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When Chyle Leaks: Nutrition Management Options

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Chylous leakage from the lymphatic system is a complex problem usually resulting from injury or abnormality of the thoracic duct. Although rare, when such leaks occur, they are often difficult to manage and correct. Nutrition therapy plays a major role in the conservative treatment of chyle leaks. This article will review the process of fat digestion and absorption, review selected references reporting nutrition interventions, discuss nutrition options for the treatment of a chyle leak, and provide information to implement such therapy.

INTRODUCTION

Chyle is an alkaline, milky, odorless fluid that provides about 200 kcal/liter. It contains greater than 30 g/L of protein, 4–40 g/L of lipid (mostly triglyceride) and cells consisting primarily of lymphocytes (1). Chyle leaks are a rare complication; they can occur for a variety of reasons after injury to the intra-abdominal lymphatics (Table 1). Leakage may manifest as a chylothorax or chylous effusion (thoracic cavity); chylous ascites (peritoneal cavity); chylopericardium (cardiac cavity) or as an external draining fistula. Approximately 60% of chyle leaks are due to lymphoma; 25% due to trauma (iatrogenic or penetrating); other causes make up the remaining 15% of cases (2). The incidence of chyle leaks varies depending on the underlying cause. The incidence after radical neck dissection is 1–2.5% (3); after cardiothoracic surgery 0.2–1% (2).

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DIAGNOSIS

The diagnosis of a chyle leak is often subjective, and diagnostic criteria may vary. To confirm that a fluid is chylous, the lipid content should be greater than that of plasma and the protein should be more than half of that of plasma (1). A milky appearance of the drainage fluid is often the initial clue. One simple method several authors advocate is to restrict enteral fat intake; if the drainage becomes clear and/or decreases, it can be assumed that a chyle leak is present (3,4). Others evaluate the drainage fluid for characteristics such as triglyceride content, alkaline pH, and presence of fat,

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Table 1
Potential Causes of Chyle Leak

- Lymphoma
- Post operative complication
  - Radical Neck Dissection
  - Cardiothoracic surgery
  - Pulmonary resection
- Penetrating Trauma
- Lymphangioleiomyomatosis (LAM)
- Cirrhosis
- Tuberculosis
- Congenital Chylothorax (neonates)
- Idiopathic

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specific gravity, cholesterol/triglyceride ratio, or lymphocyte count to confirm the diagnosis (2,5,6). More complete reviews of the etiology and diagnosis of chyle leaks are available elsewhere (7–9).

A BRIEF REVIEW OF FAT DIGESTION AND ABSORPTION

The majority of dietary fat is in the form of long chain fats (LCF). Digestion and absorption of LCF is a unique and complicated process involving multiple gastrointestinal functions and the lymphatic system. The process requires gastric lipase, pancreatic lipase, additional enzymes, a suitable intestinal pH—ideally pH 7—(achieved by secretion of pancreatic bicarbonate) and bile salts.

Lymph is derived from interstitial fluid that flows into the lymphatics; it is the only means for protein that has left the vascular compartment to be returned to the blood. As a result, the protein content of lymph has about the same content as the interstitial fluid. The amount of protein returned to the blood by the lymphatics is about one fourth to one half of the circulating plasma protein. Chylomicrons are returned to the blood stream via the thoracic duct, the final common pathway for all lymphatic flow. Ultimately, it enters the venous system at the junction of the internal jugular and subclavian veins. Two to four liters of chyle are transported through the thoracic duct each day (10). Any factor that increases interstitial fluid pressure will increase lymph flow such as:

- Mechanisms that enhance the rate of blood capillary filtration such as elevated capillary pressure or permeability;
- Decreased plasma colloid osmotic pressure; and
- Increased interstitial fluid colloid osmotic pressure.

In addition, water taken by mouth can increase the flow of chyle by 20% (11).

After LCF is ingested and delivered into the proximal small bowel, bile salts are released into the lumen creating micelles with the fat particles dissolving the hydrophobic LCF in the aqueous small bowel environment. The formation of micelles increases the surface area of LCF allowing easier access to pancreatic enzymes for hydrolysis. Pancreatic lipase is the primary enzyme involved in the breakdown of LCF. Micelles transport fatty acids and monoglycerides to the intestinal villi where they are absorbed across the intestinal mucosa. Absorption of fat takes place primarily in the proximal jejunum. Of note, bile salts are not absorbed at this point, but continue down the intestine to the ileum where they are reabsorbed and returned to the liver via enterohepatic circulation. This process of recycling bile salts is required for adequate bile flow to continue. Ninety percent of bile salts are recycled in this fashion, making for a very efficient and conservative system.

