The history of enteral nutrition therapy: From raw eggs and nasal tubes to purified amino acids and early postoperative jejunal delivery

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ABSTRACT

Although enteral feeding therapy has existed since ancient Egypt, most of the major advances in enteral feeding techniques and formulas took place during the 20th century, including postpyloric tube placement in 1910; continuous and controlled delivery of liquid nutrition in 1916; feeding during surgery and modification of macronutrients in 1918; feeding via a pump in 1930; recognition of the importance of nutrition therapy during injury recovery and the addition of micronutrients and early postoperative feeding in 1940; the introduction of commercial products during the 1950s with chemically defined formulas following a decade later; and the development of modern formulas during the 1970s. The purpose of this review is to provide a historical account of enteral nutrition, including modes and routes of delivery, types of diet, and refinements in delivery techniques and formulas and to offer the history of the therapy as a resource for developing and improving enteral feeding techniques and therapies and implementing optimal patient care strategies. *J Am Diet Assoc. 2002;102:399-404.*

Enteral feeding has come a long way since its inception in ancient Egypt, when practitioners used enemas of wine, milk, whey, and wheat and barley broths to foster good health as well as treat diarrhea (1). The history of enteral feeding therapy is full of accounts of rectal feedings and nasal and upper gastric feedings of raw egg, whiskey, and beef mixtures. In 1598, Capivacceus is reported to have used a hollow tube to put liquid down a patient's esophagus, and Aquapendente, in 1617, fed via a nasopharyngeal tube (2). In 1646, Von Helmont manufactured a flexible leather tube for esophageal tube feeding and in 1710, Boerhave suggested that the tubing could be used for feeding into the stomach (2). The intermittent use of upper gastrointestinal feedings continued during the 18th and 19th centuries, but rectal feedings were the popular method for providing enteral nutrition to patients. Once Einhorn introduced his tubing and enteral feeding technique in 1910 (3), reputable medical practitioners adopted his methods and modern techniques of gastric and intestinal therapies began to be developed, along with highly specialized enteral products. The purpose of this review is to provide a historical account of enteral nutrition, including modes and routes of delivery, types of diet, and refinements in delivery techniques and formulas (see the Table).

EARLY NASAL AND GASTRIC FEEDING

In the literature from the 18th and 19th centuries, reports of gastric feedings include use of a variety of mixtures of foodstuffs and many devices to deliver the feedings. The most popular device was a long tube with a funnel or syringe attached to the outside end. Some physicians, particularly to treat children and patients with so-called nervous afflictions, prescribed gastric feedings. Hunter is reported to be the first physician to use an orogastric tube made of a whale bone probe covered with eel skin attached to a bladder pump to feed patients a mixture of jellies, beaten eggs, sugar, milk, and wine, in 1790 (1).

Gastric feedings frequently consisted of nostril feedings, as in the case described by Dukes in 1876. Dukes (4) reported feeding with a rubber tube of one-eighth-inch bore passed just within the nostril. He recommended nostril feedings of warm milk, eggs, beef-tea, and

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Table
Timeline for development of enteral nutrition solutions and delivery methods

Date	Important events in the history of the development of enteral nutrition
Ancient Egyptians	Use of enemas of wine, milk, and grain broths
16th and 17th centuries	Use of naso- and oropharyngeal tubes
1700s and 1800s	Use of orogastric tubes to feed milk, eggs, broth, and whiskey
1800s	Nasopharyngeal devices and oral gastric tubes to feed egg, sugar, wine, and milk mixture
1800s	Rectal tubes to give raw beef, whiskey, egg, pancreatic gland, and defibrinated blood mixture
1910	First nasoduodenal tube placement
1910s	Introduction of drop-by-drop feeding, experiments on the digestive and absorptive capacity of the small intestine, and heat treatment of nutritional mixtures
1918	First reported case of jejunal feeding
1930-1940	Development of double lumen tube for feeding and decompression; use of partially digested nutritional mix with added electrolytes and vitamins
1939	First casein hydrolysate introduced
1940	Development of automatic feeding pump
1940s	Patient recovery and nitrogen balance used to assess role of enteral nutrition in patient outcome
1940s	Gastro-jejunal tube placement during surgery with early postoperative feeding
1950s	Introduction of commercially prepared powdered mixtures. Solutions provided protein, fat, carbohydrate, and 8 vitamins and 8 minerals
1950s	Refinement in hospital kitchen methodology to prepare liquefied solid foods
1955-1965	National Institutes of Health-funded study on purified, chemically defined diets
1960s	"Space Diet" (Codelid Elemental Diet) used to provide nutrition to patients with severe gastrointestinal complications
1970	Introduction of providing energy distribution of 30% as fat, 20% as protein, and 50% as carbohydrate
1980-2000	Use of enteral nutrition to support optimal digestion and absorption, to enhance immune system, to aid wound healing, and to promote intestinal health and nutrition as therapy to treat illness and injury

