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CLINICAL REVIEW

# Anaphylaxis: the acute episode and beyond

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Anaphylaxis is an alarming medical emergency,[1-3] not only for the patient or caregiver, but also sometimes for the healthcare professionals involved. Although it is thought of as uncommon, the lifetime prevalence is estimated at 0.05-2%,[4 5] and the rate of occurrence is increasing. Hospital admissions, although uncommon, are also increasing, as are admissions to critical care units.[6 7] Many anaphylaxis episodes now occur in community settings.[8] Accurate community based population estimates are difficult to obtain because of underdiagnosis, under-reporting, and miscoding, as well as use of different anaphylaxis definitions and different methods of case ascertainment in the populations studied.[5] Although death from anaphylaxis seems to be uncommon, it is under-reported.[9]

In this article, we draw on evidence from randomised controlled trials, quasi-experimental and other observational studies, and systematic reviews. We also reference key evidence based international and national anaphylaxis guidelines and their updates.[1 2 10 11]

## How is anaphylaxis defined?

The widely used definition of anaphylaxis—"a serious allergic reaction that is rapid in onset and may cause death"—is accompanied by clinical criteria for diagnosis,[3] which have been validated for use in clinical and research contexts (fig 1⇓).[1 3 11-13] In emergency departments, this definition has high sensitivity (97%) and high negative predictive value (98%), with lower specificity (82%) and positive predictive value (67%), as anticipated in a multisystem disease.[3 12] Hypotension and shock are not prerequisites for making the diagnosis of anaphylaxis. Death occurs as often after respiratory arrest as it does after shock or cardiac arrest.[14]

## What are the mechanisms, triggers, and patient risk factors for anaphylaxis?

The clinical features of anaphylaxis result from sudden release of histamine, tryptase, leucotrienes, prostaglandins, platelet activating factor, and many other inflammatory mediators into the systemic circulation. Typically, this occurs through an immune mechanism involving interaction between an allergen and allergen specific IgE bound to high affinity IgE receptors on mast cells and basophils. However, IgE independent immune mechanisms and direct degranulation of mast cells are sometimes responsible, and other episodes, especially in adults, are idiopathic (box 1).[1]

Patient risk factors for anaphylaxis include vulnerability owing to age or physiological state (box 2).[1 11 15-18] Some diseases such as asthma and cardiovascular disease, and some drugs such as β adrenergic blockers and angiotensin converting enzyme inhibitors also increase the risk of severe or fatal anaphylaxis episodes (box 2).[1 11 14 18-20] Cofactors that can amplify or augment acute anaphylaxis episodes have been identified (box 2)[1 8 11 21 22] Doctors and patients should be aware of the relevant risk factors and cofactors in the context of long term management.

## How do patients present with anaphylaxis?

Patients with anaphylaxis present with different scenarios. Some develop iatrogenic anaphylaxis after administration of a diagnostic or therapeutic agent. Others present to the emergency department after experiencing anaphylaxis in the community; in such patients, the duration of symptoms and signs varies from minutes to hours, and treatment with adrenaline (epinephrine), oxygen, intravenous fluids, an $H_1$ antihistamine, a glucocorticoid, or other drug might have already been started. In addition, many patients present to their doctor with a history of anaphylaxis that occurred weeks, months, or even years earlier, which may or may not have been appropriately investigated or followed up. Regardless of the scenario, the clinical diagnosis of anaphylaxis is based on the history of the acute episode.[1 2]

## How is an acute episode of anaphylaxis diagnosed?

### Clinical presentation

Anaphylaxis is characterised by symptom onset within minutes to a few hours after exposure to a food, drug, insect sting, or other trigger (box 1). Target organ involvement varies. Two or

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**Summary points**

Diagnosis is based on clinical presentation—sudden onset of characteristic symptoms in more than one body system, minutes to hours after exposure to a likely or known allergen

Factors associated with increased risk of severe or fatal anaphylaxis include asthma, cardiovascular disease, mastocytosis, and drugs such as β blockers

When anaphylaxis occurs, promptly call for help, inject adrenaline intramuscularly, and place the patient on the back or in a semi-reclining position with lower extremities raised

During the episode, if needed, give high flow supplemental oxygen, establish intravenous access to provide high volume fluids, and perform cardiopulmonary resuscitation

Provide at risk patients with adrenaline autoinjectors, personalised anaphylaxis emergency action plans, and medical identification

Confirm the specific trigger so that it can be avoided or allergen specific immune modulation—such as venom immunotherapy to prevent anaphylaxis from insect stings—can be carried out

**Sources and selection criteria**

We based this review on Medline and other searches for publications relevant to human anaphylaxis, including Cochrane reviews and other systematic reviews, randomised controlled trials, and quasi-experimental and other observational studies. We also used World Allergy Organization guidelines for the assessment and management of anaphylaxis and UK Resuscitation Council guidelines for emergency treatment of anaphylactic reactions (both of which were not commercially sponsored).