Once absorbed across the intestinal mucosa, the fatty acids and monoglycerides are re-esterified into triglycerides combining with cholesterol, protein and other substances to form chylomicrons. Chylomicrons enter the lymphatic system as chyle via lacteals (lymph vessels in the villous region). Fat-soluble vitamins are also absorbed into the lymphatic system by this route. The chylomicrons then travel through the lymph system and are deposited into the venous blood system over the course of several hours after a meal. Chylomicrons are then cleared from the blood stream by the enzyme lipoprotein lipase.

Short and medium chain triglycerides (MCT) are more easily absorbed than LCT. MCT is primarily absorbed directly across the intestinal mucosa and delivered to the portal vein. As the intake of LCT increases (and hence luminal concentration of LCT increases) along with MCT intake, a higher percentage of the MCT will also be absorbed via the lymphatic circulation. Sources, advantages and disadvantages of MCT will be discussed later in this article.

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Table 2
Summaries of Selected Chyle Leak References

Author(s)/Dates	Study Design	Patient Information	Nutrition Regimen
Alban CJ, et al; 1990 (19)	Case reports	Adults with postoperative chylous ascites (n = 4; 3M/1F) Age: 59–65yrs	Elemental diet followed by low fat/MCT diet (n = 1) Low-fat/MCT diet (n = 2) Immediate surgery (n = 1)
Al-Khayat M, et al; 1991 (20)	Unclear "...the means used to maintain postoperative nutrition was deliberately varied."	Adults with low volume chylous fistulae after neck dissection for metastatic squamous cell carcinoma (n = 3; 3M/0F) Age: 56–60yrs	NPO/TPN (n = 1) NG with water, Calogen (50% arachis oil in water) &/or standard tube feeding (TF) (n = 2)
Bolger C, et al; 1991 (21)	Retrospective chart reviews	Patients with chylothorax after oesophagectomy for carcinoma (n = 11) Age/gender not reported	TPN
Browse NL, et al; 1997 (22)	Retrospective, descriptive	Patients with spontaneous chylothorax (n = 20; 9M/11F) Age: 9 mos–78 yrs	Reported only 1 patient was treated with a fat free diet and MCT oil alone and 1 with repeated pleural aspirations and MCT diet supplements
Celona-Jacobs N, et al; 2000 (23)	Case report	Adult with congenital lympangiectasia (n = 1; 0M/1F) Age: 28yrs	Diet restricted initially to 15% animal fat w/ 6 tbsp MCT oil, then animal fat was further restricted to 5% animal fat with 8 tbsp MCT oil. 2–3% EFA in the form of corn oil added.
de Gier HHW, et al; 1996 (3)	Chart reviews	Chylous fistulas in adults with head/neck cancers (n = 11; 8M/3F) Age: 32–76 yrs	MCT oral diet, then Peptison via nasogastric tube, then TPN when first two methods failed.
Dougenis D, et al; 1992 (24)	Chart reviews	Adults with postoperative chylothorax after esophagogastrectomies (n = 10;7M/3F) Age: 37–81 yrs	Clear liquids / TPN
Dugue L, et al; 1998 (25)	Retrospective, descriptive	All pts w/ esophageal CA undergoing Lewis procedure w/ chylothorax (n = 23; 19M/4F) Age: 34–73yrs	TPN x 12 days
Golden P, et al; 1999 (14)	Case report	Adult with blunt trauma after MVA (n = 1; 0M/1F) Age: 53yrs	~Day 6 or 7 chylothorax diagnosed, 20 g MCT diet started, followed by TPN for 4 days without resolution. Day 12, 200 mL olive oil was given via NGT prior to surgery for ligation.
Gregor RT, et al; 2000 (4)	Retrospective, Descriptive, Case series	Adults with Head/Neck cancers (n = 5; 5M/0F) Age: 42–69yrs	Vital HN, then TPN (n= 3) Peptison (n = 2)
Hashim SA, et al; 1964 (26)	Case Reports	Adults with chyluria, chylothorax (n = 2; 2M/0F) Age: 63, 51 yrs	Diets were isocaloric, homogenized liquid formula of 40% fat (various types used), 45% CHO and 15% protein providing 35 kcal/kg and vitamins/minerals followed for 26 weeks and 10 weeks respectively after which a fat free diet was added.

