the catheter without its removal, particularly if the offending organism is *S. epidermidis*. Clearing of the biofilm and fibrin sheath by local treatment of the catheter with indwelling alteplase may increase the likelihood of eradication. Antibiotic lock therapy with high concentrations of antibiotic, with or without heparin in addition to systemic therapy, may improve efficacy. Sepsis with hypotension should precipitate catheter removal in either the temporary or the permanent TPN setting.

ENTERAL NUTRITION

TUBE PLACEMENT AND PATIENT MONITORING

The types of enteral feeding tubes, methods of insertion, their clinical uses, and potential complications are outlined in Table 98e-8. The different types of enteral formulas are listed in Table 98e-9. Patients receiving EN are at risk for many of the same metabolic complications as those who receive PN and should be monitored in the same manner. EN can be a source of similar problems, but not to the same degree, because the insulin response to EN is about half of that to PN. Enteral feeding formulas have fixed electrolyte compositions that are generally modest in sodium and somewhat higher in potassium. Acid-base disturbances can be addressed to a more limited extent with EN.

TABLE 98e-8 ENTERAL FEEDING TUBES

Type/Insertion Technique	Clinical Uses	Potential Complications
Nasogastric Tube		
External measurement: nostril, ear, xiphisternum; tube stiffened by ice water or stylet; position verified by air injection and auscultation or by x-ray	Short-term clinical situation (weeks) or longer periods with intermittent insertion; bolus feeding is simpler, but continuous drip with pump is better tolerated	Aspiration; ulceration of nasal and esophageal tissues, leading to stricture
Nasoduodenal Tube		
External measurement: nostril, ear, anterior superior iliac spine; tube stiffened by stylet and passed through pylorus under fluoroscopy or with endoscopic loop	Short-term clinical situations where gastric emptying is impaired or proximal leak is suspected; requires continuous drip with pump	Spontaneous pulling back into stomach (position verified by aspirating content, pH >6); diarrhea common, fiber-containing formulas may help
Gastrostomy Tube		
Percutaneous placement endoscopically, radiologically, or surgically; after track is established, can be converted to a gastric "button"	Long-term clinical situations, swallowing disorders, or impaired small-bowel absorption requiring continuous drip	Aspiration; irritation around tube exit site; peritoneal leak; balloon migration and obstruction of pylorus
Jejunostomy Tube		
Percutaneous placement endoscopically or radiologically via pylorus or endoscopically or surgically directly into the jejunum	Long-term clinical situations where gastric emptying is impaired; requires continuous drip with pump; direct endoscopic placement (PEJ) is most comfortable for patient	Clogging or displacement of tube; jejunal fistula if large-bore tube is used; diarrhea from dumping; irritation of surgical anchoring suture
Combined Gastrojejunostomy Tube		
Percutaneous placement endoscopically, radiologically, or surgically; intragastric arm for continuous or intermittent gastric suction; jejunal arm for enteral feeding	Used for patients with impaired gastric emptying and high risk for aspiration or patients with acute pancreatitis or proximal leaks	Clogging, especially of small-bore jejunal tube

Abbreviation: PEJ, percutaneous endoscopic jejunostomy.

Note: All small tubes are at risk for clogging, especially if used for crushed medications. In long-term enteral nutrition patients, gastrostomy and jejunostomy tubes can be exchanged for a low-profile "button" once the track is established.

Source: Adapted from the chapter on this topic in *Harrison's Principles of Internal Medicine*, 16e, by Lyn Howard, MD.

TABLE 98e-9 ENTERAL FORMULAS

Composition Characteristics	Clinical Indications
Standard Enteral Formula	
Complete dietary products (+)[a] 1. Caloric density: 1 kcal/mL 2. Protein: ~14% cals (caseinates, soy, lactalbumin) 3. Carbohydrate: ~60% cals (hydrolyzed corn starch, maltodextrin, sucrose) 4. Fat: ~30% cals (corn, soy, safflower oils) 5. Recommended daily intake of all minerals and vitamins in >1500 kcal/d 6. Osmolality: ~300 mosmol/kg	Suitable for most patients requiring tube feeding; some standard formulas can be used orally
Modified Enteral Formulas	
1. Caloric density: 1.5–2 kcal/mL (+)	Fluid-restricted patients
2. Protein	
a. High protein (~20–25% protein) (+)	Critically ill patients
b. Hydrolyzed protein to small peptides (+)	Impaired absorption
c. ↑ Arginine, glutamine, nucleotides, ω3 fat (+++)	Immune-enhancing diets
d. ↑ Branched-chain amino acids, ↓ aromatic amino acids (+++)	Liver failure patients intolerant of 0.8 g of protein/kg
e. Low protein of high biologic value	Renal failure patients for brief periods if critically ill
3. Fat	
a. Low-fat partial MCT substitution (+)	Fat malabsorption
b. ↑ Fat (>40% cals) (++)	Pulmonary failure with CO_2 retention on standard formula, limited utility
c. ↑ Fat from MUFA (++)	Improvement in glycemic index control in diabetes
d. ↑ Fat from ω3 and ↓ fat from ω6 linoleic acid (+++)	Improved ventilation in ARDS
4. Fiber: provided as soy polysaccharide (+)	Improved laxation

[a]Cost: +, inexpensive; ++, moderately expensive; +++, very expensive.

Note: ARDS, acute respiratory distress syndrome; MCT, medium-chain triglyceride; MUFA, monounsaturated fatty acids; ω3 or ω6, polyunsaturated fat with first double bond at carbon 3 (fish oils) or carbon 6 (vegetable oils).

Source: Adapted from the chapter on this topic in *Harrison's Principles of Internal Medicine*, 16e, by Lyn Howard, MD.

Acetate salts can be added to the formula to treat chronic metabolic acidosis. Calcium chloride can be added to treat mild chronic metabolic alkalosis. Medications and other additives to enteral feeding formulas can clog the tubes (e.g., calcium chloride may interact with casein-based formulas to form insoluble calcium caseinate products) and may reduce the efficacy of some drugs (e.g., phenytoin). Since small-bore tubes are easily displaced, tube position should be checked at intervals by aspirating and measuring the pH of the gut fluid (normal: <4 in the stomach, >6 in the jejunum).

COMPLICATIONS

Aspiration The debilitated patient with poor gastric emptying and impairment of swallowing and cough is at risk for aspiration; this complication is particularly common among patients who are mechanically ventilated. Tracheal suctioning induces coughing and gastric regurgitation, and cuffs on endotracheal or tracheostomy tubes seldom protect against aspiration. Preventive measures include elevating the head of the bed to 30°, using nurse-directed algorithms for formula advancement, combining enteral with parenteral feeding, and using