**Box 1 Mechanisms and triggers of anaphylaxis**

*Immune mechanism: IgE dependent**

Foods: peanut, tree nuts (such as cashews), milk, eggs, shellfish, finned fish, wheat, soy, sesame, kiwi

Drugs†: penicillins and other β lactam antibiotics

Biologicals: monoclonal antibodies, vaccines (rare)

Insect stings: bees, hornets, wasps, yellow jackets, some ants

Natural rubber latex

Seminal fluid (rare)

*Other immune mechanisms: IgE independent**

IgG mediated: infliximab, high molecular weight dextran (rare)

Immune aggregates: intravenous immunoglobulin (rare)

Drugs†: aspirin, ibuprofen, and other non-steroidal anti-inflammatory drugs

Complement and coagulation pathways

*Direct mast cell and basophil activation**

Exercise, usually with a cofactor such as a food or drug

Other physical factors: for example, cold air or cold water

Drugs†: opioids such as codeine or morphine

*Idiopathic anaphylaxis*‡*

No trigger can be identified

*Examples of mechanisms and triggers are given; the number of triggers is infinite.

†Different classes of drugs induce anaphylaxis through different mechanisms.

‡Consider the possibility of an uncommon or novel trigger (such as galactose α-1,3-galactose, the carbohydrate moiety in red meat; saliva injected by biting insects; or topically applied allergens such as chlorhexidine) or a concurrent diagnosis of mastocytosis.

more body organ systems (cutaneous, respiratory, gastrointestinal, cardiovascular, or central nervous system) are usually affected (box 3; fig 1).[1 3]

To some extent, symptoms and signs depend on age and physiological state.[1 3 15 17 18] As examples, infants and young children who cannot describe their symptoms typically develop sudden behavioural changes and become anxious, frightened, or clingy.[15] Children sometimes use terms such as “burning” or “tingly” to mean itching, and those with upper airway involvement sometimes scratch at their throat or gag. Pregnant women can experience intense itching of the genitalia, abdominal cramps, back pain, signs of fetal distress, and preterm labour.[17]

Skin symptoms and signs are reported in 80-90% of patients. In their absence, anaphylaxis can be difficult to recognise. Upper and lower respiratory tract symptoms and signs occur in up to 70% of those experiencing anaphylaxis and cardiovascular symptoms and signs in about 45%. Gastrointestinal symptoms occur in about 45% and central nervous system symptoms and signs in about 15%.

The patterns of target organ involvement vary between patients, and in the same patient from one episode to another (fig 1).[1 3] Symptoms and signs therefore differ from one patient to another and from one episode to another in the same patient in terms of type, number of organ systems affected, time of onset in relation to exposure to the inciting agent, and duration.

Anaphylaxis can range in severity from transient and unrecognised or undiagnosed episodes, to respiratory arrest, shock, cardiac arrest, and death within minutes.[1-3 14 23] At the onset of an episode, it can be difficult or impossible to predict the rate of progression, the ultimate severity, or the likelihood of death.[1 3 14] In a UK registry study of anaphylaxis related

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**Box 2 Patient risk factors for anaphylaxis**

*Age related factors*

- Infants: anaphylaxis can be hard to recognise, especially if the first episode; patients cannot describe symptoms
- Adolescents and young adults: increased risk taking behaviours such as failure to avoid known triggers and to carry an adrenaline autoinjector consistently
- Pregnancy: risk of iatrogenic anaphylaxis—for example, from β lactam antibiotics to prevent neonatal group B streptococcal infection, agents used perioperatively during caesarean sections, and natural rubber latex
- Older people: increased risk of death because of concomitant disease and drugs

*Concomitant diseases*

- Asthma and other chronic respiratory diseases
- Cardiovascular diseases
- Mastocytosis
- Allergic rhinitis and eczema*
- Depression, cognitive dysfunction, substance misuse

*Drugs*

- β adrenergic blockers†
- Angiotensin converting enzyme (ACE) inhibitors†
- Sedatives, antidepressants, narcotics, recreational drugs, and alcohol may decrease the patient's ability to recognise triggers and symptoms

*Cofactors that amplify anaphylaxis*

- Exercise: anaphylaxis associated with exercise may be food dependent or food independent; non-steroidal anti-inflammatory drugs and other listed cofactors may also be relevant
- Acute infection such as an upper respiratory tract infection
- Fever
- Emotional stress
- Disruption of routine—for example, travel and jet lag
- Premenstrual status in women and girls

*Atopic diseases are a risk factor for anaphylaxis triggered by food, latex, and exercise, but not for anaphylaxis triggered by most drugs or by insect stings

†Patients taking β adrenergic blockers or ACE inhibitors seem to be at increased risk for severe anaphylaxis. In addition, those taking β adrenergic blockers may not respond optimally to adrenaline treatment and may need glucagon, a polypeptide with non-catecholamine dependent inotropic and chronotropic cardiac effects, atropine for persistent bradycardia, or ipratropium for persistent bronchospasm.