Study Endpoints	Results	Authors Conclusions
n/a	Ascites resolved in 3/4 patients (2 responded to low-fat/MCT diet and 1 to surgery) One patient on the low-fat/MCT diet died from complications of his condition	Treatment of chylous ascites varies depending on individual patient presentation. Options for nutrition management include: elemental diet, low fat/MCT diet, or TPN
Fistula drainage	Administration of standard TF resulted in a transient increase in drainage in one patient, however, overall the administration of clear liquids, Calogen &/or TF did not result in a significant increase in wound or fistula drainage	In the management of fistulae producing small amounts of chyle, "..the use of parenteral nutrition with its potential drawbacks and attendant costs is unjustified in these cases."
Successful conservative management	8 pts were managed conservatively; 3 required thoracotomy 5 pts died of sepsis.	Mortality rate is high in patients who develop chylothorax after oesophagectomy and there is no significant difference between the conservative or surgical approach
Interventions undertaken Survival	Child treated with MCT oil and diet alive at 10 years Patient needing repeated pleural aspirations expired after 3 years	Drainage of effusion, a low fat diet w/ MCT Doil is helpful in some patients; if fluid loss exceeds 1.5 L/day (adults) or 100mL/day in child for >5–7 days, drainage should be stopped; replace all fluid, protein and electrolytes via IV.
Decrease in right pleural effusion Nutritional adequacy.	Significant decrease in size of right pleural effusion and further thoracentesis for >24 months Nutritional status remained constant.	A fat restricted diet using MCT successfully decreased chylous effusion over a 24-month period avoiding the use of TPN.
Chest tube drainage <25 mL/24 hours before drains removed.	5 closed with MCT diet alone; 6 with TPN 2 pts ultimately required surgical intervention.	MCT diet should be tried first; if drain production does not decrease, Peptison TF should be tried; TPN as last resort for ~30 days before surgical intervention.
Predisposing factors Successful fistula management	One patient was successfully treated with a closed tube thoracostomy and TPN alone Eight patients underwent ligation of the major thoracic duct; the procedure was successful in 7/8 patients	"Early reintervention by a repeat thoracotomy" is recommended for patients who experience chylothorax after esophageal surgery for carcinoma
Chylous output <500 mL or reexpansion of lung Ratio of chylous flow to body-weight day 1 & 5 following onset of chylothorax	14 pts recovered without reexploration 1 pt had septic complication from TPN Patients with mean chyle outflow <10 mL/kg did not require reoperation	Medical management was successful in 61% of patients; a daily chylous output of <10 mL/kg is reliable for predicting successful medical management within 12 days of treatment.
Decrease in chyle drainage.	No change in chyle drainage noted even on TPN, therefore pt reexplored.	No standard treatment of chylothorax is uniformly successful.
Fistula closure or reoperate	3 with spontaneous closure	Try MCT nasogastric diet, then TPN if leak does not stop; after 3–4 weeks, then reexploration.
Urine lipids and protein were measured in pt with chyluria for one year Triglycerides and protein were measured in pt with chylorthorax for >6 months.	During periods of MCT formula with fat free diet, pt with chyluria was free of symptoms Patient with chylothorax did not require thoracentesis during MCT feeding.	Diets containing MCT as the sole fat source, or low fat diets with MCT may be valuable in the clinical management of patients with chyluria, chylothorax and presumably other forms of chylous drainage.

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NUTRITIONAL MANAGEMENT

Goals of Therapy

The primary goals of nutritional management of chyle leaks are to:

1. Decrease production of chyle fluid in order to avoid aggravating the effusion, ascites or chest tube drainage;
2. Replace fluid and electrolytes; and
3. Maintain or replete nutritional status and prevent malnutrition.

Clinical indicators to assess efficacy of nutrition therapy might be: a drastic decrease in chest tube drainage; serial x-rays for clinical improvement of an effusion or a decrease in the need for serial taps. However, there are no set guidelines for any of these parameters. The length of time that nutrition therapy is pursued varies in the literature from one to 24 weeks.

Unfortunately, prospective, randomized, clinical trials are not available regarding the treatment of chyle leaks. All reports in the literature are case studies or small cohorts of patients reporting a particular author's therapeutic management. See Table 2 for a summary of selected references.

