40

Nutrition, infection and immune function

Mark L. Wahlqvist

OBJECTIVES

- To understand how immune function might be affected by nutritional factors, adversely, aberrantly and favourably.
- To relate proneness to infection to malnutrition.
- To consider the potential for nutritional reversibility of immunodeficiency in the aged, HIV positive and otherwise immunosuppressed individuals.

THE IMMUNE SYSTEM

The human host defends itself against infection in two ways, *innate* immunity which is inborn and always present, and *adaptive* immunity, which antigens induce (Janeway and Travers, 1994). Macrophages are particularly involved in the former, and lymphocytes in the latter (see Figure 40.1). There are also non-adaptive components of host defence which include cytokines and interferon production and natural killer (NK) cells. This is not to say that environmental factors may modulate these components.

Infection must surmount various barriers of the innate defence system (as shown in Figure 40.1) before requiring the adaptive response of lymphocytes, supported by other mechanisms like cytokine production or interferon production. Lymphocytes may be B, T or Null natural killer (NK) cells (in antitissue immunity). B cells which have been antigen stimulated can become highly specialised plasma cells in extravascular sites which secrete immunoglobulins (IgG, IgM, IgA, IgD and IgE). This is known as *humoral immunity*. The T cell mediates cell-mediated immune responses. The T cells, known as helper or inducer CD4, activate B cells. Those known as cytotoxic or suppressor CD8 kill infected target cells and also suppress B cell and T cell responses. There are other T cell subsets. The immune system not only deals with infections of various kinds (bacterial, viral and parasitic), but other foreign material like transplant tissue and, at times, may be directed

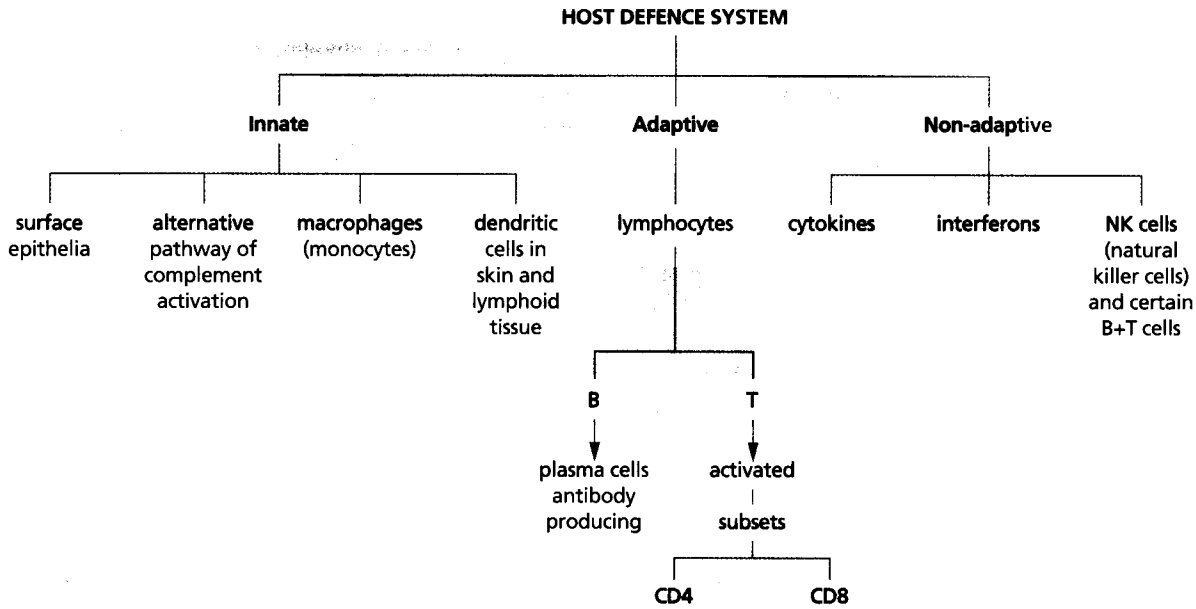

Figure 40.1 The host defence system

against the self as auto-immunity. The allergic response is an aberrant or idiosyncratic response of the immune system involving tissue mast cells and IgE antibodies to the antigen, and sometimes in eosinophilia (eosinophils in excessive numbers in blood) or an eosinophil infiltrate in tissue. Nutritional surveillance is also important in preventing tumour formation (see Chapter 41).