deaths, median times to cardiac or respiratory arrest were five minutes in iatrogenic anaphylaxis, 15 minutes in insect sting anaphylaxis, and 30 minutes in food anaphylaxis.[23]

Some patients develop biphasic or multiphasic anaphylaxis, in which symptoms resolve, then reappear hours later despite no further exposure to the trigger.[24] Protracted anaphylaxis, in which uninterrupted symptoms recur for days despite treatment, is uncommon.[1 2]

More than 40 differential diagnoses exist, including episodes of acute asthma, acute generalised urticaria, or acute angio-oedema, acute anxiety or panic attacks, and syncope (box 4).[1 2 8 14 15 18]

## What investigations should be considered?

Measurement of mast cell tryptase concentration—the most widely used laboratory test—is not universally available, takes hours to perform, is not available on an emergency basis, and is not helpful for confirming the clinical diagnosis of anaphylaxis in the initial minutes or hours after symptom onset. Treatment must therefore not be delayed to obtain a blood sample for tryptase measurement.

Total tryptase concentrations measured in serum during an anaphylaxis episode can, however, sometimes be helpful later to confirm the diagnosis, especially in patients with drug or insect sting induced anaphylaxis and those with hypotension.[1 2 10 11 25 26] Tryptase concentrations are seldom raised in patients with anaphylaxis triggered by food, or in those whose blood pressure remains normal during the anaphylactic episode. Several factors may explain this: localised mast cell degranulation—for example, in the upper airway—with less tryptase entering the circulation than after generalised degranulation; involvement of respiratory epithelial mast cells rather than perivascular and cardiac mast cells that contain more tryptase; greater distance of respiratory epithelial mast cells than perivascular mast cells from the circulation; and involvement of basophils, which release minimal tryptase.[26 27] A serum tryptase concentration within the reference range of 1-11.4 ng/mL does not refute the clinical diagnosis of anaphylaxis, and an increased concentration is not specific for anaphylaxis.[1 2]

Tryptase has a short elimination half life. Serial measurements are reported to improve test specificity and are ideally obtained 15-180 minutes after symptom onset, one to two hours later, and after resolution of the episode. A raised baseline value suggests the diagnosis of mastocytosis rather than anaphylaxis.[1 2 10 11 25 26]

## How should an acute episode of anaphylaxis initially be treated?

Figure 2⇓ outlines a systematic approach to the basic initial management of anaphylaxis that emphasises the primary role of adrenaline.[1 11] In healthcare settings, it is important to prepare for this medical emergency by using an anaphylaxis assessment and management protocol based on current national or international guidelines.[1 2 28] This protocol should be displayed in locations where all healthcare professionals and staff can access it and rehearse it.

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**Box 3 Symptoms and signs of anaphylaxis**

During an anaphylaxis episode, symptoms and signs can range from few to many. A comprehensive list is provided to aid in prompt recognition and to indicate the possibility of rapid progression to multiorgan system involvement.

*Skin, subcutaneous tissue, and mucosa*

Generalised flushing, itching, urticaria (hives), angio-oedema, morbilliform rash, pilor erection

Periorbital itching, erythema, oedema, conjunctival erythema, tearing

Itching or swelling (or both) of lips, tongue, palate, uvula, external auditory canals

Itching of the genitalia, palms, soles

*Respiratory*

Nasal itching, congestion, rhinorrhoea, sneezing

Throat itching, tightness, dysphonia, hoarseness, dry staccato cough, stridor

Lower airways: cough, increased respiratory rate, shortness of breath, chest tightness, wheezing

Cyanosis

Respiratory arrest

*Gastrointestinal*

Abdominal pain, dysphagia, nausea, vomiting (stringy mucus), diarrhoea

*Cardiovascular system*

Chest pain (myocardial ischaemia)*

Tachycardia, bradycardia (less common), other dysrhythmias, palpitations

Hypotension, feeling faint, incontinence, shock

Cardiac arrest

*Central nervous system*

Feeling of impending doom, uneasiness, headache (pre-adrenaline), altered mental status or confusion owing to hypoxia, dizziness or tunnel vision owing to hypotension, loss of consciousness

*Other*

Metallic taste in the mouth

*This can occur in patients with coronary artery disease and (owing to vasospasm) in those with normal coronary arteries.

**Box 4 Differential diagnosis of anaphylaxis**[1 2 8 14 15 18]

Common diagnostic dilemmas*: acute asthma, acute generalised urticaria†, acute angio-oedema‡, syncope or fainting, panic attack, acute anxiety attack

Postprandial syndromes, such as food poisoning, scombroidosis, pollen-food allergy syndrome (oral allergy syndrome), monosodium glutamate reaction, sulphite reaction

Flush syndromes, such as menopause, carcinoid syndrome

Excess endogenous histamine syndromes, such as mastocytosis

Upper airway obstruction as a result of non-allergic angio-oedema‡

Shock (other forms), such as hypovolaemic, septic, or cardiogenic shock

Non-organic diseases, such as vocal cord dysfunction, hyperventilation, psychosomatic episode, Munchausen's stridor

Other: certain tumours, system capillary leak syndrome (rare)

*The differential diagnosis is, to some extent, age dependent—for example, in infants, consider choking and foreign body aspiration, breath holding, and food protein induced enterocolitis. In middle aged or older patients, consider myocardial infarction or stroke.

