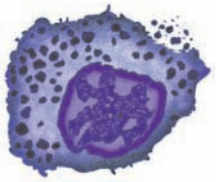


4. Food allergy in childhood

Katrina J Allen, David J Hill and Ralf G Heine

ABSTRACT

- Food allergies in children present with a wide spectrum of clinical manifestations, including anaphylaxis, urticaria, angioedema, atopic dermatitis and gastrointestinal symptoms (such as vomiting, diarrhoea and failure to thrive).
- Symptoms usually begin in the first 2 years of life, often after the first known exposure to the food.
- Immediate reactions (occurring between several minutes and 2 hours after ingestion) are likely to be IgE-mediated and can usually be detected by skin prick testing (SPT) or measuring food-specific serum IgE antibody levels.
- Over 90% of IgE-mediated food allergies in childhood are caused by eight foods: cows milk, hens egg, soy, peanuts, tree nuts (and seeds), wheat, fish and shellfish. Anaphylaxis is a severe and potentially life-threatening form of IgE-mediated food allergy that requires prescription of self-injectable adrenaline.
- Delayed-onset reactions (occurring within several hours to days after ingestion) are often difficult to diagnose. They are usually SPT negative, and elimination or challenge protocols are required to make a definitive diagnosis. These forms of food allergy are not usually associated with anaphylaxis.
- The mainstay of diagnosis and management of food allergies is correct identification and avoidance of the offending antigen.
- Children often develop tolerance to cows milk, egg, soy and wheat by school age, whereas allergies to nuts and shellfish are more likely to be lifelong.

MJA 2006; 185: 394–400

SERIES EDITORS: Andrew Kemp, Raymond Mullins, John Weiner

Food allergy is a common allergic manifestation in early childhood.[1] There has been a significant increase in public awareness of food allergies, as highlighted in media reports in Australia and overseas. However, some medical practitioners remain sceptical about the role of food allergies in a number of clinical syndromes, such as atopic dermatitis, colic and gastro-oesophageal reflux in infancy, despite an increasing body of evidence that food allergy can contribute to these conditions.[2] Our article aims to help general practitioners and other clinicians understand the principles of diagnosis and management of food allergy in childhood, and suggests when to refer patients for specialist opinion.

How common is food allergy?

The prevalence of food allergies appears to be increasing in industrialised countries, although reliable, population-based data are limited. Both prevalence figures and the spectrum of food allergens vary considerably between geographical regions, and are thought to reflect the variation in diet between different cultures.[1] However, it has been estimated that up to 6% of children under 3 years of age are affected by food allergies.[3] Infants with an atopic first-degree relative are at higher risk of allergy.

Recent studies have tried to confirm anecdotal evidence of an increased incidence of peanut allergy. In a UK study, Grundy et al found an increase in reported peanut allergy from 0.5% to 1.5% in two sequential early childhood cohorts from the same geographic area, surveyed 6 years apart.[4]

Although atopic disorders have a significant genetic basis, the recent increase is thought to be due to a change in environmental factors, including changes in diet and reduced exposure to early childhood infection.

What is food allergy?

Food allergy is defined as an abnormal immunological reaction to food proteins that causes an adverse clinical reaction. Food allergy needs to be distinguished from other types of adverse reactions to food, including:

- food intolerance (eg, lactose malabsorption);
- pharmacological reactions to food components (eg, vasoactive amines);
- food poisoning (eg, food-borne bacterial gastroenteritis); and
- toxic reactions (eg, to staphylococcal enterotoxin).

It is estimated that about a quarter of the population will have an adverse reaction to food (of which food allergy is just one type) during their lifetime, especially during infancy and early childhood.[5]

The best characterised form of food allergy is mediated by food-specific IgE antibodies. However, there is increasing recognition of non-IgE-mediated food allergy, commonly involving reactions to cows milk, soy or wheat. This is believed to result from cell-mediated immune mechanisms that are still poorly understood. This limits the ability to use skin prick testing (SPT) and serological testing in the diagnosis of non-IgE-mediated food allergic reactions. Currently, the most reliable way to assess non-IgE-mediated food allergies is by a formal sequence of dietary elimination and objective rechallenge after a period of symptomatic improvement.

