Chapter 3

Current Concepts of Intravenous Hyperalimentation

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1. Introduction

Although the concept of nutrition by vein has been developing for some time, advances that have established the technique for safe intravenous administration of total nutrients are relatively new.

From the time of discovery of the systemic circulation by Harvey in 1616, investigators have been infusing substances into veins. In 1656 Sir Christopher Wren, using a pig’s bladder attached to a goose quill, recorded the administration of ale, wine, and opium into the veins of dogs (Fortescue-Brickdale, 1904). Many attempts at intravenous infusions and blood transfusions followed, and technical improvements were made. However, it was not until the discovery of microbial infection by Pasteur (1877) and the use of Lister’s (1870) aseptic technique that serious complications of intravenous injection could be overcome. By the end of the 19th century, infusions of sugar and saline solutions into humans were routine. Following Elman’s infusion of protein hydrolysates into humans (Elman and Weiner, 1939), investigators began experimenting with a wide variety of nutrient solutions in an attempt to provide long-term total nutrition by vein. However, the hyperosmolality of the solutions caused damage (phlebitis, thrombosis) to the veins, thereby necessitating only the administration of dilute solutions (5–10% glucose), which failed to provide total energy needs.
In 1968 Dudrick et al. reported an effective method of long-term intravenous nutrition. They found that by infusing a mixture of glucose, protein hydrolysate, vitamins, and minerals directly into the superior vena cava as the sole diet, normal growth and development could be achieved in beagle puppies for longer than eight months. Infusing the markedly hypertonic solution into the large-bore, valveless central veins allows immediate dilution of the solution to isotonic concentration, thus avoiding the damage to veins that occurs with peripheral administration.

During the last decade, total intravenous hyperalimentation (hyperosmolar alimentation) has been the lifeline for numerous critically ill and/or malnourished patients. It has promoted positive nitrogen balance with anabolism where prior forms of nutritional treatment could not. Its potential as a prophylactic and therapeutic agent is still being realized. Our interest in this subject has spanned ten years and involved the management of more than 700 patients requiring specialized nutritional support.

2. Nutritional Metabolism

2.1. Body Fuels

Man has three fuel sources that he can utilize for energy, carbohydrate, protein, and fat. Carbohydrate has only very limited stores as glycogen in liver and muscle, and this is generally conserved for emergencies, such as anoxia or severe exercise. Thus, carbohydrate is of minor importance in the storage of energy. There is no storage form of protein as such. Each molecule of protein serves some useful, nonfuel function, such as structure, contractile potentiality, enzymes, or antibodies. Even though 1.0 g of protein can supply 16.7 kJ of energy, it is normally spared for its important nonfuel functions. Excess protein is metabolized, the nitrogen excreted as urea, and the energy utilized or stored as fat. Fat is the body’s major and most efficient storage form of energy and supplies 38.0 kJ/g. Any excess or deficit of energy is met by increasing or decreasing the fat reserves.

2.2. Response to Starvation

During starvation, the body receives insufficient energy to meet basal metabolic requirements and must call upon its energy reserves to meet the deficit. Blood glucose levels are maintained by increasing gluconeogenesis, using amino acids from muscle protein breakdown as substrates. During brief starvation (less than 72 hr), 10–15 g of nitrogen may be lost in the urine each day, as compared with the obligatory nitrogen loss of 1.5 g/day on a protein-free diet. However, if 100 g of carbohydrate is given, it spares the need for increased glucose produc-