NUTRITIONAL DEFICIENCY AND IMMUNE STATUS

Both primary and secondary nutritional deficiency (as a consequence of disease, even infections, but including any wasting disease like malabsorption, cardiac failure, chronic obstructive lung disease, neoplastic disease) can impair immune status through the various arms of the immune system, innate and adaptive, cellular and humoral. For example, the ability of an epithelial surface to repair an injury may be impaired in protein or in zinc deficiency and, therefore, allow transgression of infective organisms. With protein and several water soluble vitamin deficiencies, antibody responses are suppressed. In protein energy malnutrition (PEM), the reduced production of secretory IgA from epithelial or mucosal surfaces presents particular problems of susceptibility to infection in the ears, eyes and gastrointestinal tract. PEM is characterised by impairment of the complement system (this cascade system of substance production amplifies the inflammatory response), of cellular immunity, of cytokine production (especially IL-1, an interleukin) by macrophages, and of phagocytic function by monocytes (the reticulo-endothelial system) and polymorphonuclear-leucocytes (neutrophilic granulocytes). The nutrient deficiencies which can impair immune function are summarised in Table 40.1.

Not only deficiencies, but also imbalances of nutrients can impair the immune system, as with leucine excess and iron excess, and with changes in 33/36 essential fatty acid ratios (Ayala and Chaudry, 1995; DeMarco et al., 1994) (see also Chapter 22). Non-nutrients or other food components are now recognised as immuno-modulatory, notably flavonoids and other polyphenolic compounds (Middleton and Kandaswami, 1992) (Figure 40.2).

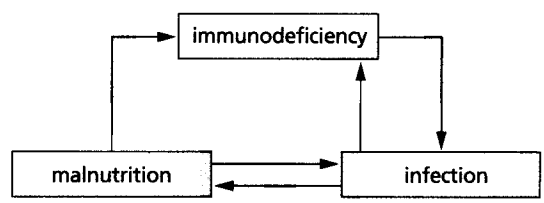

Figure 40.2 The nexus between malnutrition and infection

The nexus between malnutrition and infection

It is clear, therefore, that malnutrition, whether primary or secondary, predisposes the individual to infection and to other health problems where the integrity of the immune system is vital (see also Chapter 44). Increasingly, this means that indiviuals in the following groups are at risk:

1 where there is food shortage, as with poverty and famine (Chandra and Kumari, 1994; Lukito et al., 1994; Myrvik, 1994)
2 'in those who cannot eat enough or whose nutritional needs are increased
3 in the immunosuppressed, whether
   i for medical reasons (i.e. through use of steroids as in rheumatoid arthritis, asthma, or chronic inflammatory bowel disease or with transplant patients)
   ii through HIV (Human Immunodeficiency Virus positivity) and AIDS (Acquired immunodeficiency syndrome) (Lukito et al., 1994; Lustig, 1993)
   iii through declining immune function with age, although not all of this decline is inevitable (Lukito et al., 1994).

A vicious cycle may supervene, which is worthy of interruption at any point (see Figure 40.2). The

Table 40.1 Nutrient deficiencies which can impair immune function

Nutrient	Innate	Adaptive immunity: Humoral	Adaptive immunity: Cellular
Amino Acids			
essential	Yes	Yes	Yes
non-essential			
Arginine		Yes	
Glutamine	Yes	Yes	Yes
Essential fatty acids (ω-3 and ω-6)	Yes	Yes	Yes
Elements			
zinc	Yes	Yes	Yes
copper	Yes		Yes
iron			Yes
selenium	Yes	Yes	Yes
magnesium	Yes	Yes	
Vitamins			
B-2	Yes	Yes	Yes
B-6		Yes	Yes
folic acid	Yes	Yes	Yes
B-12		Yes	Yes
biotin		Yes	Yes
C	Yes		
A	Yes	Yes	Yes
D	Yes		
E	Yes	Yes	Yes
Non-nutrients			
flavonoids	Yes		Yes
peptides (glutathione)	Yes		Yes

