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Nutritional Management of Chyle Leaks: An Update

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Chyle leaks are an uncommon but challenging complication for clinicians. Evidence-based guidelines for the management of chyle leaks are lacking. Nutrition therapy is a key component in the care of patients with chyle leaks and can range from primary treatment to adjunctive therapy. However, the best route for nutrition, the optimal mix of nutrients, and the required duration of the therapy are unclear. This article will review the options for a nutritional care plan and provide practical tips for implementing and monitoring such a plan.

INTRODUCTION

The lymph system is a complex and integral network of lymph vessels and organs throughout the body. The lymph system includes the lymph vessels and capillaries, the thoracic duct, lymph nodes, the spleen, thymus, bone marrow and gut associated lymphoid tissue (GALT), as well as other structures. The primary functions of the lymph system include its immunological role, the absorption of excess interstitial fluid and its return to the bloodstream, and the transport of long chain fat and fat-soluble vitamins. As the name implies, the lymph system carries lymph, comprised of white blood cells (primarily lymphocytes) and chyle from the GI tract, throughout the body. Chyle (from the Latin word for "juice") contains fat, as well as protein, electrolytes, lymphocytes, and other substances.

The incidence of chyle leaks is low, however, when they do occur, they can be difficult to manage and treat. A chyle leak may manifest in a variety of ways—as a chylothorax (chylous effusion) into the thoracic cavity, as a chyloperitoneum (chylous ascites) into the abdomen, as a chylopericardium around the heart, or as an external draining fistula. Less common, but possible forms of chyle leaks also include chyloptysis (chyle in the sputum) and chyluria (chyle in the urine).

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CAUSES, INCIDENCE AND DIAGNOSIS

Potential causes of chyle leaks are listed in Table 1. The cause may be primary, such as in congenital lymphangiectasia which causes a dilation of the intestinal lymphatics and a loss of chyle into the GI tract. However, most causes of chyle leaks are secondary. Damage to the lymphatics may result as a complication of surgery. The overall incidence of a chyle leak after surgery is approximately 1–4% (1), although the incidence will vary depending on the type of surgery. For example, the incidence of a chyle leak after radical neck dissection is 1–2.5% (1,2); after cardiothoracic surgery 0.2–1% (3). Malignancies, particularly lymphomas, are a common cause of non-iatrogenic chyle leaks. Other causes of chyle leaks include blunt or penetrating trauma to the chest and cirrhosis of the liver.

Lymphangioleiomyomatosis (LAM) is another secondary cause of chyle leaks. LAM is a rare lung disease occurring almost exclusively in women during childbearing years. LAM is thought to be hormonally mediated and results in excess smooth muscle growth throughout pulmonary tissues and lymphatics causing obstruction of small airways leading to pneumothorax. A chylous pleural effusion occurs in 10% of LAM cases (4).

Table 1.
Possible Causes of a Chyle Leak

Primary
- Congenital lymphangiectasia

Secondary
- Malignancies
  - Lymphomas
- Postoperative complication
  - Radical neck dissection
  - Esophagectomy
  - Abdominal aortic aneurysm repair
  - Pancreatic resections
  - Chyle leaks after other surgeries have also been reported
- Penetrating trauma to chest or abdomen
- Cirrhosis
- Lymphangioleiomyomatosis (LAM)

The diagnosis of a chyle leak often begins with clinical signs and symptoms. The white, milky appearance of the drainage is often identifying, although the color of chyle may vary from clear (if no enteral fat intake) to reddish-brown if there are red blood cells present. In a recent study, the pleural fluid of 74 patients with chylothorax was analyzed; the researchers found that evaluating the appearance of the fluid was not a sensitive marker of a chyle leak (5). In fact, in this study, only 44% of the samples analyzed had the milky appearance normally associated with chyle.

If a chyle leak is suspected, the drainage should be tested for composition (6). A triglyceride (TG) level >110 mg/dl is diagnostic of a chyle leak (7). If the TG level is between 50–110 mg/dl, a lipoprotein analysis is required to demonstrate the presence of chylomicrons. A TG <50 mg/dl essentially rules out a diagnosis of a chyle leak unless the patient has been fasting or is malnourished (5). In cases of fasting or malnutrition, lipoprotein lipase analysis may be diagnostic (6).