stimulants for children suffering from mania, diphtheria, croup, and "fasting girls and spoilt children, who, when ill, refuse food (4)." Coulston (5), in 1872, passed a rubber tube through the nostrils to the fauces (the narrow passage from the mouth to the pharynx) and fed thick custards and mashed mutton to patients. Similarly, Hott (6) passed a tube through the nostril and then later through the mouth into the stomach and fed patients peptonized milk containing whiskey or brandy and digitalis.

In 1895, Morrison (7) used both nasogastric and orogastric tubes to feed children with diphtheria. He fed the children for 4 weeks using a solution, given 3 times each day, made of 6 oz cream, 2 oz brandy, 3 drops of tincture of nux vomica (the seed of an Asian tree of the genus Strychnos that contains the alkaloids strychnine and brucine), and a digestive ferment that consisted of liquor of pancreaticus and essence of pepsin.

In addition to tubes, other devices like a teapot with a mouthpiece and long spout were used to forcibly feed patients via the mouth in mental institutions. Reeve (8) reported designing such an instrument in 1851, and feeding patients a mixture of milk, egg, beef tea, and wine thickened with arrowroot.

RECTAL FEEDING

There was debate during the 1800s about the use of gastric feedings vs rectal feedings. Some practitioners attempted rectal feeding only if gastric feeding was not feasible, whereas others believed that colonic absorption through reverse peristalsis could support a patient's nutrition needs. Rectal feeding devices evolved from a piece of pipe with a bladder tied to one end used by Hippocrates, to long pieces of rubber tubing attached to funnels or wooden syringes (1). Jones-Humphreys (9), in 1891, reported using a one-eighth-inch diameter piece of rubber tubing that was 1 ½ ft long to feed a patient rectally. He claimed that if the fluid was slowly infused and did not return, there would be slow absorption.

Additional case reports of rectal feeding in the literature include 1 by Brown-Sequard (10), who wrote about a patient with esophageal stenosis. The patient was given enemas of a mixture of two-thirds of a pound of divided, raw beef with no fat or connective tissue and one-quarter of a pound of hog's pancreas. This mix was pushed into the rectum 2 times each day with a wooden syringe. Brown-Sequard noted that "the patient was so well fed by that means that he had not visibly lost fluid when he died, after apoplectic symptoms [symptoms related to a stroke], 8 days after the time these enemas had been first used." (10)

Advocates of rectal feeding stipulated that it was necessary to give pancreatic gland with the feeding. The earliest reports of the use of the pancreatic mix date to 1671, according to Kaufman (11). In 1878, Kaufman also claimed (11) that patients given an enemata of eggs, milk, beef broth, and pancreatic gland could live a normal life for 9 months: "It is essential that the pancreatic gland which is to be used, be from an animal quite recently killed, as the tissues and juice of that gland lose their properties very quickly if the temperature of the surrounding air is at all high."