In addition to a lack of clinical trials regarding treatment of chyle leaks, there are no accurate definitions of what constitutes acceptable 24-hour drainage, or how long conservative therapy should be undertaken before surgical intervention is pursued. Options for treatment include nutrition intervention such as: an essentially fat free diet; fat free diet supplemented with medium chain triglycerides (MCT); specialized enteral feeding (fat free, MCT based or very low fat); or total parenteral nutrition (TPN). Reinfusion of lost chyle in those patients with external drains has also been advocated (12). In patients with an external drain, a clinically useful trial to help determine enteral candidates might be:

1. An NPO period for 24 hours, determining baseline chyle output before initiating TPN, with addition of D_5 to IV support;
2. Once chyle output is determined, initiate fat free or very low fat oral or enteral feeding and observe for another 24 hours;
3. Based on results, continue oral/enteral or move to TPN.

Finally, some suggest introducing a high fat meal in patients in whom the chyle leak is believed to be closed, ensuring closure before removal of drainage tubes (13). For patients requiring surgical repair of chyle leaks, several authors recommended 6-8 oz of a mixture of milk and cream or olive oil given to the patient a few hours before surgery in order to clearly identify the leak at the time of operation (7,11,14).

FAT FREE DIET

For patients who are able to take food by mouth, a very low fat diet may be tried (see Appendix 1). If the markers outlined to guide therapy improve, then this may be *all* that is necessary. It is virtually impossible to eliminate all fat from the diet; many fruits, vegetables and "fat free" products contain *traces* of fat (designated "fat free" products may have <0.5 g fat per serving (see Table 3).

Such a diet may be difficult to maintain, unless the patient is extremely motivated and compliant. Patients must be carefully instructed on how to eliminate fat from the diet and to obtain adequate protein from fat free foods or supplements. The use of fat free oral supplements (such as Enlive!® or Resource® Fruit Beverage) may be helpful. See Table 4 for a list of fat free protein sources. Nutritional status must be monitored closely; fat-soluble vitamin and essential fatty acid supplementation, or supplemental nutrition support need to be addressed. A therapeutic vitamin and mineral supplement may be necessary to ensure complete nutritional intake.

MEDIUM CHAIN TRIGLYCERIDES (MCT)

Medium chain triglycerides (MCT) are often recommended in the treatment of chyle leaks. As discussed previously, MCT is thought to be absorbed directly across the mucosa into the portal circulation and does not require transport via the lymph system. However, there is evidence that although much MCT is absorbed directly into the portal blood system, some MCT may find its way into the lymphatic system and make up part of the lymph fluid, especially in the setting of high MCT intake. In a 1989 report, Jensen, et al, found that lymph fluid contained a significant amount of medium chain fatty acids (20% of triglyceride fatty acids) when a MCT only regimen was provided (15).

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Table 2 (continued)
Summaries of Selected Chyle Leak References

Author(s)/Dates	Study Design	Patient Information	Nutrition Regimen
Jensen GL, et al; 1989 (15)	Case report	Adult with chylothorax (n = 1; 0M/1F) Age: 27yrs	Stepwise: Low fat, MCT modular diet, TPN
Kassell, et al; 1987 (27)	Case reports,literature review, authors' experience	Adult female with intraoperative chyle leak Adult male with postoperative chylous fistula Age: 58, 48	Patient 1: Vivonex x 2 weeks after surgery Patient 2: Vivonex plus MCT by NG
Kostiainen S, et al; 1983 (28)	Case reports	Patients with chylothorax (n = 9) Age/gender not provided	Low-fat/high protein oral diet (n=4); TPN was added in 1 patient Nutrition regimen not described in 5 patients
Lucente FE, et al; 1981 (29)	Chart reviews	Patients with chylous fistula after neck dissection (n=6) or with intraoperative chyle leak (n=6)	NPO immediately post op, followed by NG feeding of fat restricted/ MCT formula
Martin IC, et al; 1993 (30)	Case series	Patients with chylous fistulas (n=3; 1M/1F/ 1 gender n/a)	MCT diet oral or via nasogastric tube (no details given)
Marts BC, et al; 1992 (31)	Retrospective chart reviews	Patients with chylothorax due to trauma or surgical injury (n = 29; 16M/13F) Age: 5 days–76 years	Low-fat diet (n = 16); some of these with MCT oil supplementation (n = 9) TPN alone (n = 4) Low fat diet w/ TPN (n = 9)
Nussenbaum B, et al; 2000 (8)	Retrospective chart reviews	Adults with chyle fistulas (n = 15; 10M/5F) Age: 26–71yrs	MCT diet to TPN if prompt response not evident.
Orringer MB, et al; 1988 (5)	Retrospective review	Adults with chylothorax after transhiatal esophagectomy (n=11; 6M/5F) Age: 26-74yrs	Undefined TPN or enteral (MCT) regimen for an average of 5 days prior to surgery (n = 9) No nutrition therapy prior to surgery (n = 2)
Pabst TS, et al; 1993 (6)	Retrospective review, literature review	Adults with chylous ascites after abdominal aortic surgery—5 from authors' institution and 22 previously reported cases (n = 27; 22M/5F) Age: 27–93 yrs	In authors' institution: NPO with TPN x 14d, then high protein/ low-fat/MCT oral diet Variety of regimens used in other reports
Ramos W, et al; 1986 (32)	Prospective, non-randomized	Adults with thoracic duct fistulas (TDF) following head and neck operations (n=18; 16M/2F) Group 1 (n = 11): Age: 52.6 ± 8.1yrs Group 2 (n = 7): Age: 52.7 ± 5.5yrs	Group 1: TPN Group 2: Fat-free non-elemental nasogastric (NG) feeding Caloric goal for both groups: 2500 kcals; actual amount received not reported
Spiro JD, et al; 1990 (33)	Retrospective chart reviews	Patients with postoperative chylous fistulas (n = 16) Age & gender not provided	Low-fat diet given orally or by NG