COMPOSITION OF CHYLE AND CLINICAL COMPLICATIONS

Chyle is an odorless, alkaline fluid; approximately two to four liters of chyle are produced each day. Nearly 70% of chyle is absorbed dietary fat, mainly in the form of triglycerides. The amount of fat per liter varies from 5–30 grams depending on dietary intake (8). In addition, chyle contains 20–30 grams or more of protein per liter (8). This includes third spaced proteins and protein degradation from internal hemorrhages, as the lymph system is responsible for the return of extravasated proteins to the circulation. The total calorie composition of chyle is approximately 200 kcal/L. Chyle has an electrolyte concentration similar to that of plasma (9). It also contains fat-soluble vitamins, erythrocytes, and other components. See Table 2 for more on the composition of chyle.

Clinical manifestations of a chyle leak are many. The leak itself can cause tissue damage by compressing the surrounding area. The depletion of lymphocytes (particularly the T cell population) impairs cell-mediated immunity and can lead to immunosuppression. Chyle is bacteriostatic and loss of chyle can place patients at higher risk of bacterial infections (8).

Table 2.
Selected Components of Chyle

Component	*Concentration*
Calories	200 kcal/L
Lipids	5–30 g/L
Protein	20–30 g/L
Lymphocytes	400–6800/mm (28)
Erythrocytes	50–600/mm (28)
Sodium	104–108 mMol/L
Potassium	3.8–5.0 mMol/L
Chloride	85–130 mMol/L
Calcium	3.4–6.0 mMol/L
Phosphate	0.8–4.2 mMol/L

Nutritional deficiencies are common due to the loss of calories (200/L), protein, and fat-soluble vitamins. Metabolic complications, such as hypovolemia, hyponatremia, and metabolic acidosis may also occur due to the loss of fluid and electrolytes.

OTHER CONSIDERATIONS

As we begin to discuss treatment options, it is important to review some of the other factors that affect the flow and volume of chyle. Interestingly, there are factors other than fat intake that will increase the flow of chyle. Any activity that increases blood flow will increase chyle flow. This includes exercise, especially torso or upper extremity exercises or anything that increases intraabdominal pressure (such as coughing or straining). Although the primary focus of nutrition therapy is on reducing fat in the diet, it has been shown that peristalsis and any enteral intake, even ingestion of water, can increase lymph flow by 20% (9). However, high fat intake (in particular long chain fat), will augment the flow rate of chyle.

BRIEF REVIEW OF FAT DIGESTION

The majority of fat from the diet comes in the form of long chain fats (>12 carbon units). Long chain fats (LCF) are absorbed through a complex process. As food is ingested, lingual lipase is secreted and begins to work on the food; in the stomach gastric lipase continues this process. As the fat moves into the intestine, bile salts are released and act as an emulsifier, allowing the hydrophobic fatty acids to be digested in the aqueous small bowel environment. The interaction of bile, fatty acids and unhydrolyzed glycerides forms micelles; micelle formation increases the surface area of the fats allowing pancreatic enzymes (primarily lipase) to work more efficiently. Bicarbonate secreted from the pancreas also plays a role as it provides the correct pH environment for pancreatic enzyme activity (pH of 7–8). Micelles transport fatty acids and monoglycerides to the intestinal villi.

Once the monoglycerides and fatty acids are absorbed within the bowel mucosa, they are resynthesized into triglycerides combining with fatty acids, cholesterol, and protein to form chylomicrons. These chylomicrons enter the lymphatic system through the lacteals, the lymph vessels in the villous region. From the lymph system, the chylomicrons enter the circulation via the subclavian vein over a period of several hours. The enzyme lipoprotein lipase then clears chylomicrons from the blood vessels, releasing fatty acids for absorption into the cells.

As a side note, most of the absorption takes place in the jejunum. Bile salts are not absorbed at this point, but continue through the intestine to the ileum where they are reabsorbed and returned to the liver via the enterohepatic circulation. In the healthy bowel, 90% of bile salts are recycled in this efficient manner. If bile salts are not reabsorbed for any reason (short bowel syndrome, mucosal disease, etc), the bile salt pool may become depleted and fat malabsorption will ensue.

TREATMENT OPTIONS

Treatment options for a chyle leak include drainage (such as an external drain, or by paracentesis or thoracentesis), pharmacological treatment (primarily Octreotide), direct surgical repair, or conservative therapy with nutrition intervention.

According to the literature, indications for surgical intervention vary among surgeons and institutions. Some indications for surgery cited in the literature include: >1 liter of chyle output per day (10), failure of the leak to close after 2–3 weeks of conservative therapy (9,10), signs of nutritional or metabolic complications from the leak (8), the possibility of further damage from

the leak (such as lung damage, flap failure) (8,10), or if the patient is deteriorating (10). When surgery is indicated, some authors recommend providing oral or enteral whole cream, or enteral formula 3–4 hours prior to surgery to aid in identifying the source of the chyle leak (9,11).

