CHAPTER 1

Introduction and structured approach to paediatric emergencies

Learning outcomes

After reading this chapter, you will be able to:

- Appreciate the focus and principles of the APLS course
- Describe the structured approach to identifying and managing paediatric emergencies
- Identify the important differences in children and the impact these have on the management of emergencies
- Appreciate that the absolute size and relative body proportions change with the age of the child
- Identify the approach to triage of a child

1.1 Introduction

The Advanced Paediatric Life Support (APLS) course equips those caring for children with the necessary skills and structured approach to identify and safely manage ill or injured children whenever or wherever they encounter them.

Children continue to die from preventable causes throughout the world. The reasons for their deaths differ between countries, however the structure and principles for managing the underlying causes are universal.

Child mortality is the lowest it has ever been and has halved in the last three decades, which is a huge achievement (12.5 million deaths of under 5-year-olds worldwide in 1990 compared with 5 million in 2020).

Worldwide data from the World Health Organization (WHO) show the leading cause of death in this age group is pneumonia, followed by preterm birth and then diarrhoeal illnesses. This compares with recent data from the USA showing the leading cause in children to be gun-related injuries. In the UK, Office for National Statistics (ONS) data show that cancer is the leading cause of death in all children followed by accidents and then congenital abnormalities.

The COVID-19 pandemic has not directly had a significant impact on child mortality. However, there are ongoing concerns about the indirect impact due to strained and under-resourced health systems; a reduction in care-seeking behaviours; a reduced uptake of preventative measures such as vaccination and nutritional supplements; and socioeconomic challenges.

Advanced Paediatric Life Support: A Practical Approach to Emergencies, Seventh Edition. Edited by Stephanie Smith.

1.2 The APLS approach

In the structured approach it is essential to remember that:

- The child's family will need support from a qualified member of the team
- Absolute size and body proportions change with age
- Observations and therapy in children must be related to their age and weight
- The psychological needs of children must be considered
- It is key to support each other as the clinical team

Physiological differences

Children, especially young ones, have significantly lower physiological reserves than adults. As a consequence, they may deteriorate rapidly when severely ill or injured and respond differently from adults to various interventions. It is essential to manage and support their respiratory and cardiovascular systems in a timely and structured manner to prevent further deterioration or even cardiovascular arrest. (See normal ranges table, inside front cover.)

Relationship between disease progression and outcomes

The further a disease process is allowed to progress, the worse the outcome is likely to be. The outcomes for children who have a cardiac arrest out of hospital are generally poor. This may be because cardiac arrest in children is less commonly related to cardiac arrhythmia, but is more commonly a result of hypoxaemia and/or shock with associated organ damage and dysfunction. By the time that cardiac arrest occurs, there has already been substantial damage to various organs. This is in contrast to situations (more common in adults) where the cardiac arrest is the consequence of cardiac arrhythmia – with preceding normal perfusion and oxygenation. Thus the focus of the course is on early recognition and effective management of potentially life-threatening problems before there is progression to respiratory and/or cardiac arrest (Figure 1.1).