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Study Endpoints	Results	Authors Conclusions
Fatty acid composition of chyle triglycerides.	Medium chain fatty acids were found in the chyle triglycerides while on the MCT modular diet, but not on the low fat or TPN regimen	Study demonstrated MCT absorption by the lymph system; that trioctanoin may be a preferable substrate in patients with chyle leaks.
Leak / fistula closure	Patient 1 had no postoperative signs of chylous fistula Patient 2 had 2 further surgical interventions; fistula then closed	Authors recommend use of Vivonex by NG with MCT added if needed to meet nutritional needs
Successful management of chylothorax	3 patients underwent surgery; others managed by conservative therapy	Treatment of chylothorax is dependent on the type and cause
Fistula prevention &/or closure	All chylous fistulas healed in 2–7 days without further surgery Intraoperative chyle leaks were corrected during surgery and no postop fistulas occurred	Prevention of chylous fistulae is key Spontaneous closure of fistulae is better than surgical closure
Successful conservative management	In all patients, chyle drainage ceased 10–15 days after MCT regime started	The use of MCT with protein, metabolic mineral mixture, folate and multivitamin proved a satisfactory approach in patients with chylous fistula
Spontaneous resolution of chylothorax	Resolution of chylothorax was achieved in all but 2 in each nutrition group 50% of surgically treated group had significant post-op infections	Conservative therapy should be tried for patients with traumatic chylothorax with emphasis on nutrition support; failure of conservative therapy after 14 days.
Spontaneous fistula closure	Only 3 of 12 pts underwent operative intervention	All patients with chyle fistulas should receive medical management initially including an MCT diet followed by TPN if drainage does not significantly decrease.
Outcome after thoracic duct ligation	Chylous drainage continued in all patients during the period of nutrition support Initial procedure successful in 10/11 patients	An aggressive surgical approach is warranted in patients with chylothorax following surgery for esophageal obstruction
Resolution of chylous ascites	Ascites resolved in all patients in authors' institution and in 20/22 previous reports (mean time to resolution: 63 days)	Conservative treatment with bowel rest, TPN and then a high protein/low-fat/MCT diet is usually successful in this population
TDF healing Duration of treatment Fistula Output Nutritional status	TDF healed in 10/11 patients in TPN group; TDF healed in 3/7 patients in NG group ($p<0.05$) Duration of treatment significantly shorter in TPN group Neither group showed significant weight loss, but the NG group had a significant decrease in serum protein levels	"TPN was more successful for the closure of TDF than nonelemental fat-free enteral nutrition" decreasing the need for surgery without increased cost or LOS
Incidence Fistula closure	4 of the patients treated with a low-fat diet and wound care required no further intervention. 12 patients required further surgical intervention	Operative intervention should be considered early in patients with fistula drainage of >600 cc per day

Table 3
Nutrient Content Claims About Fat

FDA regulations spell out what terms may be used to describe the level of a nutrient in a food and how they can be used. These are the core terms:

- Free. This term means that a product contains no amount of, or only trivial or "physiologically inconsequential" amounts of, one or more of these components: fat, saturated fat, cholesterol, sodium, sugars, and calories. For example, "calorie-free" means fewer than 5 calories per serving, and "sugar-free" and "fat-free" **both mean less than 0.5 g per serving**. Synonyms for "free" include "without," "no" and "zero." A synonym for fat-free milk is "skim."
- Low. This term can be used on foods that can be eaten frequently without exceeding dietary guidelines for one or more of these components: fat, saturated fat, cholesterol, sodium, and calories. Thus, descriptors are defined as follows:
  - Low-fat: 3 g or less per serving

Synonyms for low include "little," "few," "low source of," and "contains a small amount of."