Recently, there has been interest in the use of Octreotide (Sandostatin), a somatostatin analog, as a pharmacological means to manage a chyle leak (12,13). There are cases and case series, particularly in neonates, indicating that use of Octreotide seems to be safe and effective in various settings. Octreotide is a potent inhibitor of growth hormone, glucagon, and insulin. It also suppresses gastrointestinal hormones including gastrin, motilin, secretin, and pancreatic polypeptide as well as decreasing splanchnic blood flow. Although the exact mechanism of action of Octreotide in chyle leaks is not well defined, it is attributed to a deceleration in lymph flow, thereby facilitating the possibility of leak closure. Dosing typically begins at 50 mcg given subcutaneously TID and can be increased up to 200 mcg TID. However, there is currently no consensus on when to start therapy, the most appropriate dose, or when to discontinue the drug.

NUTRITIONAL MANAGEMENT OF CHYLE LEAKS

Goals of nutritional management include:

1. Decrease production and flow of chyle in order to provide symptom relief, avoid aggravating the leak, and allow closure of the leak if possible.
2. Replenish fluid and electrolytes losses.
3. Prevent malnutrition, aid in maintaining or repleting nutritional status.

Options for nutritional management include a low fat or fat free oral diet, enteral nutrition with a specialized formula, parenteral nutrition without oral intake, or some combination of these. We will discuss each of these in detail in the following sections.

There are a number of case reports, chart and retrospective reviews regarding nutritional management of chyle leaks (2). However, prospective, randomized trials are lacking as the incidence of chyle leaks is so low at any given institution, it would take years to get a reasonable number of patients for a prospective trial. Virtually all recommendations are based on isolated cases and cohorts of patients, and the effect of different oral foods, enteral formulas or fluids on chyle flow. There is no consensus as to the best type of regimen, how long nutrition management should be pursued, or what constitutes an acceptable amount of chyle output. Articles can be found to support any of the diet alterations listed above. A recent review of nutritional management of chyle leaks concluded that adequate evidence does not exist to recommend one method over another (1). The length of time primary dietary management is beneficial is unknown; a past review found reports in the literature ranging from 1–24 weeks (2).

An earlier article in the Practical Gastroenterology nutrition series reviewed the case studies and reports available as of 2003; please see this article for a full review (2). Below is a summary of selected recent studies and case reports published since that time.

- In a recent retrospective review, Maldonado, et al. retrospectively reviewed the charts of 74 patients with chylothorax (14). The nutrition intervention is not well described, however, the authors do state that 40 of the 74 patients received treatment that included "dietary measures (total parenteral nutrition)." The success rate of the dietary intervention is not clear; overall, 44 patients (59%) ultimately required surgery. An interesting finding of this study is that patients with nontraumatic chylothorax were significantly more likely to fail initial therapy and were significantly more likely to have persistent or recurrent chylous effusion than patients with a chyle leak due to trauma.
- Malik, et al. evaluated 7 patients that developed a chyle leak after surgery for pancreatico-duodenal malignancy (15). Patients were managed by parenteral nutrition and clear liquid diet. The chyle leak resolved in 6 of the 7 patients after a mean of 7.5 days on parenteral nutrition; one patient required surgery.
- Lagarde, et al reported on 20 patients with a chyle leak following esophageal surgery (16). Patients were treated with total parenteral nutrition and no enteral feeding. Eighty percent of patients responded to conservative therapy. The authors concluded that patients with a chyle output of >2 liters at the initiation of conservative therapy that continues 1–2 days after treatment are more likely to require surgery.

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Table 3.
Fat-Free Oral Supplements Options

	Nutrients per Serving			
Product	*Calories*	*Protein*	*Fat*	*For Information or to Purchase*
Enlive® (Abbott®)	200	7	0	www.abbottnutrition.com
Resource® Breeze (Nestle®)	250	9	0	www.NestleNutritionStore.com
NUTRA/Shake® Fruit Plus (NUTRA/Balance®)	200	6	0	www.nutra-balance-products.com

- In a retrospective review, Cormack, et al. reported on 25 pediatric patients with a chylothorax following pediatric cardiac surgery (17). Eighteen patients were treated with a low fat, nutritionally complete enteral formula containing 93% of fat as MCT. Six patients received parenteral nutrition due to their medical status. Of the 18 patients treated with EN, 14 responded to the therapy (78%). Of the parenteral group, 2 responded to nutritional therapy, although it is important to note that this appeared to be a more critically ill group of patients. Overall, 75% of patients responded to nutritional therapy.
- Mincher, et al. reported on seven cases of adult patients with chyle leaks (13). All were treated with a completely fat free diet (using a fat-free, juice-type feeding) and octreotide (50 mcg three times a day given subcutaneously for 14 days). In all cases, when this protocol was strictly followed, the chyle leak resolved quickly (<14 days) and six of the seven patients required no further intervention.