Other materials given as nutritional enematics included tobacco, meat mixed with wax and starch, and red wine. Defibrinated blood was sometimes used in rectal feeding, but Kaufman reported (11) that "the blood decomposed in the rectum...with a strong odor emanating from the patient." Perhaps the most famous case of rectal feeding was that of President Garfield as noted by Bliss in 1882 (12). President Garfield was rectally infused with peptonized beef broth, beef peptonoid, and whiskey every 4 hours for most of the 79 days he lived after suffering a gunshot wound. (President Garfield is reported to have died from infection and internal hemorrhage since the surgeons could not locate and remove the bullet.)

SMALL BOWEL FEEDING

The rectal route was used to administer water, saline, and glucose solutions until 1940, although the preferred route of enteral nutrition support had turned to gastric delivery by the

early part of the 20th century (1). The main problem with orogastric feeding was intolerance to the feeding. In 1910, Einhorn (1) solved this problem by inserting a small weighted, rubber nasogastric tube and letting it pass into the duodenum. He fed 3 patients via his duodenal tube every 2 hours with a mixture of 240 cc milk, 1 raw egg, and 15 g lactose while rectally infusing a quart of physiological salt solution.

Many other physicians, including W. G. Morgan (13) and C. R. Jones (14), adopted Einhorn's technique and implemented modifications. Morgan heated and strained the milk, raw egg, and lactose mix, and Jones suggested that some patients did not tolerate the bolus feedings delivery. In 1916, Jones conceived the idea of continuous flow using a drop-by-drop method of feeding. He found (14) that a gradual increase in the tube feeding volume was better tolerated by patients and suggested a first-day regimen of 2 oz sweet milk every 2 hours at 60 to 120 drops per minute with a daily increase by 2 oz per day up to 12 oz. He further recommended the following regimen for the egg. First, egg white was added to every second feeding, then a whole egg was added to every other feeding, and finally a whole egg was added at every feeding. If there was no intolerance as exhibited by diarrhea or distension, the butterfat content of the milk was gradually increased to achieve a total of 2,350 kcal per day. Patients fed via this method were reported to have survived for a month and gained weight.

As scientific understanding of the physiology of the gastrointestinal tract increased, physicians were concerned about absorption in the upper small intestine. Several studies were conducted during the early 1900s to test the digestion and absorption of foodstuffs fed directly into the duodenum. In 1915, Gross and Held described these experiments (15) and noted that there was adequate pancreatic and intestinal stimulation during the infusion. Gross went on to develop a duodenal tube that was larger in diameter than Einhorn's tube and had a heavy, weighted ball. He claimed that this tube, using gravity, passed to the duodenum in 15 to 20 minutes compared to the 3 to 12 hours that it took for Einhorn's tube to pass by the propulsive action of the stomach (15).

JEJUNAL FEEDING

Jejunal feeding was introduced shortly after duodenal feeding. In 1918, Anderson (16) reported passing a tube into the jejunum during surgery and feeding a solution of 200 mL peptonized milk, 15 g dextrose, and 8 mL whiskey. This regimen continued every 2 hours postsurgery to reach 2,500 kcal in 24 hours. He suggested that the feeding mixture "may contain whiskey, coffee, or other stimulant as required for immediate stimulating effect."

During World War II, physicians in the Soviet Union related accounts of jejunal feeding during surgery using the Spasokukotski technique (17). Patients were fed on the operating table with a solution of 400 cc natural milk, 50 cc sweet butter, 2 eggs, 50 g sugar, 3 to 5 g salt, and 50 to 70 cc distilled alcohol. The jejunal tube was removed after the single bolus infusion. Panikov's description of this procedure (17) included the following observation: "The satisfactory effects of the Spasokukotski method of feeding were sometimes evident in the operating room itself. Frequently we observed the color return to the cheeks, the lips became red and warm to the touch... The intestines, instead of being flaccid and pale, generally became dilated, plethoric, and obviously peristaltic. The pulse became rhythmic, the beat much clearer and the breathing much deeper."

Refinement of the nasojejunal feeding tube and solution can be credited to 2 groups. In 1939, Abbott and Rawson (18) constructed a double lumen tube with 1 opening in the stomach for gastric suction and 1 opening in the jejunum for feeding. The same year, Stengel and Ravdin (19) used the Abbott tube to feed patients with a partially digested solution.