†Acute urticaria can occur with intercurrent or subclinical infection.

‡May be due to hereditary angio-oedema types I, II, and III; use of angiotensin converting enzyme inhibitors; or cancer. Non-allergic angio-oedema is typically not associated with itching or urticaria.

At the time of diagnosis, exposure to the trigger should be halted if possible—for example, by discontinuing an intravenously administered diagnostic or therapeutic agent. The patient's circulation, airway, breathing, mental status, skin, and body weight (mass) should be assessed.[1-3 10 11]

Simultaneously and promptly, call for help—from emergency medical services in a community setting or a resuscitation team in a hospital or other healthcare setting.[1-3 10 11] In an adult, inject adrenaline 0.3 mg (0.3 mL) by the intramuscular route in the mid-outer thigh, to a maximum of 0.5 mg (0.5 mL) of a 1 mg/mL (1:1000) solution; in a prepubertal child, inject adrenaline 0.15 mg (0.15 mL) to a maximum of 0.3 mg (0.3 mL).[1-3 10 11] Adrenaline is classified as an essential drug by the World Health Organization and is available worldwide in a 1 mL ampoule (1 mg/mL), even in most low resource areas.[29]

As soon as the symptoms of anaphylaxis are recognised, the injection should be given by anyone trained or authorised to administer it. In healthcare settings, it is typically ordered or given by a doctor. However, in many immunisation clinics, infusion clinics, and allergen immunotherapy clinics, nurses are preauthorised to do this.[30] In community settings, adrenaline is often self injected through an autoinjector by the patient or injected by the parent, teacher, or other person responsible for the child. Delay in administration is associated with greater likelihood of biphasic and protracted anaphylaxis, and of death[23 24]; in a UK series, only 14% of the patients who died from anaphylaxis received adrenaline before respiratory or cardiac arrest.[23]

The adrenaline injection can be repeated after five to 15 minutes, if needed. When the initial injection is given promptly after

symptoms are recognised, patients seldom require more than two or three injections. Compared with the intravenous route, the intramuscular route has the advantages of rapid initial access and a considerably wider margin of safety.[1 2 10]

For ethical and practical reasons, no randomised controlled trials of adrenaline have been conducted during anaphylaxis. The recommendation for intramuscular injection of adrenaline is based on consistent clinical evidence supporting its use, observational studies, and objective measurements of adrenaline absorption in randomised controlled clinical pharmacology studies in people not experiencing anaphylaxis at the time of study.[31-33] The beneficial effects of adrenaline are time dependent. When given promptly, it reduces the release of mast cell mediators[34] and the possibility of escalation of symptoms.

The transient anxiety, pallor, palpitations, and tremor experienced after administration of a relatively low first aid dose of exogenous adrenaline are caused by its intrinsic pharmacological effects. These symptoms are uncommon after an intramuscular injection of the correct adrenaline dose.[14 33] They are similar to the symptoms caused by increased endogenous adrenaline during the "fight or flight" response to an acute stressful situation.[31]

Serious adverse effects such as hypertension or pulmonary oedema can occur after adrenaline overdose by any route of administration. They are most commonly reported after an intravenous bolus dose, overly rapid intravenous infusion, or intravenous infusion of a concentrated adrenaline solution 1 mg/mL (1:1000) instead of a solution that is appropriately diluted for intravenous use. Hypoxia, acidosis, and the direct effects of the inflammatory mediators released during anaphylaxis can contribute to cardiovascular complications.[1 2 33 35]

Do not allow patients with anaphylaxis to stand or sit suddenly. They should be placed on their back (or in a semi-reclining position if dyspnoeic or vomiting) with their lower extremities elevated.[14]

## What additional treatment might be indicated for an acute episode of anaphylaxis?

At any time during the episode, when indicated, additional important steps include giving high flow supplemental oxygen and maintaining the airway, establishing intravenous access and administering high volumes of fluid, and initiating cardiopulmonary resuscitation with chest compressions before starting rescue breathing.[1-3 10 11 36 37] As soon as possible, start continuous monitoring of blood pressure, heart rate and function, respiratory rate, and oxygenation using pulse oximetry to titrate oxygen therapy (fig 2).[1 10 11]

Do not delay prompt intramuscular injection of adrenaline—the first line drug—by taking time to draw up and give a second line drug such as an $H_1$ antihistamine or a glucocorticoid.[1-3 10 38 39] $H_1$ antihistamines relieve skin and nasal symptoms and glucocorticoids might prevent biphasic or protracted symptoms, but these drugs fail to prevent release of the inflammatory mediators that escalate the response; fail to relieve life threatening upper or lower airway obstruction, hypotension, or shock; and fail to prevent death.[38 39]