When determining the best route for nutritional intervention, numerous factors must be considered and monitored. Baseline parameters should be documented while the patient is NPO—i.e. the amount of chest tube drainage or other type of drainage, serial x-rays, abdominal girth, etc.—so that the response to the nutritional therapy can be monitored. The patient's baseline nutritional status should also be considered. For example, if a patient has been unable to maintain their weight on a regular diet, it is unlikely they will be able to replete their nutritional status if an extremely low-fat oral diet is prescribed. Finally, the overall plan for the patient must be considered. What is the endpoint? How much time is available to change course?

Table 4.
Examples of Fat Free Protein Sources*

Product	*Serving Size*	*Protein (g)*
Egg Beaters®	¼ c	6
Better n'Eggs®	¼ c	5
Egg whites, separated, cooked	2	7
Powdered egg whites	1 tablespoon	11.5
Egg white (Bob's Red Mill®)	2 teaspoons	3
Just Whites® (Deb EL™)	2 teaspoons	3
Fat free luncheon meat	1 oz	6
Fat free milk	8 oz	8
Non-fat dry milk powder	3 tablespoons	10
Non-fat cheese	1 oz	8
Evaporated skim milk	½ c	9
Non-fat cottage cheese	½ c	13
Non-fat yogurt (plain)	8 oz	12
High protein broth (Bernard®, 800-323-3663)	1 cup	10
High protein gelatin (Bernard®, 800-323-3663)	½ cup	12
High protein egg whites (Bernard®, 800-323-3663)	1 tablespoon	5
UNJURY® Unflavored Whey Protein (800-517-5111)	1 scoop	20
Pro-Stat® (Medical Nutrition USA, Inc., 800-221-0308)	2 tablespoons	15
Beneprotein® (Nestle®, 888-240-2713)	1 scoop	6

*Carbohydrate calories may be present in some of these sources

ORAL DIET

For patients who are well nourished and able to take food by mouth, a fat-free oral diet may be an option (see Appendix A for suggestions). Keep in mind that fat is a great calorie source; if fat is severely limited in the diet, additional calories will need to be obtained elsewhere. This means larger volumes of food will need to be consumed and more meals and snacks will need to be added throughout the day. This may be difficult for many patients who continue to undergo treatment and may not be an appropriate choice for patients who are already at nutritional risk.

It is virtually impossible to remove all fat from the diet. Many fruits, vegetables and even "fat free" products contain traces of fat ("fat free" = <0.5 g/serving). A sample diet is provided in Appendix A (a more in-depth version is available at: *www.ginutrition.virginia.edu* under patient educational materials). There are no studies to demonstrate exactly how much fat is acceptable to promote closure of a given chyle leak. Patients must be carefully instructed on how to minimize fat in their diet while meeting calorie and protein needs (see Table 3 for fat free oral supplement options and Table 4 for fat free protein options).

Nutritional status should be monitored carefully in patients on a fat free diet. Fat-soluble vitamins and/or essential fatty acids (EFA) may need to be supplemented (see also EFA section). A therapeutic multivitamin and mineral supplement may also be necessary to ensure complete nutrient intake on this restrictive diet. Some patients may need supplemental nutrition support, such as nocturnal infusion of a low or fat free enteral formula.

MEDIUM CHAIN TRIGLYCERIDES

Medium chain triglycerides (MCT) are frequently ordered for the treatment of chyle leaks—in fact, what the dietitian typically receives is an order for a "MCT diet." The advantage of MCT is that they do not require transport via the lymph system. Hydrolization to medium chain fatty acids (MCFA) occurs rapidly, allowing absorption across the brush border where the MCFA then bind with albumin and are transported directly to the liver via the portal vein. It is important to note that there is no such thing as a "MCT diet."