INTRODUCTION OF MODIFIED MACRONUTRIENTS

The Stengel and Ravdin feeding solution consisted of a sterile mix of acidified skim milk, commercial pepsin, sodium bicarbonate, sodium chloride and dextrose (19). In addition, these researchers promoted adding 1 cc viosterol of fish liver oil, 20 mg thiamin chloride, 50 mg nicotinic acid, and 100 mg of vitamin C as tolerated.

In 1939, Stengel and Ravdin designed the first casein hydrolysate. Their subsequent studies used a peptone hydrolysate supplied by Merck and Company (Whitehouse Station, NJ) and contained an amino nitrogen for a total nitrogen ratio of 1:187. The Stengel and Ravdin enteral product supplied an average of 74 g protein and 181 g glucose in 1,024 kcal (19). In addition, Stengel made several other important contributions to advances in enteral feeding, including the development of an automatic feeding device that was made by modifying a transfusion pump.

RESEARCH ON ENTERAL NUTRITION AND PATIENT OUTCOMES

Co Tui et al published research on the role of enteral nutrition relative to patient outcome in 1940 (20). They treated 8 patients with high-energy jejunal feedings started 2 hours postsurgery. The patients were given a casein hydrolysate and maltodextrose solution that supplied greater than 50 kcal/kg and 0.6 g nitrogen/kg. The patients fed the high-energy solution gained weight, maintained positive nitrogen balance, and remained in bed for half the time of the controls, who were given peripheral infusions of glucose and saline and, on postoperative day 6, oral doses of tea, sugar, and pepsinized milk. The role of nutrition in the recovery of patients continued to be examined as reports of patients in negative nitrogen balance were circulated (21,22). Establishing a positive nitrogen balance in patients after surgery became important during this time and physicians began to focus on the amount of nitrogen being given to patients.

In 1945, Riegel et al (23) compared the effect of 5 feeding regimens on nitrogen balance in patients following surgery. Some of the patients were fed orally and some via an orojejunal tube. The 5 diets used were: food from a metabolic kitchen, either in the form of a liquid, soft, or full hospital diet; Amigen, an enzymatic digest of casein and pancreas (Mead Johnson Nutritionals, Evansville, Ind), with added glucose, starch or maltodextrose; Amigen and hospital diet; Lactalbumin hydrolysate (Wyeth-Ayerst Pharmaceuticals, St Davids, Pa) with added glucose, starch, or maltodextrose; and gastrostomy mixture prepared with 500 mL skim milk, 50 g skim milk powder, 50 g cottage cheese, 50 g soybean flour, and 1 egg. The nitrogen balance studies for the first 5 postoperative days showed that most of the patients in equilibrium or positive nitrogen balance were receiving at least 0.3 g nitrogen per kilogram body weight and 30 kcal/kg. The patients fed with jejunal tubes had the greatest average fecal loss of nitrogen (3.3 g/day vs 1.4 g/day with gastric feeding and 1.0 g/day with the oral diets).

During the 1940s, Bisgard (24) concluded that parenteral fluid therapy was not needed for 2 reasons: fluids could be

given via the tube feeding and vitamins should be added to the tube-feeding solution. In addition, Bisgard was an advocate of early postoperative nutrition support and practiced a technique of surgically placing a gastro-jejunal feeding tube through which he fed the patients immediately postsurgery. Oral feedings were started on postoperative day 4 with jejunal feedings continuing until day 7 or 8.

Modifications to the feeding tubes and solutions continued and were reported in 1952 by Fallis and Barron (25), who used polyethylene tubes with an outside diameter of 1.9 mm and introduced the tubes nasogastrically by using a mercury-filled balloon attached to the tube by catgut sutures that dissolved in the stomach. The tube-feeding solution was made from 500 mL homogenized milk, 175 g liver protein hydrolysate, 300 g cerelose (a partially hydrolyzed cereal starch), 75 g powdered milk, 4 eggs, plus water and electrolytes.

