The Need to Reassess Dietary Fiber Requirements in Healthy and Critically Ill Patients

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KEYWORDS

- Dietary fiber • Clinical studies • Fiber supplementation • Colon cancer
- *Clostridium difficile*

KEY POINTS

- Human dietary fiber requirements are based on the quantity known to be associated with cardiovascular health. It is more appropriate that they should be based on the nutritional needs of the colonic microbiota, which maintain colonic health and homeostasis.
- Diets containing more than 50 g of fiber per day are associated with low colon cancer risk.
- Current nutritional support of hospitalized patients overlooks the nutritional needs of the colonic microbiota, leading to colonic starvation and increased risk of dysbiosis, *Clostridium difficile* overgrowth, and acute colitis.

NORMAL HUMAN DIETARY FIBER REQUIREMENTS

The definition of dietary requirements is extremely difficult.[1] Traditionally requirements have been based on the quantity of food needed to maintain a normal body weight, or in the case of micronutrients to maintain normal blood levels. This presupposes that the definition of normal levels is known. People can be slim and fit or fat and fit. Blood levels of vitamins have to drop precipitously before tissue deficiency occurs and a pathologic phenotype is displayed.

The explanation for this problem is that nutrients are stored in good times that allow people to survive feasts and famines. Thus, overweight has been associated with improved outcome from the ICU.[2] On the other hand, slimness is associated with prolonged lifespan.[3]

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With dietary fiber, the definition of normal requirements becomes even more complex and difficult. Populations can survive on low fiber intakes for years, and patients with a colectomy do not need any fiber, as its chief role is to provide food for the colonic microbiota. However, the industrial and agricultural revolutions led to a massive increase in food production that supported the population explosion. Unfortunately, it also led to the progressive reduction in consumption of whole foods, which in turn led to dramatic reductions in food fiber content through food processing to promote storage and transportation. The development of fast foods through advanced food technology has culminated in the increased consumption of simple sugars, together with increased intake of processed meat and saturated fat, which characterize the western diet. This diet is responsible for the emergence of a group of chronic ailments, termed westernized diseases, which present the greatest challenge to health care in the United States today. Obesity, colon cancer, and cardiovascular diseases are perhaps the best examples. The lack of dietary fiber due to low intakes of coarse grains, fruits and vegetables is common to all, as their content of complex carbohydrate reduces satiety and glycemic responses to feeding, thereby reducing the risk of obesity. Obesity is associated with an increase in the incidence of at least 9 cancers, as documented by a recent review by the American Institute of Cancer Research, illustrated on **Fig. 1**.

The lack of fiber is particularly pertinent to the remarkably high incidence rates of colon cancer in westernized societies. For example, rates are uniformly high in all segments of the US population with levels of approximately 65 cases per 100,000 population in African Americans, 55 cases per 100,000 population in Caucasian Americans,[4,5] and as high as 100 cases or more per 100,000 population in Alaska Native People.[6] In stark contrast, colon cancer is rarely seen in rural African communities consuming their traditional high-fiber (~50 g/d), low-meat, and low-fat diets, at less than 5 cases per 100,000 population.

The explanation for this is the effect fiber has on the colonic microbiota. People have evolved over hundreds of million years on a high-fiber diet. Although people have characteristically been omnivores and hunter-gatherers, meat and fat intakes have been low and occasional, while foraging has been continual. Recent advances in dental microwear and stable isotope technology have provided evidence that grain consumption has always been part of the human diet.[7] Thus, human digestive tracts evolved in tandem with dietary exposure, but the few hundred years since the agricultural revolution have been insufficient to enable people to do without fiber. Basically, the small intestine is extremely efficient in digestion, absorbing 95% of what we eat. These absorbed nutrients maintain general body composition and health. However, some starches and proteins contain carbohydrate structures that are resistant to human enzymatic digestion and enter the colon. The anatomy of the colon evolved to produce a reservoir to hold up the digestive stream to allow infrequent defecation, just as the stomach evolved to become a reservoir to enable people to eat periodic meals, rather than having to nibble all day like a rat. The colonic reservoir increased the ability of the gastrointestinal (GI) tract to reabsorb all the fluid and electrolytes secreted by the upper GI tract to enhance the digestive efficiency of human enzymes. Perhaps more importantly, it created a home for environmental microbes that have the missing enzymes needed to complete the digestion of dietary residues, such as complex carbohydrates and dietary fibers. A perfect symbiotic, or mutualistic, relationship was set up where the fiber provided food for the microbes, while the microbes only partially broke the carbohydrate skeletons down to short chain fatty acids, notablely acetate, butyrate, and propionate. These metabolites were released into the lumen and became the preferred nutritional sources for the colonic epithelium. The colonocytes differ from all other body cells in their preferred utilization of butyrate for energy production. Thus, naturally occurring foods provided sufficient fiber residues to maintain the health of the microbiota and the colon.