NUTRITION AND IMMUNITY: VITAMINS AND MINERALS

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Abstract

Infectious diseases impinge on animal health and welfare. Appropriate nutrition may aid in minimizing the incidence of infectious diseases by optimizing immunity. Formulating diets that optimize immunity requires knowing the specific cellular mechanisms by which nutrients affect immunity, and how these mechanisms pertain to specific nutrients and pathogens. Understanding the nuances of nutrition and immunity is important because higher dietary levels of some nutrients is not always better and a nutritionist can do harm to immunity and animal health by over fortification.

Introduction

Animals are continuously being challenged by pathogens. Vaccination is helpful, but is not an option most of the time. Thus, we are reliant on the animal's own immune system to thwart challenges from most pathogens. An important question is whether the nutritional needs for immunity differ markedly from the requirements for growth and reproduction that are the basis of current established requirements of domestic animals.

Methods

The immune system is a complex network of many cell types and accessory proteins and assessing its quality is difficult. Many nutritionists are not trained in immunology and lack the necessary background to design informative studies on immunocompetence or to interpret their results. Simply measuring every immunological end point possible is sure to indicate nutritional influences, but interpreting these differences and establishing whether a change is beneficial or detrimental is often impossible. This has resulted in a confusing and ugly literature that is rife with ambiguus and misinterpreted results. It is prudent to take a "first principles" approach to the field of diet and immunity so that mistakes are avoided.

Results and Discussion

Mechanisms by which diet affects immunity can be lumped into 5 general categories.
1. Nourish the cells of the immune system. Like all cells of the body, leukocytes need nutrients to do their jobs and to multiply when necessary. But the number of leukocytes in the body is small and they do not contribute much to the total requirement for nutrients. The time when the greatest quantity of nutrients is needed for immunity is during the acute phase response that occurs in the early stages that follow a challenge. During the acute phase response, the liver is recruited to aid the immune system by pumping out large quantities of protective proteins (acute phase proteins), resulting in an increased need for several trace minerals, including zinc, copper, and manganese. Unfortunately, the absorption of many trace nutrients is impaired by the immune

response and it is important to have adequate stores of these nutrients prior to an infectious challenge.

2. Nourish the pathogen. In order to multiply, pathogens must acquire their required nutrients within the environment of their host's tissues. Many important virulence genes of pathogens code for nutrient acquisition molecules. In rodents, humans and pigs, iron is the first limiting nutrient for the growth of many pathogens in serum as well as the intestines of the neonate. During the acute phase response to a pathogen, the immune system orchestrates the clearance of iron from body fluids and this further limits the amount of iron available to pathogens. Adding iron fertilizes the pathogens and augments their growth and virulence. In several avian species, biotin is the first limiting nutrient for pathogen growth. During the acute phase response avidin is produced, which binds biotin tightly and prevents its acquisition by pathogens. Obviously, adding more of some nutrients is not always better, especially during an infection.

3. Modify the responses of leukocyte (immunomodulation). Some constituents of food modify the response of key regulator populations of leukocytes by affecting the threshold of stimuli needed to evoke a response, changing the type of response, or modifying the duration of the response. Nutrients that have strong immunomodulating activities include long chain polyunsaturated fatty acids (PUFA), carotenoids, secondary plant compounds (e.g. genistein, flavonoids and many others found in herbals) and vitamins A, C, D, and E. These nutrients modify immune responses by receptor mediated signaling (e.g. PPAR and RXR) and by affecting eicosanoid release. The n-3 PUFAs influence macrophages to be less inflammatory, enhance antibody responses and influence T-lymphocytes to be less willing to engage in a cell-mediated response. The key point is that n-3 PUFAs, like all immunomodulatory nutrients, enhance some components of the immune response but diminish others. Thus, it is not appropriate to say that they "improve" immunity; we can only say that they change immunity. In some pathogen milieu the change might bolster overall protection and decrease incidence of diseases, but in other situations the same nutrient might cause detrimental shifts in immunity and enhance the overall disease problems. Obviously immunomodulating nutrients must be used with care and knowledge. They are not magic bullets.

4. Protect against immunopathology. An inflammatory response is typically accompanied by generation of free radicals and the release of cytokines and nitric oxide. Inflammation is essential to effective immunity to pathogens and is carried out by macrophages, neutrophils and other cells of the innate immune system. But damage to host cells causes chronic damage to tissues and dampens the effectiveness of the immune response. Protecting host cells against oxidative damage caused by the inflammatory response by fortifying diets with antioxidant nutrients (vitamins E and C) is now used clinically in humans and companion animals.

5. Influence the microbial ecology of the gut. The cell wall and other fiber components of feedstuffs affect microbial communities because they are not digestible by the host and serve as the primary substrates for microbial growth. Consequently, dietary ingredients markedly influence the mix of potentially beneficial, benign, and pathogenic species in the digestive tract and affect the degree of exposure of animals to pathogens. Further, the commensal microflora modulates cytokines produced by epithelial cells and leukocytes. Different strains of microbes have differing immunomodulatory actions, some being inflammatory and others having antiinflammatory or secretory IgA-inducing properties. Non-digestible oligosaccharides are thought to encourage the growth of bacterial populations that minimize inflammation and enhance IgA secretion.