COMMERCIAL FORMULAS ARE DEVELOPED

As procedures for producing commercial enteral products were refined by companies such as Mead Johnson and Wyeth-Ayerst, the debate about the best type of tube-feeding solution was escalated. Many different feeding mixtures, including homogenized solid food substances, combinations of supplemented dairy products; and elemental food substances in sterile, sealed containers were being used.

In 1954, Pareira et al (26) contributed to the debate by publishing the results of a large study of their tube-feeding solution, which was a dry mixture suspended in water. The solution, developed in conjunction with Mead Johnson, was composed of powdered whole milk, nonfat milk solids, calcium caseinate, dextrose, maltodextrose, 8 vitamins (thiamin, riboflavin, ascorbic acid, niacin, pantothenate, pyridoxine, folic acid, and vitamin B-12), 8 minerals (calcium, phosphorus, potassium, sodium, chloride, sulfur, magnesium, and iron), and choline. The experimental nasogastric tube-feeding solution supplied 3,500 kcal, 210 g protein, 600 g carbohydrate, 30 g fat, and vitamins and minerals at Recommended Dietary Allowances levels. Two hundred forty patients were included in the study and were fed solely with the enteral formula for periods ranging from 4 to 63 days. The formula was administered via continuous 24-hour drip, intermittent doses in 4 to 6 aliquots per day, or a combination of the 2 methods. Seven percent of the patients experienced gastrointestinal problems and the tube feeding was discontinued in 2% of the subjects due to severe diarrhea. There were no reports of aspiration or clogged tubes.

HOSPITAL KITCHENS PREPARE ENTERAL PRODUCTS

In 1953 and 1956, Barron and colleagues at Henry Ford Hospital (Detroit, Mich) published a series of papers on enteral feeding (27-30). Barron advocated the use of tube feedings made in hospital kitchens as better tolerated, more medically sound, and more cost-effective than commercially prepared formulas. According to Barron and Falls (29), "accumulating evidence stresses more and more the complexity of nutritional needs of the human body.... Up to the present time, we know of no manufactured preparation which can surpass or even equal such natural foods as beef steak, liver, eggs, milk, fruits, and vegetables." The Henry Ford Hospital method for producing enteral feedings consisted of using strained baby foods, blenderized hospital diets strained through fine mesh, and foods processed through a serum mill purchased from Admiral Tool and Die Company (Chicago, IL). The "Large Serum Mills or Comminuting Machines for Large Scale Use" were machines that could liquefy solid foods rapidly and on a large scale, allowing mass production (30). The blenderized formula supplied 180 g protein and 2,600 kcal per day and cost $1.80 per day to make in the hospital kitchen. Barron et al (28) developed a pump, with the assistance of Chrysler Corporation (now DaimlerChrysler, Auburn Hills, Mich), to push the mixture down the tube. "The patient can sit, lay, stand, and turnover without stopping the flow. It is noiseless, light, compact, and dependable."

THE DEVELOPMENT OF CHEMICALLY DEFINED FORMULAS

Two important events directed enteral feeding toward chemically defined formulas during the late 1950s and 1960s. The issues included the publication by Rose, in 1949, of the essential amino acid requirements of men (31), and hospitals' increasing emphasis on the use of antiseptic procedures and technologically advanced medical intervention. A large-scale study on chemically defined diets was undertaken at the National Institutes of Health in conjunction with Vivonex Corporation (Mountain View, CA) between 1955 and 1965.