Promptly transfer patients who are refractory to initial treatment of anaphylaxis to the care of specialists in emergency medicine, critical care medicine, or anaesthesiology. Such specialists and their teams are trained, experienced, and equipped to provide skilled management of the airway and mechanical ventilation, and to manage shock by administering adrenaline or other vasopressors through an infusion pump. The absence of established dosing regimens for intravenous vasopressors necessitates frequent dose titrations based on continuous monitoring of vital signs, cardiac function, and oxygenation.[1-3 10 36 37]

After treatment and resolution of anaphylaxis, keep patients under observation in a healthcare facility for at least four to six hours.[1-3] Observe those who have experienced respiratory or circulatory compromise for eight to 10 hours, or even longer.[1]

## How should patients be equipped for self treatment of anaphylaxis in the community?

Tell patients that they have experienced a potentially life threatening medical emergency. If possible, they should be discharged with an adrenaline autoinjector, or at a minimum, a prescription for one, and taught why, when, and how to inject adrenaline (box 5).[1-3 8 10 11 14 36] They should also be equipped with a personalised emergency action plan that lists common anaphylaxis symptoms to help them recognise a recurrence and reminds them to inject adrenaline promptly using an autoinjector and seek prompt medical help.[36] Such plans typically also list patients' confirmed anaphylaxis trigger(s), their relevant comorbidities (such as asthma or cardiovascular disease), and relevant concurrent drugs. In addition, patients should wear medical identification (bracelet or card) that states their diagnosis of anaphylaxis, its causes, and any relevant diseases or drugs.

## Beyond the acute episode: how should anaphylaxis be investigated?

The natural course of anaphylaxis is one of recurrent acute episodes, unless the patient's specific triggers are identified and consistently avoided. Appropriate investigation and follow-up after recovery from an episode may protect against recurrences.[14] Confirm triggers suggested by a meticulous history of previous episodes by measuring allergen specific IgE in serum or by performing allergen skin tests (or both), because self identification of food, drug, and stinging insect triggers by patients may be non-specific or incorrect and prevention of recurrence must be trigger specific. Avoid testing with large numbers of allergens because sensitisation to allergens is common even without a history of symptoms or signs after exposure to the specific allergen. Skin tests are optimally performed about four weeks after the acute episode, rather than immediately after, when test results may be falsely negative. Patients with a convincing history of anaphylaxis who have negative skin tests within a few weeks after an episode should be retested later.[1]

Some patients will need additional investigations to rule out other diseases in the differential diagnosis. Patients with idiopathic anaphylaxis need additional tests to investigate any unusual or novel triggers and to rule out mastocytosis.[40] Other patients might need additional tests to distinguish asymptomatic sensitisation to an allergen, such as a food or venom, from risk of subsequent clinical reaction to this allergen.[1-3 36] Allergen component tests, such as microassay based immunoassays, might help to distinguish patients who are sensitised to an allergen and at increased risk of anaphylaxis after exposure to the allergen from those who are sensitised but clinically tolerant (remain asymptomatic after exposure to the allergen).[41]

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**Box 5 Discharge management of anaphylaxis and long term risk reduction**[1-3 10 11 14 36 37]

*Discharge management**

- Equip with an adrenaline autoinjector or a prescription for one†
- Give the patient an anaphylaxis emergency action plan (personalised, written)
- Provide medical identification (such as bracelet, wallet card)
- Arrange for a medical record electronic flag or chart sticker
- Make a follow-up appointment with a doctor (see below)

*Long term risk reduction: investigations for sensitisation to allergen(s)‡*

- Skin tests or measurement of allergen specific IgE concentrations
- Challenge or provocation tests conducted by trained and experienced staff in a well equipped medical setting using incremental amounts of the relevant allergen, such as a food or drug

*Long term risk reduction: avoidance and immune modulation‡*

- Food triggered anaphylaxis: strict avoidance of relevant food(s)
- Drug triggered anaphylaxis: avoidance of relevant drugs and use of safe substitutes; if indicated, conduct desensitisation in a medical setting
- Stinging insect triggered anaphylaxis: avoidance of stinging insects; subcutaneous venom immunotherapy
- Idiopathic anaphylaxis: consider the possibility of a novel or atypical trigger§; examine the skin and measure a baseline serum tryptase concentration to rule out mastocytosis
- Optimal management of asthma and other concomitant diseases*

*All doctors play an important role in preparing patients for self treatment of anaphylaxis by teaching them how to recognise the common symptoms and signs and how to inject adrenaline safely using an autoinjector. In addition, all doctors play a role in optimal management of asthma, cardiovascular disease, and other comorbidities that contribute to the severity of anaphylaxis and death.

†No adrenaline autoinjectors contain an ideal dose for infants weighing <10-12 kg.

‡Allergy and immunology specialists play an important role in ascertaining the trigger(s) of an anaphylaxis episode, providing written information about avoidance of specific triggers, and, where relevant, preventing anaphylaxis by desensitisation to a drug or initiating and monitoring stinging insect venom immunotherapy.