Properties of food allergens

Although, in theory, any food protein may have the ability to sensitise the immune system, more than 90% of IgE-mediated food allergies in children are caused by just eight food items: cows milk, soy, hens egg, peanuts, tree nuts (and seeds), wheat, fish and shellfish. Typically, food allergens are glycoproteins that are relatively resistant to digestion and cooking. A large number of food allergens have now been identified and characterised (eg, β-lactoglobulin in cows milk, ovomucoid [Gal d 1] in egg and *Arachis hypogaea* allergen 1 [Ara h 1] in peanut). On each of these proteins, specific epitopes (structural components of the antigen molecule) have been mapped that interact with food-specific IgE antibody or T cell receptors. Further characterisation of these epitopes will be essential for developing food vaccines or genetically modified hypoallergenic foods. Epitopes also appear to have a prognostic role in food allergies. Linear epitopes are typically associated with long-term, persistent allergies, whereas conformational (three-dimensional) epitopes may be associated with more transient allergies.[6]

Glossary

Amino acid-based formula (AAF). Elemental infant formula in which the ingredients are present in their most digested form (such as amino acids and glucose). These formulas are regarded as the most hypoallergenic available and are useful for children with severe forms of food allergy, including cows milk allergy, multiple food allergies and food protein-induced enterocolitis.

Extensively hydrolysed formula (EHF). Cows milk-based formula that has been treated with enzymes to break down most of the proteins that cause symptoms in infants with cows milk allergy. It is important to note that *partially* hydrolysed formula is not indicated for treatment of infants with cows milk allergy.

Eosinophilic oesophagitis. Eosinophilic infiltration of the oesophagus, which is usually devoid of eosinophils. It may occur as part of a wider involvement of the gastrointestinal tract.

Epitope. An antigenic determinant (the structural component of an antigen molecule that is responsible for the specific interaction with the antibody).

Oral allergy syndrome. Food allergy symptoms involving the mouth and pharynx — usually in the form of oral itching, lip swelling, labial angioedema and occasionally glottal oedema — resulting from direct contact with the offending food. Some clinicians restrict use of the term to the pollen–food allergy syndrome.

Toll-like receptors. Pattern recognition receptors on cells of the innate immune system that recognise conserved bacterial structures. Toll-like receptor-dependent signals provided by intestinal bacteria may inhibit the development of allergic responses to food antigens via stimulation of regulatory T cells. ◆

When should food allergy be suspected?

Allergic reactions to foods encompass a spectrum of symptoms, ranging from mild cutaneous involvement to life-threatening anaphylactic reactions (Box 1, Box 2).[1] The relationship between food exposure and clinical reaction may be obvious, as in an acute IgE-mediated reaction to peanut ingestion. In such cases, elimination of the food will prevent further symptoms. However, the overall contribution of a food antigen to multifactorial conditions such as atopic dermatitis, eosinophilic oesophagitis, gastro-oesophageal reflux, or infantile colic is less well understood. In these cases, a food protein may induce the disorder or trigger an exacerbation, but elimination of the offending antigen, while reducing the severity of a disease, may not result in complete remission.

Diagnosis of food allergies requires a detailed dietary history, including the time interval between food intake and the onset of symptoms, to establish the link between exposure and allergic response. Acute reactions usually occur within 2 hours of ingesting a food, and typical presentations include urticaria, angioedema, vomiting or anaphylaxis. Delayed-onset reactions develop within 24–72 hours after food ingestion and are more difficult to define. Clinical presentations in delayed reactions include atopic dermatitis, infantile colic, gastro-oesophageal reflux, oesophagitis, diarrhoea and constipation.

Atopic dermatitis

Atopic dermatitis in infancy is closely associated with both IgE-mediated and non-IgE-mediated food allergy. The association is strongest in infants with moderate to severe eczema that begins before 12 months of age (Box 3). As food allergy often resolves in early childhood, the association between food allergy and eczema is much weaker in older children and adults than in infants.