Source: U. S. Department of Health and Human Services U. S. Food and Drug Administration, FDA Backgrounder May 1999; http://www.cfsan.fda.gov/~dms/fdnewlab.html (accessed 4/4/04).

MCT is available as MCT oil or in specialized oral/enteral supplements and contains 8.3 calories per gram (1 Tb = 15 mL = 115 kcal). Unfortunately, MCT oil is unpalatable and not generally well accepted by patients. MCT oil also tends to be very expensive, a cost not usually covered by insurance if taken orally. MCT must be provided in moderation. Too much may cause diarrhea and gastrointestinal distress. Doses of 60–70 grams/day (4–5 tablespoons; ~500–600 calories) spread out throughout the day are generally tolerated. MCT-containing products contain a high percentage of MCT, but may also contain LCF as well. Table 5 provides a summary of selected products containing MCT.

Patients following a fat free or diet with MCT oil as the only fat source for any length of time may need to supplement essential fatty acids (EFA) and fat soluble vitamins. Essential fatty acid deficiency (EFAD) can begin to occur within as little as five days without provision (16). MCT oil contains negligible, if any, EFA (Mead Johnson's = 29% C8, 67% C_{10} and < 4% greater than C10) (http://www.meadjohnson.com/products/hcp-adult-med/mctoil.html). EFA cannot be produced by the body and must be received in the diet. Linoleic acid is the primary EFA. Linolenic acid and arachadonic acid are other associated fatty acids that can be produced by the body in the presence of adequate linoleic acid. EFAD can result in skin lesions, eczema, impaired wound healing, thrombocytopenia, and growth problems. EFA needs can be met by providing approximately 2%–4% of

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Table 4
Examples of Fat Free Protein Sources*

Product	Serving Size	Protein (g)
High Protein Foods		
Egg Beaters®	1/4 C	6
Better n' Eggs®	1/4 C	5
Egg whites, separated, cooked	2	7
Powdered egg whites	1 tbsp	11.5
Egg white (Bob's Red Mill®)	2 tsp	3
Just Whites® (Deb EL™)	2 tsp	3
Fat free luncheon meat	1 oz	6
Fat free milk	8 oz	8
Non fat dry milk powder	2 tbsp	10
Non fat cheese	1 oz	8
Evaporated skim milk	1/2 C	9
Non fat cottage cheese	1/2 C	13
Non fat yogurt (plain)	8 oz	12
High protein broth (Hormel HealthLabs 800/866-7757)	6 oz	10
High Protein gelatin (Hormel HealthLabs 800/866-7757)	4 oz	12
Fat Free Oral Liquid Supplements		
Boost® Breeze™	1 can	8
Enlive!® Clear Liquid Beverage	1 box	10
Resource® Fruit Beverage	1 box	9
Nutritional Supplement Protein Powders		
Beneprotein® Instant Protein Powder (Novartis 800/622-2689)	1 scoop	6
Casec® (MJ 800/247-7893)	1 teaspoon	5.6
Promod® (Ross 800/986-8502)	1 scoop	6.6
ProPass® (Hormel HealthLabs 800/866-7757)	1 scoop	6
HI ProCal® (Hormel HealthLabs 800/866-7757)	1 packet	8

*Carbohydrate calories may be present in some of these sources
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Table 5
Selected MCT Products*

MCT Oils: Serving size = 2 tablespoons

Product	MCT (g)	Calories	Cost	Manufacturer
Mead Johnson® MCT Oil	14.4	130	$1.53	Mead Johnson www.meadjohnson.com 800/361-6323
Functional Gourmet MCT Oil	27.6	228	$0.89	www.iherb.com
MCT Power(Tropical Punch Flavor)	12	100	$1.00	Universal Nutrition www.universalnutrition.com 800/872-0101

*This is just a sample of products available on the market
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total caloric intake (approximately 40–80 kcal) of essential fatty acids per day for a 2000-calorie diet. Linoleic acid is found in vegetable oils, especially those made from safflower, sunflower or corn oil. For EFA content of selected vegetable oils see Table 6. It may be possible to replace EFA by topical application of EFA, however, if this is to be continued for a significant length of time, EFA status should be monitored (17).