§See examples in box 1 footnotes.

Most doctors will want their patients with anaphylaxis to be investigated by a qualified allergy specialist, although ready access to such specialists and to basic tests for sensitisation to allergens is a problem in many parts of the world.[1-3 10 11 29 36 42] In the United Kingdom, an evidence and consensus based national care pathway has been designed to improve assessment and management of infants, children, and young people who have experienced anaphylaxis.[43]

## How can recurrences of acute anaphylaxis be prevented?

Personalised written instructions about avoidance of confirmed relevant trigger(s) and safe alternatives should be provided for patients at risk, who should also be directed to reliable, up to date information resources. In healthcare settings, flag medical records with “anaphylaxis” and list relevant triggers.[1-3 14]

For anaphylaxis to foods, strict avoidance of the relevant foods, even in trace amounts, is currently the only recommended approach for prevention of recurrence. Long term avoidance of food triggers can be stressful because of the threat of hidden crossreactive or cross contaminating allergens. New immune modulation strategies to achieve clinical and immunological tolerance to implicated foods and prevent recurrences of food triggered anaphylaxis are within reach, as demonstrated in randomised controlled trials, although they are not yet recommended for clinical implementation because of high adverse event rates.[1-3 22 36 44-46]

For anaphylaxis to a drug, prevention of recurrence involves substitution of a safe effective non-crossreacting agent, preferably from a different pharmacological class. If such an agent is not available, desensitisation to the implicated agent is indicated to induce temporary clinical tolerance for one uninterrupted course of treatment with that agent. Desensitisation to antimicrobials, antifungals, antivirals, chemotherapeutics, monoclonal antibodies, and other agents is carried out in specialised hospital units.[1-3 47 48]

For anaphylaxis to stinging insect venoms, recurrences can be prevented by a three to five year course of subcutaneous immunotherapy with the relevant standardised specific venom(s). This approach, which is based on high quality randomised controlled trials, should be initiated and monitored by an allergist. It leads to clinical and immunological tolerance, and in about 90% of adults and 98% of children, to longlasting protection against recurrence.[1 49 50]

For exercise induced anaphylaxis and food dependent exercise induced anaphylaxis, recurrence can be prevented by avoiding relevant co-triggers such as foods, non-steroidal anti-inflammatory drugs, or alcohol and avoiding exercise under adverse environmental conditions (extreme cold or heat, high humidity, or high pollen counts). Patients should not exercise alone and should carry an adrenaline autoinjector and a mobile phone. If an episode occurs despite preventive measures, treatment involves discontinuing exertion immediately on recognition of initial symptoms, calling for help, and self injecting adrenaline promptly.[1]

Pharmacological approaches are commonly used in the prevention of anaphylaxis. As an example, patients at high risk of anaphylaxis from infusion of radiocontrast medium during diagnostic procedures, or those with frequent episodes of idiopathic anaphylaxis, are often treated prophylactically with an $H_1$ antihistamine, glucocorticoid, or other drug. Most prophylactic regimens are based on clinical experience rather than on randomised controlled trials.[1]

## Do patients with a history of anaphylaxis need long term follow-up?

Patients at risk for anaphylaxis in the community should be monitored regularly—for example, at yearly intervals—by their

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doctor. Such visits provide the opportunity for personalised education on how to prevent recurrences, recognise anaphylaxis symptoms, and self inject adrenaline correctly. An important aspect of follow-up is to help patients (and carers of at risk children) control asthma or other comorbid disease that potentially increase the risk of severe or fatal anaphylaxis episodes.[1-3 11 36]

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Contributors: FERS conceived the review, interpreted the literature, extracted the evidence, and drafted the manuscript. AS commented critically on drafts of the manuscript. Both authors approved the final version. FERS is guarantor.

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### Areas of ongoing research

- Development of rapid in vitro tests to confirm the clinical diagnosis at the time of the episode
- Development of additional in vitro tests to distinguish patients at risk of anaphylaxis from those with asymptomatic sensitisation
- Observational studies of adrenaline in anaphylaxis and randomised controlled clinical pharmacology studies (with or without placebo) of different doses and routes of administration in people not experiencing anaphylaxis at the time of study
- Randomised placebo controlled trials (listing clinical trial registration numbers) of second line drugs, such as systemic glucocorticoids, in patients with anaphylaxis
- Randomised controlled trial (clinical trial registration number ISRCTN29793562) of access to a 24 hour helpline providing expert management advice for the emergency management of anaphylaxis in infants, children, and young people
- Randomised placebo controlled trials of immune modulation to prevent anaphylaxis from food (listing clinical trial registration numbers)

