation, computed thoracic tomography (CT) enhanced identification of extravasation [1] (Fig. 3 right).

2.3. Percutaneous treatment

Once adequately opacified, the cisterna chyli was accessed percutaneously via a right posterior transhepatic approach with the patient in left posterior oblique position (Fig. 4) [2,3]. A 20 cm 22-gauge Chiba needle (Cook, Inc, Bloomington, IN) was guided fluoroscopically into the cisterna chyli, and a coaxially steerable 80 cm 0.46 mm Nitrex guide wire (Microvena, White Bear Lake, MN) was advanced into the thoracic duct (Fig. 5). The inner two pieces (4-Fr dilator and locking cannula) of an Accustick II access cannula (Boston Scientific, Natick, MA) were advanced over the guide wire, positioning the plastic 4-Fr catheter within the thoracic duct. Water-soluble, non-ionic contrast material was injected to further evaluate the site of contrast extravasation or to increase the possibility of identifying extravasation if it was not seen on initial lymphangiogram.
When extravasation was confirmed, the plastic cannula was exchanged over the guide wire for a microcatheter (Renegade, Boston Scientific, Natick, MA, or Rapid Transit, Cordis, Miami Lakes, FL), which was advanced to a position proximal to the extravasation. N-butyl cyanoacrylate (Trufill n-BCA, Cordis, Miami Lakes, FL) was diluted 1:3 with ethiodized oil and injected under fluoroscopic guidance until the thoracic duct proximal to the extravasation was opacified (Fig. 6). The microcatheter was removed promptly to avoid gluing it in place. Metallic embolization coils (Boston Scientific, Natick, MA) were used alone or adjunctively (Fig. 7). The practice has evolved into embolization with coils followed by glue whenever possible. Occlusion of thoracic duct and leak cessation were confirmed by injecting a small amount of water-soluble non-ionic contrast. The plastic cannula was removed and the procedure concluded.

3. Results

3.1. Diagnosis

Prior to first attempted lymphangiogram for a clinical diagnosis of chylothorax, pleural fluid analysis was positive for triglycerides (>110 mg dl⁻¹) in 14, negative in 11, and not done in 12. Chylomicrons were present in 16, negative in 11, and not done in 10. Either analysis was positive in 17, and neither done in eight. Thus, biochemical analyses were diagnostic in 59% of patients with the clinical diagnosis of chylothorax.

Of the 36 patients in whom lymphangiography was able to be performed (97%), contrast extravasation was observed in 20 (56%), equivocal in one (2.8%), and not observed in 15 (42%). Of the 16 with no or equivocal contrast extravasation, 12 CT scans were performed. Of these, no extravasation was observed in 11, but extravasation was confirmed in the patient with an equivocal lymphangiogram. Therefore, contrast extravasation was observed in 21 patients (58%; Fig. 1).

Of the 21 lymphangiograms with contrast extravasation, triglycerides were positive in nine, negative in seven, and not done in five; chylomicrons were positive in 10, negative in seven, and not done in four. Either analysis was positive in 11 and neither done in three, a positive biochemical diagnosis in 61% of patients with contrast extravasation. In the 15 patients without contrast extravasation, triglycerides were positive in five, negative in three, and not done in seven; chylomicrons were positive in six, negative in three, and not done in six. Either analysis was positive in six and neither done in five, a positive biochemical diagnosis in 60% of patients without contrast extravasation.

3.2. Percutaneous treatment

Percutaneous treatment was performed in 21 of the 36 patients (58%; Fig. 1). One patient required two interventions. Thoracic duct embolization was achieved in 12 patients (gluing only in four, coils only in three, and both in five), and 10 thoracic duct disruptions were performed in nine (two in one patient) (Fig. 1). Disruption was performed when embolization was not possible because of inability to assess the cisterna chyli (n = 2), pass the guide wire cranially (n = 7), and advance the delivery device (n = 1).