In a series of papers Winitz et al reported findings about the use of purified diets in rats and humans (32-37). Animal tests of chemically defined diets determined that mixtures of purified amino acids, salts, vitamins, and glucose with a fat supplement could sustain adequate growth and reproduction in rats (32,35). In human studies with purified, elemental diets completed at the California Medical Facility in Vacaville, Calif (33,34,36,37), Winitz and colleagues fed 15 adult males for 22 weeks on a liquid-formula diet composed of 18 purified L-amino acids, with rigid procedures for ensuring analytical and optical purity of the amino acids, highly purified grades of crystalline glucose monohydrate and sucrose, 16 vitamins (12 water soluble and 4 fat soluble) assayed for purity and potency, 15 minerals (American Chemical Society reagent grade or US Pharmacopeia grade), and purified ethyl linoleate. Average daily energy intake was 2,900 kcal. Physical and laboratory studies on the men revealed no adverse changes from baseline. Serum albumin and hemoglobin levels were maintained within normal limits. Physical tests, including electrocardiograms, radiography of chest and long bones, ophthalmological studies, and dental exams, revealed no abnormalities or evidence of deterioration. Because the enteral formula did not contain fiber, bowel movements decreased in frequency and consistency. An earlier study in the series had indicated that the addition of 2 to 4 g carboxymethyl cellulose per chemically defined diet meal resulted in better stool consistency (34). Wintz et al therefore concluded that chemically defined diets provided adequate nutrition support and maintained normal physiological function and physical well-being in the subjects (37).

During the late 1960s and 1970s, advocates for the use of chemically defined liquid formulas continued to highlight the benefits. In 1967, Butler wrote an article praising the use of chemically defined liquid diets in which he described how enteral formulas could be modified by a dietitian to meet the individual needs of a patient (38). According to Butler, a dietitian could mix aliquots of portion-packaged, commercially available powdered products for patients without specialized nutritional needs or use modular components to specialize a diet. Butler was convinced that enteral feedings were highly

beneficial and he wrote, "food is really physiological medicine and should be dispensed with fastidious preparation. Such perspicacity in selection of our metabolic fuel can only result in an increased efficiency of the intricate human mechanism. The author is impressed by the possibility that were one to live voluntarily and exclusively on a precision diet, he could extend his life span to 150 years."

THE INTRODUCTION OF PARENTERAL NUTRITION AND THE CONTINUED REFINEMENT OF ELEMENTAL FEEDING

In 1968, Dudrick et al (39) reported the case of an infant sustained for 5 months on parenteral nutrition as her sole source of nutrition support. This was the first report of long-term parenteral nutrition being able to support life. The report was accepted with great enthusiasm, and subsequently, parenteral nutrition became the nutrition treatment of choice for any patient, who because of surgery, infection, ileus, or complications, was not able to eat for more than a few days.

Despite widespread use of parenteral nutrition, there were still medical practitioners who believed that the enteral route was possible in almost all patients. In the same year as the Dudrick et al study, Thompson et al (40) reported the case of a patient with only 4 cm of jejunum who was fed an enteral solution. In conjunction with Schwarz Bio-Research (Orangeburg, NY), Thompson and colleagues designed an elemental diet (Codelid Elemental Diet, often referred to as the "Space Diet"), modeled after that used by the US space program. The diet supplied essential nutrients but required minimal digestion, could be quickly absorbed, and produced little fecal residue. The Codelid Elemental Diet contained 18 purified amino acids, sucrose, 11 minerals, 12 water-soluble vitamins, 3 fat-soluble vitamins, and ethyl linoleate. The elemental diet was started on postoperative day 39, with the patient receiving parenteral nutrition and casein hydrolysate via a gastrostomy tube before day 39. Following initiation of the Codelid Elemental Diet, the patient was reported to be in positive nitrogen balance but continued to have septicemia and died at day 85. Autopsy results revealed an important finding. Despite loss of stomach epithelium, there was increased villus height and absorption capacity in the duodenum and remaining 4 cm of jejunum.

In 1969, Stephens and Randall (41) reported the results of a clinical trial with the Codelid Elemental Diet fed to 7 catabolic patients with conditions such as short bowel syndrome following massive bowel resection, gastrointestinal fistulas, pancreatitis, ulcerative colitis, and Crohn's disease at Rhode Island Hospital in Providence, RI. Four of the patients received supplemental parenteral support for fluid and electrolyte management, energy, and protein. Positive nitrogen balance was achieved, and in some cases, weight gain was reported in patients with inflammatory bowel disease or pancreatitis. One patient had spontaneous fistula closure. Subsequent studies found that elemental diets were a valuable feeding modality for patients needing jejunostomy feedings due to fistulas or surgical resections (42,43).