Although MCT is primarily absorbed directly into the portal blood system, there is evidence that some MCT may find their way into the lymphatic system and make up part of the lymph fluid, especially in the setting of high MCT intake, or high total fat intake (18,19). 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 (18). Furthermore, in those with alterations in absorption and in the presence of steatorrhea, ingestion of large amounts of MCT decreases the absorption of long chain triglyceride (LCT), thereby increasing stool losses (19).

MCT preparations contain a mixture of caproic (C6:0 @ 1 to 2%), caprylic (C8:0 @ 65 to 75%), capric (ClO:0 @ 25 to 35%), and lauric acids (C12:0 (1 to 2%) (19). MCFA for MCT preparations are obtained by the hydrolysis of coconut oil. The MCFA are then fractionated, and are then reesterified with glycerol into MCT. It is important to note that coconut oil and MCT are *not the same,* as only 66% of coconut oil is MCT—the rest is long chain fat (i.e. coconut oil should *not* be used in the treatment of chyle leaks). MCT is liquid at room temperature and is relatively water-soluble.

MCT is available as MCT oil or in specialized oral and enteral supplements. MCT contain 8.3 calories per

Table 5.
Incorporating MCT into the Diet

- Sip or eat slowly at least initially
- Start with 5 mL TID divided over the day at a meal or snack (or as enteral bolus if tube fed).
  - Do not exceed 4–6 tablespoons (12–18 teaspoons)/day
- Although MCT can be taken as small "shots" over the day, it is not delicious.
- Add to a fat free beverage of choice such as fruit juices, skim milk, coffee drinks, etc.
- Flavorings can be added (coffee, vanilla, almond, cocoa, fruit flavoring, etc.).
- Consider diluting with equal volume of water or other fat free beverage (Gatorade, coffee, lemonade, soda)
- Add to fat free hot cereals, mashed potatoes, vegetables, pasta, soups, salad dressings, applesauce or other fruit sauces

Table 6.
Examples of Commercial MCT Oils*

- Twinlab® MCT Fuel® orange: 16 oz @ $17.44 www.twinlab.com
- Now® MCT Oil: 32 oz @ $14.00–$18.00 www.nowfoods.com
- Sci-Fit® MCT oil: 32 oz @ $17.00–$37.00 online
- Smart Basics MCT oil, 16 oz @ ~$8.50 online
- Nestle® MCT OIL®: six, 1 quart bottles @ $400.00 ($66.65/32 oz bottle); www.NestleNutritionStore.com

*Examples only, not meant to endorse or recommend any specific product

gram (14.25 grams = 1 tablespoon = 15 mL = 115 kcal). Unfortunately, MCT oil is not terribly palatable and, therefore, is not generally well received by patients. MCT oil also tends to be fairly expensive—a cost not usually covered by insurance. MCT should be provided in moderation. Too much in the diet has been associated with crampy abdominal pain, abdominal distension, nausea, emesis, bloating, diarrhea, and borborygmi (stomach growling) (20). Doses of 4–6 tablespoons (50–100 mL) or 385–765 calories spread over the course of the day are generally tolerated. See Table 5 for suggestions on use of MCT oil; also see Table 6 for information on commercially available MCT oil and Table 7 for enteral nutrition products that contain MCT. Note that MCT-*containing* products contain a high percentage of MCT, but may also contain LCF as well. MCT does not contain essential fatty acids (EFA), so those who remain on a fat free diet with supplemental MCT for >3 weeks will need a source of EFA (see EFA section below).

There is a potential risk in those patients with a propensity for ketosis or metabolic acidosis (such as those in diabetic ketoacidosis or renal failure respectively) as MCT is oxidized in the liver to form ketone bodies that may aggravate acidosis (19,20). From a clinical perspective, clues to look for would be ketones in the urine or a dropping serum bicarbonate (HCO_3) level with no other clear explanation.

ENTERAL NUTRITION

Enteral nutrition (EN) with a specialized formula is an option for patients who cannot take adequate food by

Table 7.
MCT Containing and Very Low Fat Commercial Enteral Formulas

Enteral Product	*Kcal/mL*	*$ Cost/ 1500 kcal*	*Total g fat/ 1500 kcal*	*MCT/LCT %*		*MCT:LCT/ 1500 kcal (g)*	
Optimental®[1]	1.0	36.70	42	28	72	11.9	30.7
Peptamen®[2]	1.0	42.48	59	70	30	41	17.5
Peptamen® AF[2]	1.2	40.85	68	50	50	62.5	62.5
Peptamen® 1.5[2]	1.5	36.67	55	70	30	39	16.8
Perative®[1]	1.3	13.23	56	40	60	22.4	33.6
Portagen®[3]* (powder)	1.0	19.28	75	87	13	62.2	9.3
Vital® HN[1] (powder)	1.0	36.50	16	48	52	7.2	7.8
Vital® HN 1.5[1]	1.5	30.01	57	47	53	26.8	30.3
Vivonex® TEN[2] (powder)	1.0	41.65	4	n/a	n/a	—	—