Percutaneous treatment was performed in four patients with negative lymphangiograms: embolization in one and disruption in three (Fig. 1). In two of these, it was believed that lymphangiography could be falsely negative because of prior lymphoma therapy or upper-extremity deep venous thrombosis. In two other patients with high pleural fluid output, respiratory failure or positive biochemical diagnosis...
led us to believe that lymphangiography could be falsely negative.

Four patients with contrast extravasation did not have percutaneous treatment (Fig. 1). In two the cisterna chyli could not be accessed, and in one each unfavorable body habitus and thymic extravasation prevented percutaneous treatment.

3.2.1. Safety of percutaneous treatment

There was no mortality. After lymphangiogram, one patient aspirated and required intubation, but recovered fully. After percutaneous treatment, one patient suffered a bile leak that was diagnosed and managed by endoscopic cholangiography and bile duct stenting.

3.2.2. Efficacy of percutaneous treatment

Surgical reoperation for chylothorax was performed in eight patients (Fig. 1). Right thoracotomy with thoracic duct ligation and decortication was performed in five (one of whom subsequently required a pleuro-peritoneal shunt), right thoracotomy and decortication in one, bilateral pleurex catheters in one, and oversewing of the thymus in one. Four of these reoperations occurred after disruption and four after no percutaneous treatment (two after lymphangiogram with contrast extravasation and two after lymphangiogram without contrast extravasation). No patient whose thoracic duct was percutaneously embolized required reoperation.

Median chest drainage for the 3 days before first attempted lymphangiogram (n = 37) was 530 ml day⁻¹ (range 0–2700 ml day⁻¹, 25% < 310 ml day⁻¹ and 25% > 800 ml day⁻¹). Median chest drainage for the 10 days after first lymphangiogram without percutaneous treatment (n = 15) was 35 ml day⁻¹ (range 0–920 ml day⁻¹, 25% = 0 ml day⁻¹ and 25% > 260 ml day⁻¹), after first thoracic duct disruption (n = 9) was 175 ml day⁻¹ (range 0–3200 ml day⁻¹, 25% < 26 ml day⁻¹ and 25% > 530 ml day⁻¹) and after thoracic duct embolization (n = 12) was 100 ml day⁻¹ (range 0 to 1120 ml day⁻¹, 25% = 0 ml day⁻¹ and 25% > 210 ml day⁻¹).

Total parenteral nutrition (TPN) was instituted in 32 patients (86%) prior to lymphangiogram. Median duration of TPN after first lymphangiogram without percutaneous treatment (n = 15) was 2 days (range 1–19 days), after first thoracic duct disruption (n = 9) 7 days (range 4–40 days), and after thoracic duct embolization (n = 12) 5 days (range 2–26 days).

First percutaneous treatment (n = 21) occurred a median of 10 days after the index thoracic operation (range 6–33 days, 25% ≤ 8 days and 25% ≥ 22 days). Patients were discharged a median of 7 days (range 4–58 days, 25% ≤ 5 days and 25% > 10 days) after first lymphangiogram without percutaneous intervention (n = 15), 10 days (range 2–48 days, 25% < 8 days and 25% > 19 days) after the first percutaneous treatment (n = 21), 8 days (range 2–19 days) after thoracic duct embolization (n = 12) and 19 days (range 6–48 days) after first thoracic duct disruption (n = 9).

4. Discussion

Presence of chyle in the pleural space defines chylothorax. Although a simple definition, diagnosis of chylothorax may be difficult: There is no constituent that is unique to chyle [5]; diagnosis may be based on rapid accumulation of large quantities of chyloous-appearing fluid [6], and the gross description of chest drainage is a poor indicator of chylothorax [5,6]. The problem is further heightened by (1) reliance on clinical diagnosis of chylothorax in the transitory postoperative course, (2) occurrence of chylothorax predominately in patients who have had esophagectomy and have not yet been fed, and (3) treatment (bowel rest and TPN) prior to lymphangiography, which may be therapeutic itself. Pleural fluid analysis and lymphangiogram were each able to confirm the diagnosis of chylothorax in about 60% of clinically diagnosed patients. Therefore, the diagnosis of chylothorax in this changing postoperative period requires clinical acumen supplemented by pleural fluid biochemical analysis and diagnostic lymphangiography.