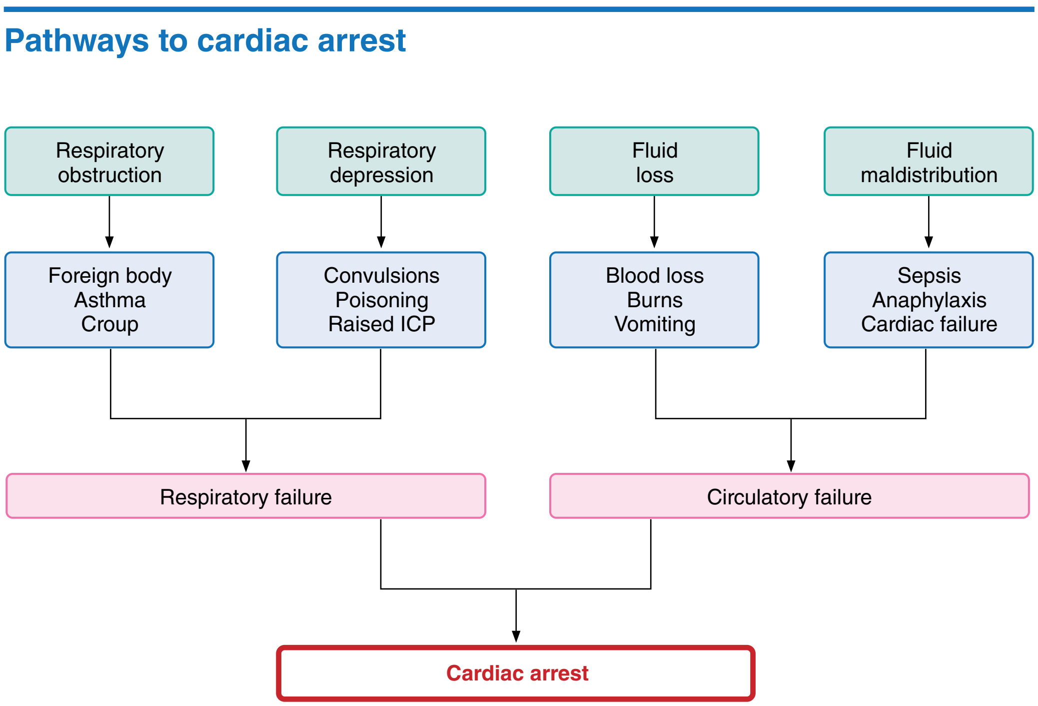

Figure 1.1 Pathways leading to cardiac arrest in childhood (with examples of underlying causes)
ICP, intracranial pressure

Standardised structure for assessment and stabilisation

A standardised approach for resuscitation enables the provision of a standard working environment and access to the necessary equipment to manage ill or injured children. The use of the standardised structure enables the whole team to know what is expected of them and in which sequence.

Once basic stabilisation has been achieved, it is appropriate to investigate the underlying diagnoses and provide definitive therapy.

> Definitive therapy (such as surgical intervention) may be a component of the resuscitation

Resource management

Provision of effective emergency treatment depends on the development of teams of healthcare providers working together in a coordinated, well-led manner (Figure 1.2). It is important that all training in paediatric life support focuses on how to best use the equipment and human resources available and emphasises the key nature of effective communication.

Figure 1.2 Advanced paediatric life support (APLS) in action

Early referral to appropriate teams for definitive management

Emergency departments are unlikely to be able to provide definitive management for all paediatric emergencies, and a component of stabilisation of critically ill or injured children is the capacity to call for help as soon as possible, and where necessary transfer the child to the appropriate site safely.

Ongoing care until admission to appropriate care

In most parts of the world it is impossible to transfer critically ill children into intensive care units or other specialised units within a short time of their arrival in the emergency area. Therefore, it is important to provide training in the ongoing therapy that is required for a range of relatively common conditions once initial stabilisation has been completed.

1.3 Important differences in children

Children are a diverse group, varying enormously in weight, size, shape, intellectual ability and emotional responses. At birth a child is, on average, a 3.5 kg, 50 cm long individual with small respiratory and cardiovascular reserves and an immature immune system. They are capable of limited movement, have immature emotional responses though still perceive pain and are dependent upon adults for all their needs. At the other end of childhood, the adolescent may be more than 60 kg, 160 cm tall and look physically like an adult, often exhibiting a high degree of independent behaviour but who may still require support in ways that are different from adults.

Competent management of a seriously ill or injured child who may fall anywhere between these two extremes requires a knowledge of these anatomical, physiological and emotional differences and a strategy of how to deal with them.

Weight

The most rapid changes in weight occur during the first year of life. An average birth weight of 3.5 kg will have increased to 10 kg by the age of 1 year. After that time weight increases more slowly until the pubertal growth spurt. This is illustrated in the weight charts shown in Figure 1.3.

As most drugs and fluids are given as the dose per kilogram of body weight, it is important to determine a child's weight as soon as possible. The most accurate method for achieving this is to weigh the child on scales; however, in an emergency this may be impracticable. Very often, especially with infants, the child's parents or carer will be aware of a recent weight. If this is not possible, various formulae or measuring tapes are available. The Broselow or Sandell tapes use the height (or length) of the child to estimate weight. The tape is laid alongside the child and the estimated weight read from the calibrations on the tape. This is a quick, easy and relatively accurate method. Various formulae may also be used although they should be validated to the population in which they are being used.