[1]Abbott® Nutrition: 800-227-5767 or www.abbottnutrition.com
[2]Nestle® Nutrition: 800-422-2752 or www.nestle-nutrition.com/Public/Default.aspx
[3]Mead Johnson Nutrition: 800-222-9123 or www.meadjohnson.com
*Per Mead Johnson: "Portagen powder is not nutritionally complete. If used long term, supplementation of essential fatty acids and ultra-trace minerals should be considered."

Table 8.
Essential Fatty Acid Content of Lipid Emulsions

Product & Distributor	Oil (%)		EFA Content (%)		g fat/ 250 mL IVLE*	% EFA/ 250 mL IVLE	g EFA/ 250 mL IVLE	g EFA mL IVLE	EFA kcal/mL IVLE	mL of IVLE to meet 4% EFA/kcal level listed	
	Safflower	Soybean	Linoleic	Linolenic						1000 kcal (4% = 40 kcal)	2000 kcal (4% = 80 kcal)
Intralipid 20% (Baxter)		20	50	9	50	59	29.5	0.12	1.06	37.7	75.3
Intralipid 30% (Baxter)		30	44–62	4–11	75	48–73 (avg = 60)	36–55 (avg = 45)	0.18	1.62	24.7	49.4
Liposyn II 10% (Hospira)	5	5	65.8	4.2	25	70	17.5	0.07	0.63	63.5	127
Liposyn II 20% (Hospira)	10	10	65.8	4.2	50	70	35	0.14	1.26	31.7	63.5
Liposyn III 10% (Hospira)		10	54.5	8.3	25	63	15	0.06	0.54	74.1	148.1
Liposyn III 20% (Hospira)		20	54.5	8.3	50	63	31	0.12	1.12	35.8	71.7
Liposyn III 30% (Hospira)		30	54.5	8.3	75	63	47	0.19	1.69	23.6	47.3

Note: Propofol equivalent to 10% Liposyn III, hence 100mL × 0.06 = 6 g EFA (54 kcal of EFA)
*IVLE: Intravenous lipid emulsion
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mouth, or who are unable to tolerate or comply with an essentially fat free diet. Options for EN include MCT based formulas, very low fat elemental formulas, or a modified regimen using a fat free oral supplement. The following general guidelines may be helpful as one part of determining the appropriate nutritional plan; these guidelines are based on clinical experience and a review of the available literature (5,8,21–24).

- EN may be effective if chyle output is less than 1000 mL/day:
  - A low fat semi-elemental formula may be effective if output is less than 500 mL/day
  - An elemental formula may be required if output is greater than 500 mL/day

Many enteral formulas contain varying levels of MCT, but also contain varying levels of LCF (Table 7). Very low fat enteral formulas are low in total fat, but vary in MCT and LCT content (Table 7). The majority of enteral formulas contain adequate amounts of fat to meet EFA needs in a specified volume, but there are exceptions. Clinicians should evaluate the specific formula being used to determine if it meets full EFA needs, as well as full vitamin, mineral and micronutrient needs for an individual patient. Specialized enteral formulas can be expensive, and enteral formula cost may or may not be covered by insurance. However, the cost and risks of these specialized formulas is less than that of parenteral nutrition.

Another option that we have used at the University of Virginia Health System for short-term use (<3 weeks) is a modified enteral regimen using a fat free oral supplement (see Table 3). Although these products are usually taken by mouth, with some modification they may be an option for EN in certain patients. This option can be less expensive than specialized EN formulas and these products are often easier for patients to obtain and purchase. While these formulas are not formulated to be a sole source of nutrition for an extended period of time, they may be reasonable to use for a short period of time. A fat-free protein source, a small amount of safflower oil to meet EFA needs, and a therapeutic multivitamin with minerals will help

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Table 9.
Essential Fatty Acid Content of Common Oils and Portion Needed to Meet 4% of Total Calories

Oil	*g EFA/ tsp*	*Kcal EFA/ tsp*	*4% EFA cal per 1000 cal (tsp)*
Almond	0.9	7.8	5
Canola	1.5	13.3	3
Corn	2.7	24.3	1.7
Flaxseed	3.3	29.7	1.4
Olive	0.5	4.5	8.9
Soybean	2.9	26.0	1.5
Sunflower	3.3	29.6	1.4
Walnut	3.2	28.8	1.4
Wheat germ	3.1	27.9	1.4

100 g oil = 20 teaspoons; 5 g = 1 teaspoon oil
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to make the regimen more nutritionally complete. There are no trials or data to support such a regimen, however if calories, protein, EFA, vitamins and minerals are adequate, we would not expect nutritional complications in the short term.