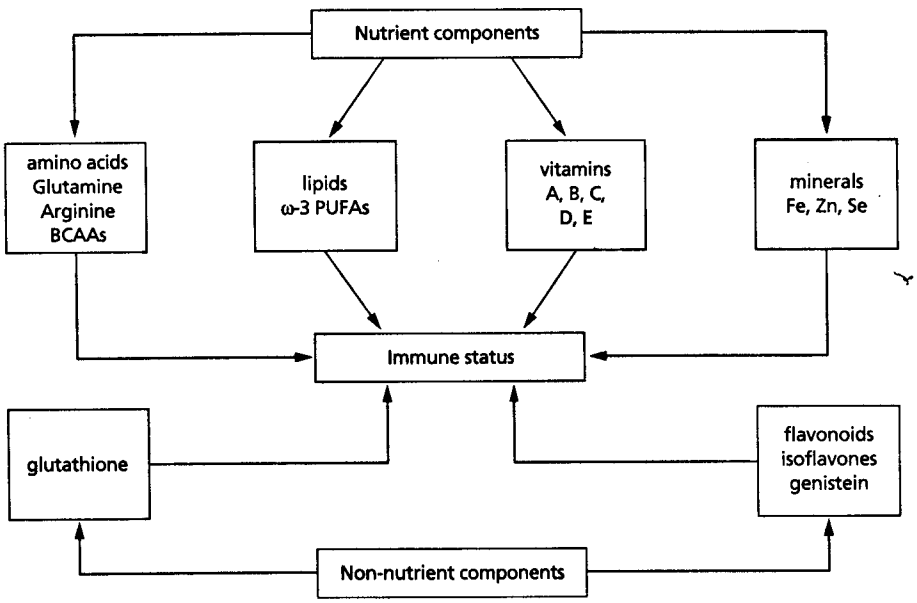

Figure 40.3 Food factors affecting immune status (BCAAs = branched chain amino acids; PUFAs = polyunsaturated fatty acids)

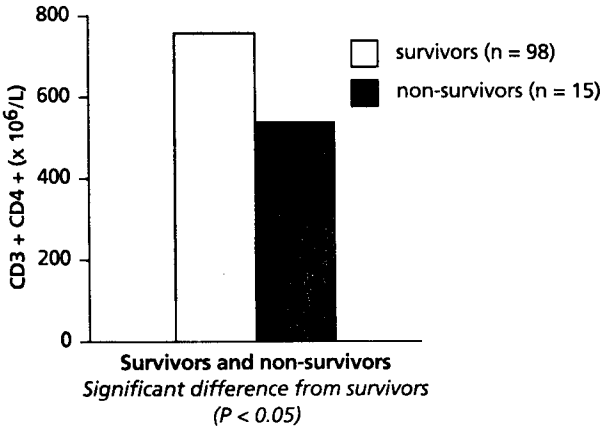

Figure 40.4 **Immune function is predictive of mortality. Baseline lymphocyte subset counts in 113 elderly institutionalised people in Melbourne, Australia who do or do not survive over 22 months (Lukito, 1995)**