Cows milk allergy

Cows milk allergy (CMA) affects about 2% of infants under 2 years of age in industrialised nations and is the most common form of food allergy in this age group. CMA can present with IgE- or non-IgE-mediated manifestations, with up to 50% thought to be non-IgE-mediated. Symptoms and syndromes that should alert the clinician to the possibility of CMA are outlined in Box 1. Importantly, CMA is not limited to formula-fed infants, as intact cows milk proteins (such as β-lactoglobulin and α-lactalbumin) have been found in breastmilk. In most children with CMA, the allergic response develops within 4 weeks of starting cows milk formula,[8] and in the great majority of cases CMA resolves by 3 years of age.[9]

Food protein-induced gastrointestinal syndromes

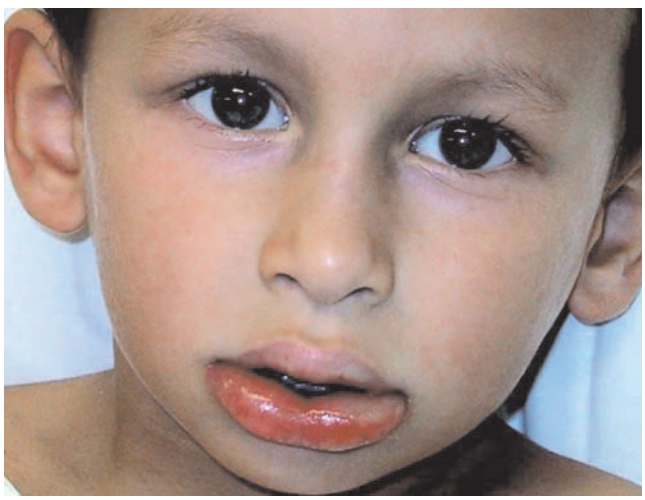
Food protein-induced gastrointestinal syndromes are becoming increasingly recognised in young infants. This group of disorders presents with symptoms related to various parts of the gastrointestinal tract, including:

- the small intestine: infants with food protein-induced enteropathy present with diarrhoea and failure to thrive;
- the colon: the most common cause of low-grade rectal bleeding in young infants is food protein-induced proctocolitis;[10,11] and
- the small intestine and colon: food protein-induced enterocolitis syndrome (FPIES) is characterised by more extensive disease of the small intestine and colon (see below).[12]

Other gastrointestinal disorders, such as eosinophilic oesophagitis, have also been shown to be associated with food allergies. This condition is discussed in a separate Focus article in this issue.[13]

FPIES often presents with profuse diarrhoea, vomiting, dehydration and failure to thrive. In about 20% of patients, the presentation can be dramatic, with acute dehydration leading to episodes of circulatory collapse and shock.[12] Allergy to multiple food proteins is common in FPIES, and although cows milk and soy are considered the main causative allergens, infants can present with FPIES following their first exposure to grains (such as oats or wheat), rice or poultry.[12] Interestingly, FPIES does not seem to

Lip angioedema in a child with nut allergy



1 Spectrum of allergic reactions to food proteins

	Group 1	Group 2	Group 3
Time to onset of reaction	< 1 hour	1–24 hours	> 24 hours
Ingested volume required for reaction	Small	Moderate	Large
Symptoms	Immediate food hypersensitivity, urticaria, erythema, angioedema, vomiting, anaphylaxis	Vomiting, diarrhoea, colitis, functional intestinal obstruction	Diarrhoea, atopic dermatitis, failure to thrive, gastro-oesophageal reflux, severe infantile colic
Syndromes	Oral allergy syndrome	Food protein-induced enterocolitis syndrome	Food protein-induced enteropathy, enterocolitis and proctocolitis; multiple food allergy
Immune class	IgE-mediated	Mixed IgE- and non-IgE-mediated	Non-IgE-mediated
Immunological characteristics	Large weal on skin prick test, raised levels of food-specific serum IgE antibodies	Not known	Enhanced T cell reactivity

2 Symptoms that should alert the clinician to the possibility of food allergy in children, particularly in the first months of life*

Clear relationship between food and symptoms (high risk)

- Anaphylaxis, generalised allergic reaction (angioedema, erythema, urticaria) or severe vomiting within 1–2 hours of ingesting a newly introduced food
- Oral allergy syndrome (oral/perioral pruritus associated with food-specific serum IgE antibodies)
- Food protein-induced eosinophilic gastrointestinal syndromes of infancy (persistent vomiting or bloody diarrhoea in first months of life)

Clear relationship between food and symptoms in only a subset of children presenting with these symptoms (lower risk, but evaluation often warranted)