FAT SOLUBLE VITAMINS (VITAMINS A, D, E, K)

For patients who are unable to take adequate nutrition by mouth, enteral nutrition by feeding tube is recommended. Options for enteral feeding formulas include an MCT-based formula, very low fat elemental formula, or an oral fat free supplement. Table 7 compares several commercial products available. MCT-based formulas contain high levels of MCT and low amounts of LCF. Very low fat elemental formulas contain low levels of both MCT and LCF. The amount of LCF in these formulas allows them to meet essential fatty acid (EFA) needs and fat-soluble vitamin needs. However, LCF in levels higher than needed (2%–4% of total calories) may contribute to increased chyle output. Also, as mentioned previously, high levels of MCT may find their way to the lymph system and contribute to chyle output. Finally, these formulas are often very expensive, although not as expensive or risky as parenteral nutrition.

One inexpensive option that we have found useful in patients able to take oral nutrition is to use a modified regimen of fat free liquid nutritional supplement (Resource Fruit Beverage, Enlive!, Boost Breeze—Table 7) combined with a therapeutic multivitamin/mineral supplement and fat free protein as needed. Although these products are not meant to be the sole source of nutrition for extended periods, they are reasonable to try short-term before moving to more expensive enteral formulas or TPN. Simple modifications such as a fat free protein source and a small amount of safflower oil to meet EFA needs can be added for short-term use (<2–3 months—no data to support, but if calories, protein, EFA, vitamins and minerals are adequate for this period of time, would not expect a nutritional deficiency to add to morbidity). Although these types of beverages are generally used for

Table 6
Essential Fatty Acid (EFA) Content of Selected Vegetable Oils (34)

Vegetable Oil	g EFA/tsp	Kcal EFA/tsp	# tsp for 60 EFA (3% of 2000 kcal)
Safflower	0.67	6.0	10.0
Canola	1.4	12	5.0
Flaxseed	3.4	30	2
Sunflower	3.0	27	2.2
Corn	2.7	24	2.5
Olive	0.4	3.6	16.5
Sesame	1.8	17	3.5
Soybean	2.6	23	2.6
Peanut	1.4	13	4.6

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Table 7
Comparison of Very Low Fat Enteral Formulas and Oral Supplements*

Formula	Kcal/l	Total Fat (g/L)	Fat Kcal/L	MCT (g/L)	LCT (g/L)	Cost/1000 Kcal	Ready-Made vs Power
AlitraQ®	1000	15.5	140	8.2	7.3	$28.75	Power
Criticare HN®	1060	5.3	48	0	5.3	$25.80	Ready-made; bottle
Lipisorb®	1350	57	513	48.5	8.5	$9.11	Can & power
Nestle f.a.a™	1000	11.2	101	2.7	8.4	$28.00	Ready-made; can
Peptinex DT®	1000	17.4	157	8.7	8.7	$17.22	Ready-made; can
Perative®	1300	37.4	337	15	22.4	$8.66	Ready-made; can
Portagen®**	1010	48	432	41.8	6.2	$8.59	Power
Tolerex®	1000	10	90	0	10	$16.50	Power
Vital HN®	1000	10.8	97	6.0	4.8	$20.00	Power
Vivonex® T.E.N.	1000	2.8	25	0	2.8	$18.15	Power
Fat Free Oral Supplements**							
Resource® Fruit Beverage	1060	0	0	0	0	$4.87	Ready-made; brick pack
Enlive!®	1250	0	0	0	0	$4.52	Ready-made; brick pack
Boost® Breeze™	680	0	0	0	0	$8.64	Ready-made; can

*Information gathered from manufacturers websites and 800# customer service
**Not meant to be sole source of nutrition; will need addition of some nutrients
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oral supplementation, with some additions, they can also be part of a fat free enteral regimen. This regimen provides only enough LCF to meet EFA needs. It is also cost effective and easy for patients to obtain.