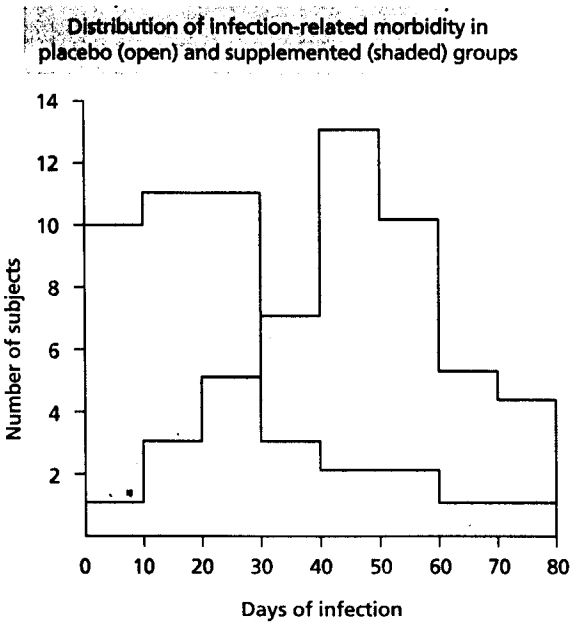

Figure 40.5 **Effect of vitamin and mineral supplementation on infection (Chandra, 1992)**

most threatening health problems in this cycle are the advent of anorexia and diarrhoea which may limit the ability to support nutritionally the immuno-compromised (Tomkins, 1992). The underrecognition or failure to anticipate the development of hospital malnutrition can allow the needless presence of nutritionally related immunodeficiency and proneness to infection, with increased hospital morbidity and mortality (Lukito, 1995).

Overnutrition and immune status

Although it is still unclear, there are indications that obesity may also lead to immune dysfunction (Stallone, 1994; Lukito et al., 1995; Klurfeld, 1993). Here, part of the problem may be the nature of the pathogenesis (mode of development) of obesity with physical inactivity and use of food of low nutrient and other food component density. Yet another contributor may be recurrent dieting and weight loss which may include lean mass as well as fat mass.

Food allergy

Most food sensitivities are reactions which are not allergic, although some are. These include adverse reactions to certain food proteins in seafood, chicken, nuts, milk, eggs, soy and even rice (Kamath, 1995). They may manifest in the skin, respiratory tract, gut, or in mood responses. Coeliac disease is a gluten induced enteropathy of an allergic kind. Lactose intolerance is not a food allergy (see also Chapter 43).

NUTRITIONAL REVERSIBILITY OF IMMUNODEFICIENCY

There is now good evidence that, in part, immunodeficiency is reversible by nutritional means, to the extent that it has been nutritionally caused (Chandra and Kumari, 1994; Chandra, 1992). This applies where food or nutrient intake has been inadequate, or nutrient losses excessive or nutrient demands increased (as in metabolic stress as far as glutamine and arginine are concerned) (Cynober et al., 1995; Baumgartner et al., 1995; Gogos Kalfarentzos, 1995; Adjei et al., 1995). Nutritional rehabilitation programs among children which reduce respiratory and gut infections most clearly show this phenomenon. So, too, do studies in the aged, in those known to be nutritionally impaired (Chandra and Kumari, 1994) and those likely to become impaired in the community (Chandra and Kumari, 1994; Lukito et al., 1994) (see Figure 40.5).

SUMMARY

- The immune system is both innate (dependent on surface epithelia, the alternative complement pathway, macrophages and dendritic cells) and adaptive (dependent on lymphocytes, both B and T cells). There are also non-adaptive components of host defence which include cytokines, interferon and natural killer cells.
- A range of food component deficiencies can contribute to immunodeficiency.
- There is a close nexus between infection and malnutrition which may allow a vicious cycle leading to high mortality rates.
- Overnutrition may also lead to immune dysfunction which involves mast cells and IgE antibody production in response to the antigen and sometimes eosinophils.
- A measure of immunodeficiency can be nutritionally reversible.

REFERENCES

Adjei AA, Yamauchi K, Nakasone Y, Konishi M & Yamamoto S. Arginine-supplemented diets inhibit endotoxin-induced bacterial translocation in mice. *Nutrition* 1995; 11:371–4.

Ayala A & Chaudry IH. Dietary n-3 polyunsaturated fatty acid modulation of immune cell function before or after trauma. *Nutrition* 1995; 11(1):1–11.

Baumgartner TG, Cerra FB, Jensen GL & Summer WR. Immunonutrition in the ICU: the power of special nutrients. *Journal of Critical Care Nutrition* 1995; 3(1):4–19.

Chandra RK. Effect of vitamin and trace-element supplementation on immune responses and infection in elderly subjects. *Lancet* 1992; 340 (8828): 1124–7.