- Gastro-oesophageal reflux, unresponsive to acid suppression
- Atopic dermatitis presenting in the first 12 months of life, unresponsive to topical treatment
- Severe unremitting infantile colic presenting in the first weeks of life
- Persistent constipation in infancy, with onset at the introduction of cows milk formula

* Modified from an American Gastroenterological Association position statement.[7] ◆

3 Case scenario*

A 4-month-old exclusively breastfed female infant was assessed as having atopic dermatitis, which persisted despite appropriate use of emollients and topical steroids. The mother had an unrestricted diet. Skin prick testing (SPT) of the child produced weals of 4 mm to cows milk, 3 mm to hens egg and 2 mm to peanut. The mother was advised to avoid dairy (but not soy) products, eggs, peanuts and tree nuts and to continue standard eczema treatment of the baby. She was instructed in how to examine food labels to avoid cows milk, casein, lactoglobulin and other dairy-containing products.

Within 2 weeks, the baby's dermatitis had dramatically improved, but not completely resolved, and there was significantly less requirement for topical steroids. Recommendations were given on introducing solids at 6 months of age and delaying the introduction of egg, nut and cows milk products until after 12 months of age.

When re-assessed at 12 months, the child's dermatitis was relatively mild, and inadvertent exposure to cows milk had occurred 2 months earlier without clinical reactivity. She was able to tolerate egg cooked in cake, but not uncooked egg in cake batter, which had caused facial urticaria. Repeat SPT gave the following weal results: cows milk, no reaction; egg, 6 mm; and peanut, 5 mm. Egg and peanuts were excluded from the child's diet over the next 12 months. At 2 years of age, SPT weal results were: egg, 3 mm; peanut, 1 mm; and other tree nuts, no reaction. A formal hospital-based challenge to egg was negative, and egg and nuts were successfully reintroduced into the diet with no exacerbation of dermatitis.

Comment

Cooking partially destroys the allergen in egg, and so patients with mild to moderate reactivity may tolerate egg if well cooked. The clinical significance of a reaction to egg becoming less severe over subsequent skin prick tests in the context of a history of previous clinical reaction needs to be determined by deliberate challenge. Even then, the size of the weal does not correlate well with the severity of any reaction that occurs.

* This is a fictional case scenario based on similar real-life cases. ◆

occur in breastfed infants, suggesting that larger amounts of the offending antigen are required to elicit intestinal mucosal inflammation. By contrast, food protein-induced enteropathy and proctocolitis may occur in either formula-fed or breastfed infants.[10,11]

Multiple food allergy

Multiple food allergy (previously known as "multiple food protein intolerance of infancy") is characterised by delayed-onset food-allergic reactions to breastmilk, formula milk (including extensively hydrolysed formula [EHF] and soy) and a broad range of solid foods. Infants with multiple food allergy may present with symptoms such as intermittent vomiting, diarrhoea, poor feeding, irritability, severe atopic dermatitis or failure to thrive.[14] Resolution of the symptoms occurs only after the introduction of an amino acid-based formula (AAF). Such infants have complex nutritional requirements and should be referred early for specialist assessment and management.

Which tests aid in diagnosis?

Skin prick testing

SPT provides a readily available and inexpensive means of assessing IgE-mediated food allergy. There is no minimum age for SPT, which can be performed in babies and infants with useful results.

A positive skin prick test result has a relatively low positive predictive value (ie, a significant number of patients with a positive result may be asymptomatic), but a skin prick test has a high negative predictive value (ie, a negative result indicates that IgE-mediated food allergy is unlikely). Non-IgE-mediated mechanisms cannot be assessed by SPT and may require formal food challenges to firmly identify the offending food antigen. Diagnostic SPT decision points have been defined for several food allergens (Box 4).

Food-specific serum IgE levels

Food-specific serum IgE antibody levels can be used as an alternative to SPT in assessing IgE-mediated food allergy, although laboratory reference ranges vary widely.[20,21] Low levels of food-specific serum IgE may be found in healthy individuals without clinical reactivity to the food (ie, there is sensitisation but not allergy). Food-specific serum IgE levels should be quantified in kU_A/L (units are kU/L for total IgE and kU_A/L for allergen-specific IgE antibodies) rather than expressed on semi-quantitative scales (such as low/medium/high), as diagnostic decision points are available for several major food allergens (Box 4).