The percutaneous treatment strategy has evolved, and the current technique is detailed under methods. Once the lymphangiogram has been performed, the treatment algorithm is as follows.

- If extravasation is demonstrated, the thoracic duct below the leak is embolized with coils followed by glue distal to the coils. This is an attempt to ensure stability of the glue embolus, preventing its possible later dislodgement, and limiting its proximal spread.
- If no extravasation is demonstrated, but the clinical diagnosis of chylothorax has been confirmed by pleural fluid analysis, it is assumed that either the lymphangiogram is falsely negative or the leak has sealed but needs to be reinforced; in this situation, coils are used to embolize the thoracic duct. Glue is avoided in these patients in an effort to prevent its proximal and lateral spread in the lymphatic system, which could theoretically migrate intravascularly or damage developing lympho—lympho or lympho—venous collaterals. The slower occlusion offered by coils potentially allows more gradual shift of lymph flow from the thoracic duct to collateral circulation, protecting the delicate developing collaterals.
- If extravasation is demonstrated but the thoracic duct cannot be cannulated, usually because no definite cisterna chyli exists, needle laceration of large retroperitoneal ducts or junction of cisterna chyli and thoracic duct is attempted. Supposedly, creation of a controlled leak in the intact retroperitoneum distal to the thoracic duct leak will divert lymph flow from the damaged thoracic duct to collaterals. This study indicates that disruption is less likely to be successful than embolization.
- If no extravasation is demonstrated and the pleural fluid analysis is negative, no intervention is undertaken.

In all patients, slow return to oral intake and early avoidance of a fatty diet allowed time for collateral formation.

Percutaneous treatment may not immediately stop the flow of chyle; therefore, it rarely abruptly terminates chyloous chest drainage. Time to develop collateral lymphatic circulation is variable and patient and procedure related. Management of clinically diagnosed chylothorax usually includes TPN, which confounds evaluation of efficacy of percutaneous treatment. Thoracic duct embolization reduces length of postoperative hospital stay to the range...
of those patients having lymphangiogram without percutaneous treatment (the majority of whom do not demonstrate thoracic duct leak). The value of thoracic duct disruption is questionable because of the subsequent need for reoperation in nearly half these patients.

A major limitation of this report is the evolutionary nature of this percutaneous diagnostic and treatment strategy. This report reflects our entire experience, including our earliest percutaneous attempts, lessons learned, and techniques refined.

Chylothorax continues to be a clinical challenge to diagnose and treat. Lymphangiography has a diagnostic role in chylothorax and is the platform for percutaneous intervention. Thoracic duct embolization is feasible, safe, and minimizes need for reoperation.

References

[1] Sachs PB, Zelch MG, Rice TW, Geisinger MA, Risius B, Lammert GK. Diagnosis and localization of laceration of the thoracic duct: usefulness of lymphangiography and CT. AJR Am J Roentgenol 1991;157:703–5.

[2] Cope C. Diagnosis and treatment of postoperative chyle leakage via percutaneous transabdominal catheterization of the cisterna chyli: a preliminary study. J Vasc Interv Radial 1998;9:727–34.

[3] Hoffer EK, Bloch RD, Mulligan MS, Borsa JJ, Fontaine AB. Treatment of chylothorax: percutaneous catheterization and embolization of the thoracic duct. AJR Am J Roentgenol 2001;176:1040–2.

[4] Cope C, Kaiser LR. Management of unremitting chylothorax by percutaneous embolization and blockade of retroperitoneal lymphatic vessels in 42 patients. J Vasc Interv Radial 2002;13:1139–48.

[5] Staats BA, Ellefson RD, Budahn LL, Dines DE, Prakash UB, Offord K. The lipoprotein profile of chylous and nonchylous pleural effusions. Mayo Clin Proc 1980;55:700–4.

[6] Roy PT, Carr DT, Payne WS. The problem of chylothorax. Mayo Clin Proc 1967;42:457–67.