Chandra RK & Kumari S. Effects of nutrition on the immune system. *Nutrition* 1994; 10(3):207–10.

Cynober L, Fürst P & Lawin P. *Pharmacological nutrition.* W. Zuckschwerdt Verlag GmbH, Germany, 1995.

DeMarco DM, Santoli D & Zurier RB. Effects of fatty acids on proliferation and activation of human synovial compartment lymphocytes. *Journal of Leukocyte Biology* 1994; 56:612–15.

Gogos CA & Kalfarentzos F. Total parenteral nutrition and immune system activity: a review. *Nutrition* 1995; 11(4):339–44.

Janeway CA, Jr & Travers P. *Immuno Biology. The Immune System in Health and Disease.* Current Biology Ltd/Garland Publishing Inc., London, New York, 1994.

Kamath KR. Antigen absorption: food, fire or fuel? *Asia Pacific Journal of Clinical Nutrition* 1995; 4(4): 371–5.

Klurfeld DM. Cholesterol as an immunomodulator. In: *Nutrition and immunology.* Klurfeld DMJ (ed). Plenum Publishing Corp., New York, 1993 pp. 79–89.

Lukito W. Nutrition and immune dysfunction in the aged. PhD thesis Monash University, Melbourne, 1995.

Lukito W, Boyce NW & Chandra RK. Nutrition and immunity. In: *Medical Practice of Preventive Nutrition.* Wahlqvist ML & Vobecky JS (eds). Smith-Gordon Co Ltd, London, 1994 pp 27–51.

Lukito W, Hutchinson PE, Wahlqvist ML, Boyce NW, Hsu-Hage BHH, Strauss BJG, Kouris-Blazos A & Bainbridge R. Body composition and lymphocyte subsets in an Anglo-Celtic elderly population. *Asia Pacific Journal of Clinical Nutrition* 1995; 4:69–72.

Lustig JR. Nutrition and HIV infection. *Asia Pacific Journal of Clinical Nutrition* 1993; 2:3–14.

Middleton E and Kandaswami C. Effects of flavonoids on immune and inflammatory cell functions. *Biochemical Pharmacology,* 1992; 43:1167–79.

Myrvik QN. Immunology and nutrition. In: *Modern nutrition in health and disease.* 8th edn. Vol 1. Lea & Febiger, Malvern, PA, 1994, pp. 623–62.

Stallone DD. The influence of obesity and its treatment on the immune system. *Nutr Review* 1994; 52:37–50.

Tomkins AM. Nutrition and infection. In: *Protein Energy Malnutrition.* Waterlow JC (ed). Edward Arnold, London, Melbourne, 1992, pp. 290–324.

FOOD AND NUTRITION

Australasia, Asia and the Pacific

Edited by
Mark L. Wahlqvist

Contributors
Madeleine Ball
David R. Briggs
Patricia A. Crotty
Gwyn P. Jones
Antigone Kouris-Blazos
Louise B. Lennard
Richard S.D. Read
Iain Robertson
Ingrid H.E. Rutishauser
Mark L. Wahlqvist
Naiyana Wattanapenpaiboon

Thanks to Antigone Kouris-Blazos for her editorial and technical assistance.

ALLEN & UNWIN

First published in 1997 by
Allen & Unwin Pty Ltd
9 Atchison Street, St Leonards, NSW 1590 Australia
Phone: (61 2) 8425 0100
Fax: (61 2) 9906 2218
E-mail: frontdesk@allen-unwin.com.au
Web: http://www.allen-unwin.com.au

National Library of Australia
Cataloguing-in-Publication entry:

Food and nutrition: Australasia, Asia and the Pacific.

Bibliography.
Includes index.
ISBN 1 86448 220 6.

1. Food. 2. Nutrition. I. Wahlqvist, Mark L.

641.3

Set in 11/13 pt Bembo by DOCUPRO, Sydney
Index compiled by Russell Brooks
Printed by Dah Hua Printing Press Co. Ltd, Hong Kong

10 9 8 7 6 5 4 3 2 1

Contents