PARENTERAL NUTRITION

Due to the increased costs and higher rate of complications associated with parenteral nutrition (PN), EN should be considered whenever possible. There are no concrete indications for PN in chyle leaks (other than, of course, a non-functioning gastrointestinal tract). Based on reports to date, patients that have a chyle output >1000 mL/day while NPO will likely require PN as EN is not likely to improve such elevated output. If patients are not responding to a modified oral or enteral regimen, or are having increased chyle output on EN, PN may be warranted.

IV lipid emulsions (IVLE) are designed to be delivered directly into the blood stream. They do not travel through the lymph system and do not contribute to chyle flow. Therefore, IVLE are not contraindicated and can provide a valuable source of calories, as well as essential fatty acids for patients requiring parenteral nutrition support. If needed, IVLE can also be used periodically in those on very low fat or fat free oral or enteral nutrition regimens.

ESSENTIAL FATTY ACIDS

Essential fatty acids (EFA) cannot be produced by the body and must be obtained from the diet. Linoleic acid is the primary EFA. Other associated fatty acids are linolenic acid and arachadonic acid, but these can be produced in the body with adequate linoleic acid. EFA are necessary for healthy cell membrane formation, cholesterol metabolism, blood clotting, as well as proper development and functioning of the brain and nervous system. Linoleic acid is a major precursor in the production of eicosanoids, such as thromboxanes, leukotrienes, and prostaglandins.

Symptoms of EFA deficiency may develop in 2–4 weeks. Signs of deficiency include skin lesions, eczema, impaired wound healing, thrombocytopenia, and growth problems. EFA deficiency can be diagnosed by lab values; a triene:tetraene ratio >0.4 is generally considered to indicate a deficiency. This lab is a send out, is expensive, and takes 7–10 days for results; therefore prevention is the best approach.

Patients who are on a fat-free diet for a prolonged period (more than 3–4 weeks) will need a source of EFA. MCT does not contain essential fatty acids, so those receiving supplemental MCT will still require a source of EFA. IVLE provides EFA, therefore, patients receiving parenteral nutrition with lipids should meet their requirements (see Table 8). The sedative Diprovan® (propofol) is provided in an IVLE and hence will also provide EFA—for every 150 mL infused, EFA needs will be met for a person requiring 2000 calories per day. Of note, obese patients on a limited fat or fat-free enteral or parenteral regimen are also at risk for developing an EFA deficiency, although the deficiency may take longer to develop. Linoleic acid accounts for ~10% of stored lipid; mobilization of fat stores releases >2–3.5 g of the linoleic acid required daily (25)

The daily requirement of EFA can be met by providing 2–4% of total calories as linoleic acid. Table 9 shows the EFA content of commonly available oils and the amounts needed to meet daily EFA needs. If no

Table 10.
Use of Topical Oils to Treat Essential Fatty Acid Deficiency

Positive Studies	*N*	*Outcomes*
Skolnik 1977 (29)	N = 1 Case Study: 19 year old	Signs and symptoms of EFA deficiency resolved after 21 days of topical application of safflower oil (60–70% linoleic acid)
Friedman Z 1976 (30)	2 newborn infants	Topical application of sunflower seed oil corrected biochemical markers of essential fatty acid deficiency in 2 infants receiving fat-free parenteral nutrition.
Miller DG 1987 (31)	5 patients on home parenteral nutrition	After phase 1 of the trial (4 weeks with no parenteral lipid), triene:tetraene ratio increased from 0.1–0.5. After phase 2 (topical application of safflower oil for 4–6 weeks), triene:tetraene ratio returned to 0.2.
Negative Studies		
Hunt 1978 (32)	6 study patients (9 controls)	After topical application of sunflower seed oil, 1 mild deficiency improved; others did not. After 76 days, 4 patients measured all had severe deficiency
Sacks 1994 (33)	N = 1 Case study: 40 year old	Topical application of vegetable oil rich in linoleic acid failed to treat EFA deficiency. Serum levels normalized and cutaneous findings resolved only after intravenous administration of lipid.
McCarthy 1983 (34)	N = 10 (critically ill patients)	Topical application of corn oil did not prevent EFA deficiency (as diagnosed by serum levels) in critically ill patients receiving fat-free parenteral nutrition.
Lee 1993 (35)	N = 6 (3 infant pairs)	All infants in the study quickly developed EFA regardless or whether topical safflower oil was applied. In all cases, EFA deficiency corrected once parenteral lipid was introduced.

enteral fat is possible, IVLE may be provided periodically. See Table 8 for the EFA content of IVLE available in the United States.