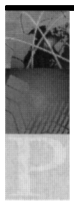
MODERN COMMERCIAL FORMULAS

With the increasing availability and manufacturing of commercial enteral products in the late 1960s and early 1970s, hospitals began to examine the cost of producing their own blenderized products. Although commercial formulas were more expensive to purchase than whole meal or milk-based blenderized diets were to make in the hospital kitchen, the labor savings were substantial (44). In addition, those concerned with equipment, sanitation, osmolarity, and viscosity favored the use of commercial, canned enteral products.

In 1970, Gormican and Catli (45) published their development procedures and test results of an enteral product designed to be "nutritionally appropriate, free of significant bacterial contamination, easy to administer, of consistent viscosity and low in cost." The Wisconsin formula, which was formulated in cooperation with Gerber Products Company (Fremont, Mich), was meant to supply the ratio of carbohydrate, protein, and fat normally consumed by a healthy person. The formula supplied 30% of energy as fat, 20% as protein, and 50% as carbohydrate. The most notable change was the amount of fat (33 g/L), which was far greater than the quantity found in commercially available, dehydrated products (2 mg/L). Gormican and Catli fed the formula to 83 patients and 5 healthy men and found significantly decreased gastrointestinal problems, particularly diarrhea, when compared to studies of patients fed elemental diets. Measurements of nitrogen retention were all positive and studies of fat absorption showed no fat malabsorption (45).

The development of the Wisconsin formula contributed enormously to the argument that patients needed to be fed as normal a diet as possible. Most enteral products today are based on the idea of feeding the carbohydrate, fat, and protein ratio found in a standard diet. However, most products are lactose free and use casein hydrolysates, first derived by Stengel and Ravdin (19) in 1939, as the protein source. The carbohydrate used in enteral products is mainly maltodextrin and sucrose, whereas the fat is vegetable oil. All products supply essential and nonessential vitamins and minerals, and some contain fiber. Only a few of the chemically defined, purified diets designed and tested by Winitz and colleagues are still commercially available today. As early as 1950, researchers such as Orten and colleagues (46) questioned the absorption efficiency of highly purified elemental diets with free amino acids. Research during the past 3 decades has favored the use of both intact protein and small peptides in semielemental formulas as advantageous for maximizing protein digestion and absorption (47-50).

Current scientific work focuses on modulating the body's response to injury and the use of individual nutrients as adjunct therapy to treat illness (51-54). For example, individual nutrients such as arginine and n-3 fatty acids are being studied as promoters of wound healing and the immune response (51,52). Glutamine is being added to enteral products to support the gastrointestinal mucosa (54), and nondigestible oligosaccharides are being proposed as stimulators of the growth of beneficial bacteria in the gastrointestinal tract (55). Hospitals no longer routinely prepare tube feedings from the food produced in their own kitchens, and only a few food-based enteral products are crrently being sold. However, medical nutrition specialists have returned to many of the practices of the past, such as early postoperative enteral feeding, jejunal feeding, providing enteral nutrition to patients with severe gastrointestinal abnormalities, and using nutrition support as an integral part of the medical treatment of injury and illness. Although enteral nutrition support will never return to the early origins of rectal and gastric feeding with milk, egg, and whiskey, it has become a blend of the old and the new.



APPLICATIONS

Enteral nutrition products today are based on solutions that were first proposed in the 1930s, and most of today's delivery techniques were first introduced more 90 years ago. The history of the evolution of enteral nutrition should not be overlooked in the quest to improve on current enteral feeding techniques and therapies, but should be used as a resource for developing and implementing optimal patient-care strategies. Researchers and medical practitioners from the early and middle part of the 20th century addressed questions about enteral nutrition therapy that are being debated today, such as tolerance concerns, tube placement, formula selection, nutrient composition, early post-operative nutrition support, and the use of enteral nutrition therapy as a adjunct medical therapy.

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