> If a child's age is known, the normal ranges table will provide you with an approximate weight (inside front cover) and allow you to prepare the appropriate equipment and drugs for the child's arrival in hospital. Whatever the method, it is essential that the carer is sufficiently familiar with the tools to use them quickly and accurately under pressure. When the child arrives, you should quickly review their size to check if it is much larger or smaller than predicted. If you have a child who looks particularly large or small for their age, you can go up or down one age group.

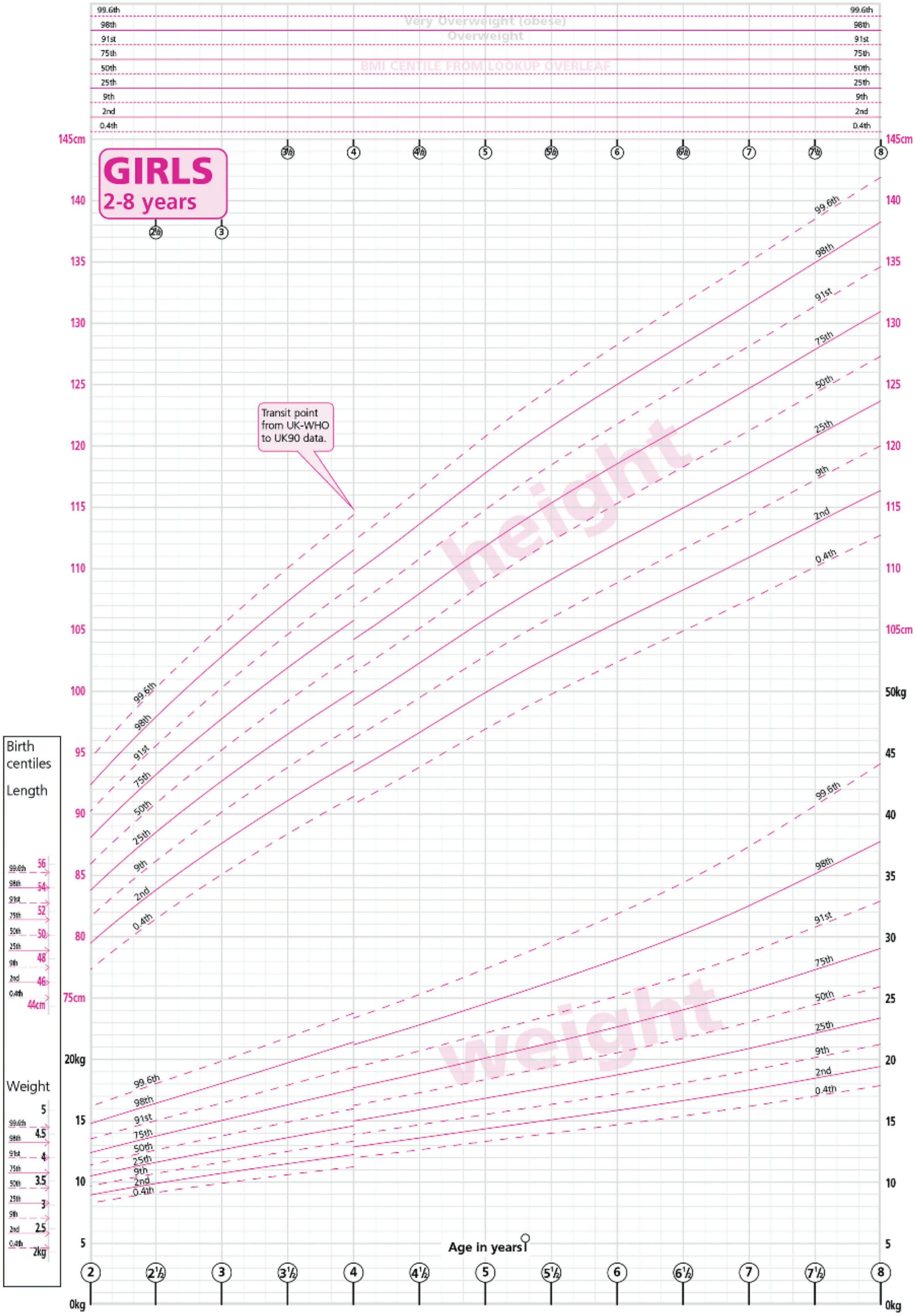

Figure 1.3 Example of centile chart for weight in girls (2–18 years)