[7] Moher D, Schulz KF, Altman D. The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomized trials. JAMA 2001;285:1987–91.

Appendix A. Conference discussion

Dr W.H. Warren (Chicago, IL): It is a very interesting paper. Have you had any instance of embolization to the lung and respiratory compromise?

Dr Boffa: No, we limit the amount of the ethiodized oil that we inject into the lymphatic system. There have been some concerns that injecting more than 20 cc can be complicated by embolization of material into the lungs, but we have not experienced that.

Dr S. Jordan (London, UK): Thank you very much. I enjoyed your talk very much. I think that this technique is very impressive. You showed a graph of the day-by-day coil leak before and after the intervention. I think quantity of the day-by-day coil leak was actually reducing before the intervention. How long did you persist with conservative management before deciding that you needed to intervene in these patients?

Dr Boffa: Once a chylothorax is suspected, patients actually begin a conservative intervention in the form of bowel rest and nutritional support.

The lymphangiogram took place a median of 10 days after the index thoracic procedure. I think the observed decline in chest tube output reflects the bowel rest and the TPN support. I do think this graph can be confusing. The patients were very different in each arm of the procedure groups. For example, many of the patients in whom no intervention was performed did not have a leak identified by lymphangiogram. Therefore, the biology, anatomy, and process differed from those in patients in which a leak was demonstrated.

Dr Jordan: It is interesting to note that the patients without an intervention seem to do the best, statistically in your group. Can you explain that?

Dr Boffa: The majority of patients in whom nothing was done had a negative lymphangiogram. Within the spectrum of lymphatic leaks that can be considered chylothoraces, the patients you are referring to probably had a less severe leak (or else the lymphangiogram should have detected it).

That being said, it becomes unclear how to best determine the impact of a thoracic duct intervention (embolization or disruption). I think the most compelling evidence I can offer comes from our yet unpublished experience with chylothorax after esophagectomy. In that series of more than 40 patients, 50% underwent a reoperation to ligate the thoracic duct. In the present series, none of the embolized patients required a reoperation. This suggests that at least some of the embolized patients were saved from a second surgery by percutaneous procedure. Other parameters, such as chest tube drainage, duration of TPN, and length of stay, are too dependent on the degree of the initial lymphatic leak, and are difficult to interpret in such a heterogeneous group.

Dr H.B. Ris (Lausanne, Switzerland): Thank you for presenting this elegant technique which is obviously quite a delicate one. Can you tell us about its learning curve and in how many patients you were able to cannulate the thoracic duct via translumbar punction. I ask this question after disappointing results obtained by translumbar punction for chemical lumbar sympathectomy.

Dr Boffa: We discovered early on that embolization was the preferred procedure. Therefore, any patient who was disrupted represented an attempted embolization in which we either could not access the thoracic duct, or a wire could not be advanced to guide a catheter into the duct for embolization. There were nine disrupted patients plus the four other patients with positive lymphangiograms in whom nothing was done. We have not actually looked within this time period to track the prevalence of disruption over time, but my general sense is that we have done more embolizations in the later 2 years than in the first 2 years. We have two dedicated interventional radiologists, Dr Sands and Dr Geisinger, who have embraced this technology. Their original procedure time was more than 6 h, which as you might imagine the patients did not appreciate. Now it can be done in closer to 4 h. I would summarize by saying that in the 37 patients we presented here, execution of the thoracic procedure. I think the observed decline in chest tube output reflects the bowel rest and the TPN support. I do think this graph can be confusing. The patients were very different in each arm of the procedure groups. For

Dr A. Toker (Istanbul, Turkey): I want to ask the cost of the procedure and the cost effect in coming days.

Dr Boffa: The most expensive part of this procedure is the monopolization of the interventional radiologists. When we first started this technique, we basically shut down the interventional radiology suite for the entire day. I do not know the exact cost of the materials (coils and glue) and the imaging (fluoroscopy plus CT scan); however, I think it would be at least comparable to a second operation but without subjecting patients to the morbidity of another procedure.