Atopy patch testing

In recent years, the atopy patch test (APT) has been introduced as a diagnostic tool for delayed-onset food allergies, including atopic dermatitis and eosinophilic oesophagitis. The APT is based on cutaneous, cell-mediated responses after epicutaneous application of food allergens. It has been suggested that the APT, in conjunction with IgE-based testing, significantly improves the diagnostic accuracy of allergy testing, again reducing the need for formal challenges.[17] However, the role of patch testing in diagnosis of food allergy requires further clarification and is an area of ongoing research.

IgG antibodies to food antigens

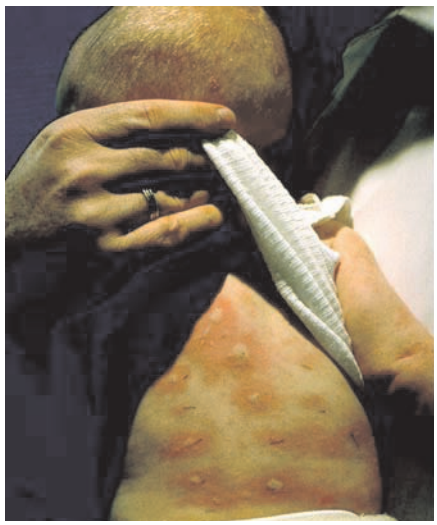
IgG antibodies to food are commonly detectable in healthy adult patients and children, independent of the presence or absence of food-related symptoms. There is currently no evidence that food-specific serum IgG antibody levels are clinically useful for diagnosing food allergy in children, as they are thought to simply indicate previous exposure to the food in question, but this remains an area of research.

Diagnostic challenge and food elimination

In patients with equivocal SPT or food-specific IgE results below the diagnostic decision points, confirmation of the diagnosis can only be achieved by formal food challenge.[22] Challenge protocols are based on increasing oral doses of food allergen, beginning at a very low dose. The doses are administered at predetermined time intervals until the first symptoms occur. Challenges are usually performed in hospital because of the risk of anaphylaxis. However, home challenges undertaken by parents may be suitable in patients with mild allergic reactions and a negative skin prick test, as the risk of a severe immediate reaction or anaphylaxis is minimal. Open-label challenges are usually sufficient in clinical practice, as long as symptoms can be objectively assessed. Double-blind, placebo-controlled food challenges are used for patients with subjective symptoms or in the research setting.

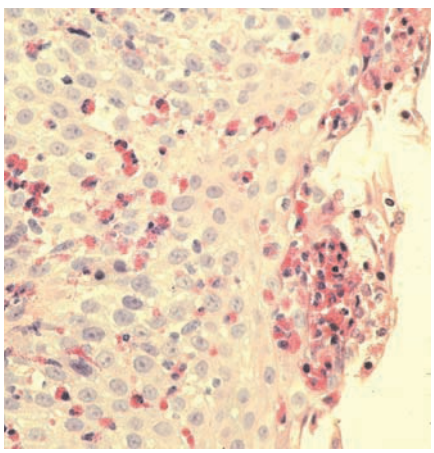
Elimination diets are also an important diagnostic step in investigating delayed-onset food allergies, which are usually non-IgE-mediated (Box 5). Decisions on whether to undertake formal food challenges and whether to perform them in hospital are influenced by the likelihood of food allergy — based on the history and the interpretation of allergy test results — and the perceived risk of a severe reaction on challenge.

Skin prick test weals in an 8-month-old baby



The infant had a history of immediate hypersensitivity reaction to cows milk and egg. Skin prick testing also showed positive reactions to a range of other foods, including cashew, peanut, sesame seed and wheat. ◆

Eosinophilic oesophagitis



Oesophageal mucosa (haematoxylin–eosin stain, original magnification × 400). Courtesy of Associate Professor C W Chow, Royal Children's Hospital, Melbourne, VIC. ◆

Gastrointestinal biopsies

Endoscopic biopsies from the upper and lower gastrointestinal tract may provide important diagnostic information in patients with suspected food allergy syndromes, such as eosinophilic oesophagitis, food protein-induced enteropathy or infantile proctocolitis. Ideally, biopsies should be obtained before commencing corticosteroid therapy or elimination diets. Endoscopy is also useful to rule out conditions such as coeliac disease, which may be considered in the differential diagnosis. In patients with severe infantile constipation, a rectal biopsy is helpful to test for Hirschsprung's disease or eosinophilic proctocolitis.