Some have advocated the use of topical oils to meet EFA needs. While this approach may be appealing, case reports to date have not been very promising (See Table 10). Having said that, if one is in the position where other options do not exist, it is a low risk intervention and a trial may be warranted. EFA levels would have to be monitored to determine efficacy on an individual basis.

MONITORING RESPONSE TO NUTRITION THERAPY

Once any nutritional regimen is initiated, response must be carefully monitored. Unfortunately, there are no concrete definitions of what constitutes an acceptable amount of drainage, what defines tolerance of the nutritional regimen, or how long conservative treatment should be pursued. Positive signs that a patient is tolerating a nutritional regimen include a decrease in chest tube or other external drainage volume, decrease in the size of pleural effusion based on serial x-ray, a decrease in abdominal girth, or a decrease in the frequency and volume of paracentesis or thoracentesis.

A recent case report also indicates that micronutrients may need to be monitored in patients with chyle leaks. Berranger, et al reported on a case of an 11 year old boy with disseminated lymphangiomatosis who developed a severe selenium deficiency despite selenium being provided at recommended levels with PN (26). Symptoms included hypotonia with lower extremity weakness and cardiomyopathy. Serum levels correlated with severe selenium deficiency.

Selenium loss from the chylous fistula was estimated at 6.3–18.7 μg/L.

CHYLE REINFUSION

There may be a few select patients with enteral access for feeding and an ongoing external chyle leak who are not operative candidates. If the external leak is significant enough, it may be worthwhile reinfusing this nutrient-rich fluid into the enteral access port during times off enteral feeding. This may prevent the need for IV fluids, either regularly or periodically, and keep the patient at home (27). A more extensive review of reinfusion is available elsewhere (27).

CONCLUSION

Nutrition therapy is an integral part of the treatment for chyle leaks. Clear, evidence-based guidelines for the best route of nutrition are not available. Patients should be evaluated on an individual basis to determine what type of regimen is likely to be successful. Regardless of the type of nutrition regimen initiated, patients must be monitored closely for signs of tolerance and clinical response. Nutritional status, including protein status, EFA, fat soluble vitamins, and electrolyte balance, must be carefully evaluated to avoid deficiency or further complications. Table 11 summarizes some of the considerations when treating patients with a chyle leak. ■

Table 11.
Summary: Management of Chyle Leaks (2)

Adequate protein intake
- Chyle contains significant amounts of protein (20–30 g/L)
- Recommendations for protein intake should account for such losses if an external drain is present or with repeat chylous fluid paracentesis
- Adequate intake may be a challenge for patients on a fat free oral diet

Essential fatty acid deficiency (EFAD)
- 2–5% of 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 and/or physical signs of EFAD
- IV lipid 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 A.
Fat Free (FF)/Very Low Fat Diet for Chyle Leak
(A more in-depth version is available at: *www.ginutrition.virginia.edu* under patient educational materials)

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 prepared without added fat (limit to ½ cup per day)—black, pinto, kidney, white, lima (butter beans), lentils • FF refried beans	• Whole eggs • Other meat • Nuts/seeds • Peanut butter, other nut butters • Soybeans/edamame
Dairy	• FF dairy products, including: FF milk, FF cheese, FF sour cream, FF cream cheese, FF cottage cheese, FF yogurt, FF frozen yogurt, FF ice cream • 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	

(continued on page 32)

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Appendix A (continued)
Fat Free (FF)/Very Low Fat Diet for Chyle Leak

Food Group	*Foods Allowed**	*Foods Not Allowed*
Miscellaneous/ Condiments	• FF salad dressing, ketchup, barbeque sauce, mustard, soy sauce, hot sauce, FF salsa, relish, syrup • FF Broth/FF soups	
Fats	• FF mayonnaise • FF salad dressing • FF creamers (flavored and plain) • FF whipping cream/Cool whip	• Butter, margarine, cream • Lard • All vegetable oils • Low fat or regular mayonnaise, regular salad dressings

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

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