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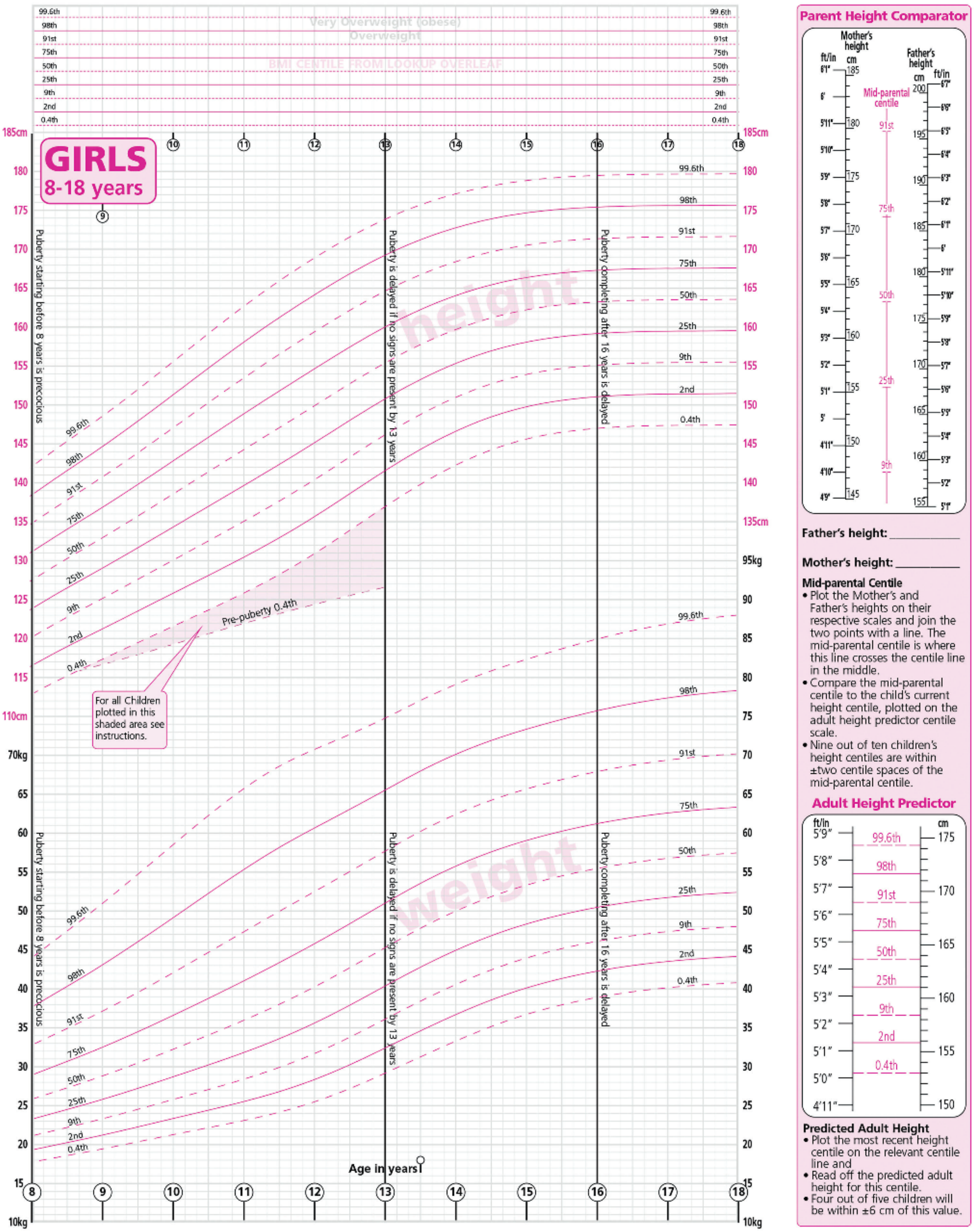

Figure 1.3 (*Continued*)

Anatomical

As the child's weight increases with age the size, shape and proportions of various organs also change. Particular anatomical changes are relevant to emergency care.