Management

The main principle of food allergy management is avoidance of the offending antigen. An incorrect diagnosis is likely to result in unnecessary dietary restrictions, which, if prolonged, may adversely affect the child's nutritional status and growth. For patients requiring prolonged restrictive diets, a formal dietetic evaluation is recommended to ensure that nutritional requirements are met.

Cows milk allergy

There is not complete agreement on first-line treatment for infants with CMA. About 10% of infants with CMA will not

tolerate EHF, presumably because of residual allergenicity of larger peptide and protein molecules present in the formula, and an AAF may be required. The current Australian Pharmaceutical Benefits Scheme (PBS) recommendation is that a soy-based formula should always be trialled before prescribing EHF. However, a recent European position statement has recommended that soy-based formula should not be used as first-line treatment for infants under 6 months of age, because of a high level of concurrent soy allergy and questions about the appropriateness of soy formula in this age group.[27] In Europe, EHF is the first-line formula for treating CMA — except in infants suspected of having multiple food allergy, who require an AAF. (Most infants will tolerate several non-formula foods by 18 months and can cease AAF by 3 years of age.[28]) In the light of international recommendations, the current Australian PBS recommendation may need to be reviewed.

Self-administered injectable adrenaline

Over 90% of fatal or near-fatal anaphylactic reactions to foods are caused by peanuts and tree nuts.[29] Intramuscular injection of adrenaline is the treatment of choice for anaphylaxis, regardless of aetiology. EpiPen auto-injectors (CSL Limited, Melbourne, VIC) containing a single dose of adrenaline are available for emergency treatment of anaphylaxis. The doses commonly recommended by specialist bodies (such as the Australasian Society of Clinical Immunology and Allergy [ASCIA]) differ from those in the manufacturer's product information. In Australia, it is recommended that EpiPen Junior (0.15 mg) be prescribed for patients weighing 10–20 kg and EpiPen (0.30 mg) for patients over 20 kg.

The use of adrenaline auto-injectors in Australian children has increased by 300% over the past 5 years, with 1 in 544 Australian children aged under 10 years now using them.[30] This may indicate that EpiPen is being prescribed to patients in low-risk categories, but no population-based data are currently available on the appropriateness of EpiPen use in Australia.

4 Diagnostic decision points

Skin prick testing (SPT)

SPT diagnostic decision points have been defined for several food allergens, including cows milk, egg and peanut.[15,16] These are cut-off values for SPT weal diameters that predict a positive food challenge result with over 95% accuracy. Correlation of a clear clinical reaction to a food antigen with a skin prick test result above a diagnostic decision point has reduced the need for formal food challenges. Predictive SPT weal diameters have been shown to be smaller in young children under 2 years of age.[15]

There is some variation in published diagnostic decision points, which may be due to differences in patient cohorts and challenge protocols, as well as variations in allergen extract potency and SPT method used. For this reason, interpretation of the decision points probably needs to be assessed on a centre by centre basis.

Food-specific IgE levels

Diagnostic decision points for food-specific IgE levels have been defined for cows milk, egg, peanut and fish. These are the cut-off food-specific IgE levels that predict positive food challenges with at least 95% accuracy.[17] The decision points for cows milk- and egg-specific serum IgE in infants under 2 years of age are lower than in older patients.[18,19] ◆

Guidelines published by ASCIA recommend that patients with previous food-induced anaphylaxis should be provided with an EpiPen.[31] Its prescription should also be considered for patients with a history of a significant generalised allergic reaction and at least one of the following risk factors: age over 5 years, history of asthma, allergy to peanuts or tree nuts, or limited access to emergency medical care.

Parents and carers of children carrying an adrenaline auto-injector should be provided with an anaphylaxis action plan and be trained in using the device. In addition, patients should be reviewed regularly to assess the ongoing need for an EpiPen and reinforce its correct use.

Can food allergies be prevented?