Total parenteral nutrition (TPN) is sometimes used in the treatment of chyle leaks. Due to the risks and complications associated with TPN, including increased infectious complications, gastrointestinal atrophy, and increased cost, TPN should be reserved for situations where other options have failed. Parenteral lipids are phospholipids designed for intravenous infusion. They are delivered directly into the blood stream and as a result do not pass through the lymph system as chyle. Therefore, IV lipids are not contraindicated in patients with chyle leaks.

CONCLUSION

Chyle leaks are infrequent complications seen in the clinical setting. However, because of the direct effect oral or enteral nutrition plays, this complication can be challenging for the clinician. Evidenced-based clinical trials are lacking, hence clear guidelines for nutritional management are not available. Treatment and monitoring is empiric in many cases, but the treatment may be problematic due to expense, palatability, compliance, insurance coverage and unclear endpoints. Presented here are options for the clinician to try before resorting to parenteral nutrition. See Table 8 for a summary of guidelines for patients with chyle leaks.

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Table 8
Summary Guidelines in the Nutritional Management of Chyle Leaks

Adequate protein intake
- Chyle contains significant amounts of protein (22–60 g/L)
- Recommendations for protein intake should account for such losses if an external drain is present or with repeated chylous fluid "taps"
- Adequate intake may be a challenge for patients on a fat free oral diet

Essential fatty acid deficiency (EFAD)
- 2%–4% of total calories from EFA required to avoid EFAD
- May occur within 1-3 weeks of a fat free diet
- Diagnosis: triene to tetraene ratio of >0.4 &/or physical signs of EFAD (see section on MCT oil for more details)
- IV fat emulsion may be required if a patient is unable to tolerate any oral/enteral fat or if it is unwise to try adding oral/enteral fat
- MCT oil does not provide significant EFA

Fat soluble vitamins
- Fat soluble vitamins are also carried by the lymphatic system
- A multivitamin with minerals is generally recommended for patients on a restricted oral or enteral regimen
- Water soluble forms of vitamins A, D, E, and K may be better utilized

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Appendix 1
Foods Very Low in Fat (FF = Fat Free)

Food Group	Foods Allowed*	Foods Not Allowed
Fruits	• Most fresh, frozen or canned fruit • Raisins / FF dried fruit • Fruit juice • Jelly / fruit spreads	• Canned fruit pie fillings
Vegetables	• Plain fresh, frozen or canned vegetables • Vegetable/tomato juice • FF tomato sauce/paste • Pickles	• Olives • Avocado • Coconut • Vegetables in butter, cream sauce, cheese sauce or with other sauce or toppings • Vegetables canned in oil • Fried vegetables
Breads/Cereals/ Starches	• FF bread, FF crackers, FF cold cereals (no nuts), FF rice cakes, FF bagels, FF pasta, rice • FF air popped popcorn, FF potatoes, sweet potatoes, yams • FF muffins	• Breads or cereals containing fat • Cereals with nuts • Breads or cereals topped with butter • Microwave popcorn
Meat & alternatives	• FF luncheon meat • FF hot dogs • EggBeaters or egg substitute, egg whites • FF varieties of veggie burgers • Beans—black, pinto, kidney, white, garbanzo, lentils, soybeans, edamame, lima (butter beans) • FF refried beans	• Whole eggs • Other meat • Nuts / seeds • Peanut butter, other nut butters
Dairy	• FF dairy products, including: milk, cheese, sour cream, cream cheese, cottage cheese, yogurt, frozen yogurt, ice cream, Dannon FF Light n' Fit Smoothie, Yoplait Nouriche • FF Carnation Instant Breakfast	• Low fat or full fat dairy products • Fat containing creamers
Beverages	• Fruit juices/nectars, fruit beverages, Lemonade • Soft drinks • Gatorade, sports drinks • Tea, coffee	• Beverages made with low fat or full fat dairy products
Desserts	• Gelatin • Chewing gum, hard mints, jelly candy, gummy candy, licorice • FF frozen juice bars / FF Popsicles, sorbet, Italian ice • FF animal crackers, FF cookies	
Miscellaneous/ Condiments	• FF salad dressing, ketchup, barbeque sauce, mustard, soy sauce, hot sauce, FF salsa, relish, syrup • Broth / FF soups	
Fats	• FF mayonnaise • FF salad dressing • FF creamers (flavored and plain) • FF whipping cream/Cool whip	• Butter, cream • Margarine • Lard • All vegetable oils • Low fat or regular mayonnaise, regular salad dressings

*Fat content may vary based on product & brand; read labels to confirm the fat content of a specific item.

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