### Tips for non-specialists

- Be prepared to diagnose anaphylaxis on the basis of clinical criteria and to provide fast, effective, and safe treatment by injecting adrenaline 0.01 mg/kg (using a 1 mg/mL (1:1000) solution, to a maximum adult dose of 0.5 mg) intramuscularly in the mid-outer thigh
- Specialist referral is suggested for all patients to confirm specific triggers, discuss allergen avoidance, and if relevant, receive immunomodulation (for example, to prevent recurrence of anaphylaxis triggered by stinging insect venom) or investigate idiopathic anaphylaxis
- Specialist referral is strongly suggested for patients who are at increased risk of severe or fatal anaphylaxis because of concomitant asthma, cardiovascular disease, or mastocytosis

### Additional educational resources

*Resources for healthcare professionals*

- World Allergy Organization (www.worldallergy.org)—Federation of 89 national and regional allergy and clinical immunology organisations; developed the World Allergy Organization Guidelines for the assessment and management of anaphylaxis
- Resuscitation Council UK (www.resus.org.uk)—Produced the Resuscitation Council (UK) guidelines for the emergency treatment of anaphylactic reactions

*Resources for patients*

- Anaphylaxis Campaign (www.anaphylaxis.org.uk)—This UK charity provides information, support, and a helpline for people with anaphylaxis
- Anaphylaxis Canada (www.anaphylaxis.ca)—This not for profit organisation supports, educates, and advocates for people with anaphylaxis and their families; it also supports anaphylaxis research
- Australasian Society of Clinical Immunology and Allergy (www.allergy.org.au)—ASCIA has developed anaphylaxis guidelines, action plans, a list of frequently asked questions about adrenaline autoinjectors, and e-training for first aid (community) treatment of anaphylaxis
- Food Allergy Research and Education (www.foodallergy.org)—This not for profit organisation (formerly the Food Allergy and Anaphylaxis Network) is dedicated to food allergy research and education, with the mission of ensuring the safety and inclusion of people with food allergies, while seeking a cure