One hypothesis to explain the increased incidence of sensitisation to food allergens is that the reduction in early childhood infections or in exposure to microbial products (eg, endotoxin) may impede the development of early immunoregulatory responses. This leaves the immune system more susceptible to inappropriate reactivity to innocuous antigens, resulting in an "allergic" reaction.[32]

Postnatal development of mucosal immune homoeostasis is influenced by the type of commensal microbiota present in the neonatal period (eg, the predominance of bifidobacteria in breastfed infants may be protective against food allergy), as well as the initial timing and dose of dietary antigens.[33] Recent research suggests that toll-like receptor-dependent signals provided by intestinal bacteria may inhibit the development of allergic responses to food antigens via stimulation of regulatory T cells.[34]

A recent study found that differences in the neonatal gut microbiota precede the development of atopy, suggesting a role for commensal intestinal bacteria in the prevention of allergy.[35] This research has led to the hypothesis that probiotics may promote oral tolerance. Perinatal administration of *Lactobacillus casei* GG has been reported to reduce the incidence of atopic dermatitis, but not food allergy, in at-risk children during the first 4 years of life.

Exclusive breastfeeding seems to have a preventive effect on the early development of asthma and atopic dermatitis up to 2 years of age, but the evidence for prevention of food allergies is less clear. The delayed introduction of solids until after 4 months is believed to partially protect infants from developing food allergies, but this has recently been questioned.[36] If exclusive breastfeeding is not possible, a hydrolysed formula is recom-

5 Evidence-based practice tips*

- Elimination diets are an important step in the diagnosis of delayed-onset food allergies, as these are usually non-IgE-mediated (Level III-2).[23]
- Children with moderate to severe atopic dermatitis not responding to topical steroids and presenting in the first 6 months of life should be assessed for food allergies (Level III-2).[24]
- Mothers with a family history of atopy need not undertake an elimination diet to specific foods during pregnancy in order to prevent food allergy (Level I).[25]

*Based on National Health and Medical Research Council levels of evidence.[26] ◆

Fact or fiction — true or false?

1. Children often develop tolerance to cows milk, egg, soy and wheat by school age, whereas allergy to peanuts, tree nuts, and shellfish is more likely to be lifelong (T/F)

2. Food allergy does not occur in exclusively breastfed infants (T/F)

3. Symptoms of food allergy may manifest as colic, gastro-oesophageal reflux or atopic dermatitis in infancy (T/F)

1. True. Methods of frying or boiling peanuts, as practised in China, appear to reduce the allergenicity of peanuts compared with the dry-roasting method practised widely in the United States. This may help explain the difference in prevalence of peanut allergy observed in the two countries.

2. False. Intact food proteins are secreted into breastmilk and may elicit food allergy. Infants may respond to a maternal elimination diet.

3. True. As many as 80% of infants with moderate to severe atopic dermatitis presenting to a tertiary care centre are found to have IgE-mediated food hypersensitivity, but this figure is likely to be significantly lower in community-based practices. ◆

mended for the first 4 months of life in infants at high risk of food allergy (ie, those with an atopic first-degree relative).[37] Currently there is no evidence for the protective role of maternal elimination diets during pregnancy.[25]

Future therapeutic options

Several novel treatments for food allergy are currently under evaluation. However, none of these are currently available outside clinical trials. The role of injectable immunotherapy[38] for treating food allergy is limited because of the high risk of inducing anaphylaxis. By contrast, sublingual immunotherapy to food allergens may be better tolerated in children, although its clinical efficacy has not yet been clearly shown.

Recombinant anti-IgE antibody (omalizumab) has been used with limited success to treat food allergy. A recent study of patients with severe peanut allergy showed an increased threshold of tolerance (on average, from one-half to nine peanuts) on oral food challenge after being given a course of omalizumab.[39] Although such a protocol might protect an individual with severe peanut allergy against most inadvertent peanut ingestions, the therapy is expensive, requires regular administration, and is not currently approved in Australia for the treatment of food allergy.

Finally, there is the prospect of producing genetically modified foods from which the major allergens have been removed.[40]

Competing interests

David Hill has received support for clinical research projects from SHS/Nutricia and presented lectures at sponsored meetings.

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(Received 1 Jun 2006, accepted 28 Aug 2006) ❑