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# Figures

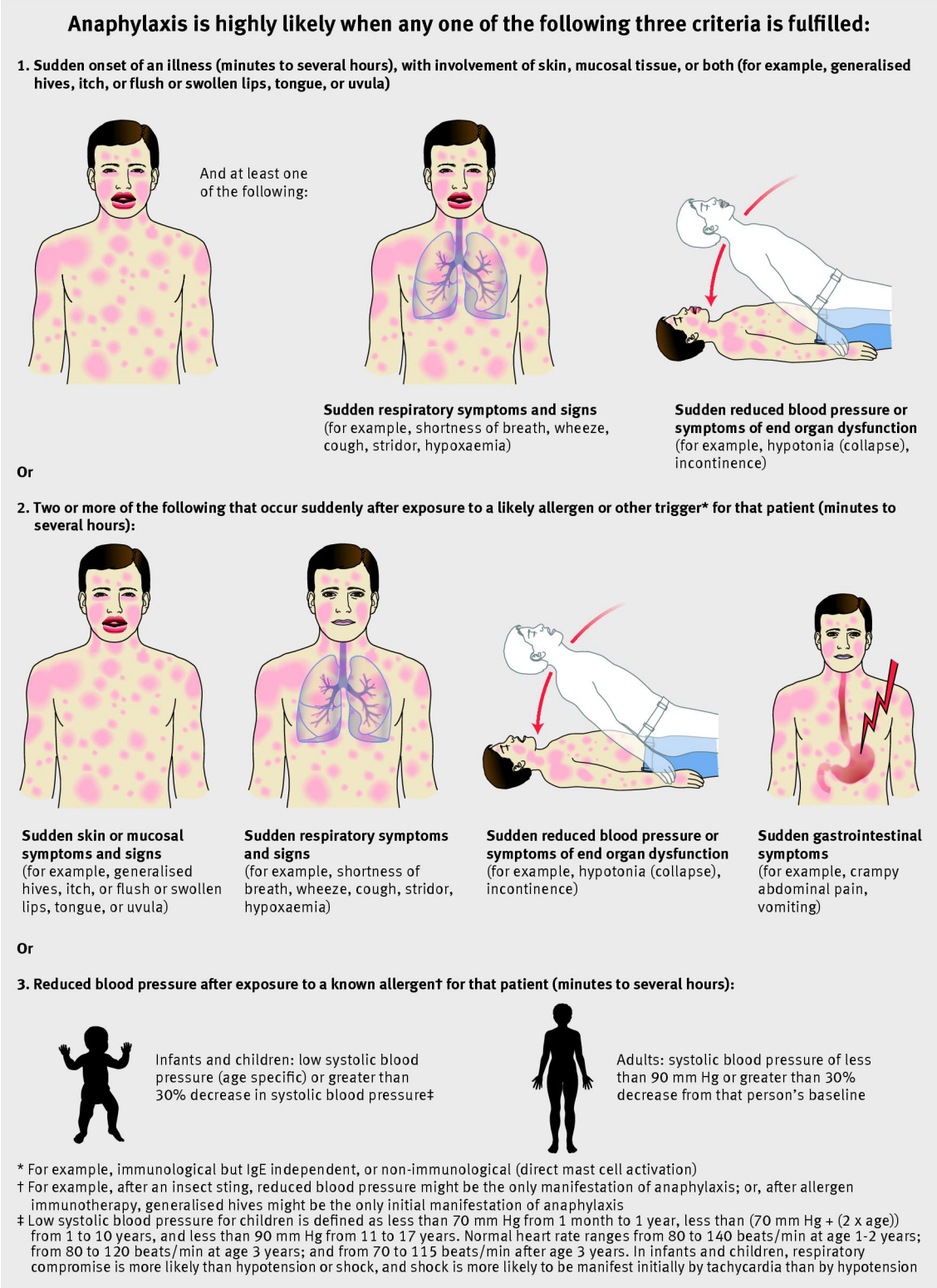


**Fig 1** Clinical criteria for the diagnosis of anaphylaxis as illustrated in the 2011 World Allergy Organization anaphylaxis guidelines. These diagnostic criteria were developed by a National Institutes of Health sponsored international consensus group in 2004-06 to facilitate prompt recognition of anaphylaxis[1 3]

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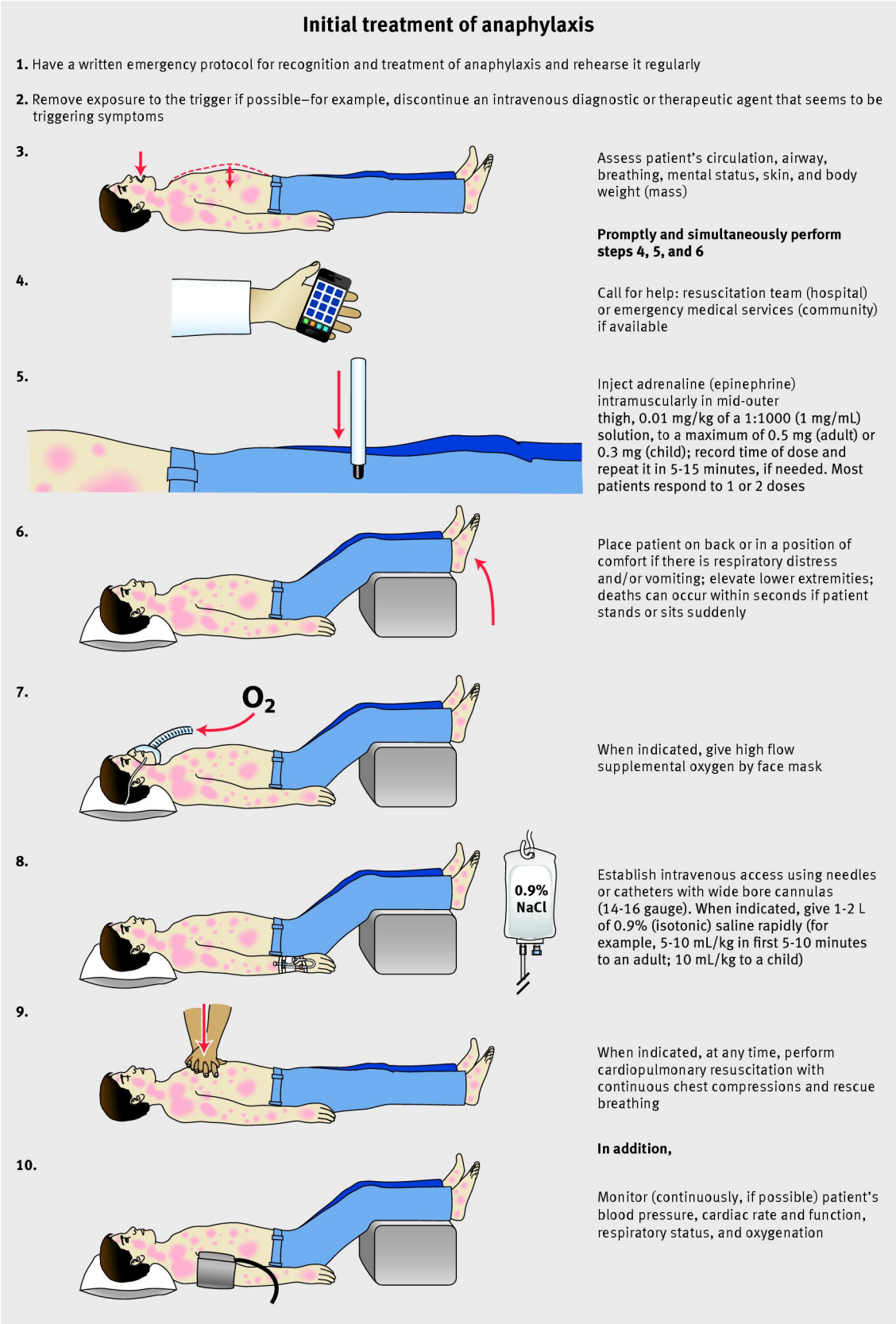


**Fig 2** Initial treatment of anaphylaxis as illustrated in the 2011 World Allergy Organization anaphylaxis guidelines[1]

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