Airway

The airway is influenced by anatomical changes in the tissues of the mouth and neck. In a young child the occiput is relatively large and the neck short, potentially resulting in neck flexion and airway narrowing when the child is laid flat in the supine position. The face and mandible are small, and teeth or orthodontic appliances may be loose. The tongue is relatively large and not only tends to obstruct the airway in an unconscious child, but may also impede the view at laryngoscopy. Finally, the floor of the mouth is easily compressible, requiring care in the positioning of fingers when holding the jaw for airway positioning. These features are summarised in Figure 1.4.

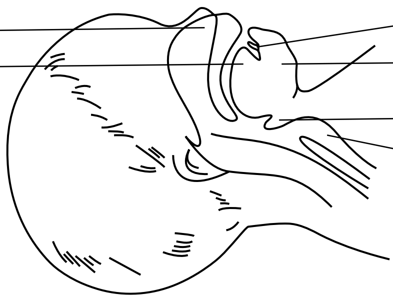

Figure 1.4 Summary of significant upper airway anatomy

The anatomy of the airway itself changes with age, and consequently different problems affect different age groups. Infants less than 6 months old are primarily nasal breathers. As the narrow nasal passages are easily obstructed by mucous secretions, and as upper respiratory tract infections are common in this age group, these children are at particular risk of airway compromise. Adenotonsillar hypertrophy may be a problem at all ages, but is more usually found between 3 and 8 years. This not only tends to cause obstruction, but also may cause difficulty when the nasal route is used to pass pharyngeal, gastric or tracheal tubes.

The trachea is short and soft. Overextension of the neck as well as flexion may therefore cause tracheal compression. The short trachea and the symmetry of the carinal angles (the angle between the right and left main bronchi) mean that not only is tube displacement more likely, but a tube or a foreign body is also just as likely to be displaced into the left as the right main-stem bronchus.

Breathing

The lungs are relatively immature at birth. The air–tissue interface has a relatively small total surface area in the infant (less than 3 m^2). In addition, there is a 10-fold increase in the number of small airways from birth to adulthood. Both the upper and lower airways are relatively small and are consequently more easily obstructed. As resistance to flow is inversely proportional to the fourth power of the airway radius (halving the radius increases the resistance 16-fold), seemingly small obstructions can have significant effects on air entry in children. This may partially explain why so much respiratory disease in children is characterised by airway obstruction.

Infants rely mainly on diaphragmatic breathing. Their muscles are more likely to fatigue as they have fewer type I (slow-twitch, highly oxidative, fatigue-resistant) fibres compared with adults. Preterm infants' muscles have even fewer type I fibres. These children are consequently more prone to respiratory failure.

The ribs lie more horizontally in infants, and therefore contribute less to chest expansion. In the injured child, the compliant chest wall may allow serious parenchymal injuries to occur without necessarily incurring rib fractures. For multiple rib fractures to occur the force must be very large; the parenchymal injury that results is consequently very severe and flail chest is tolerated badly.

Circulation

At birth the two cardiac ventricles are of similar weight; by 2 months of age the RV : LV weight ratio is 0.5. These changes are reflected in the infant's electrocardiogram (ECG). During the first months of life the right ventricle (RV) dominance is apparent, but by 4–6 months of age the left ventricle (LV) is dominant. As the heart develops during childhood, the sizes of the P wave and QRS complex increase, and the P-R interval and QRS duration become longer.

The child's circulating blood volume per kilogram of body weight (70–80 ml/kg) is higher than that of an adult, but the actual volume is small. This means that in infants and small children, relatively small absolute amounts of blood loss can be critically important.

Body surface area

The body surface area (BSA) to weight ratio decreases with increasing age (Figure 1.5). Small children, with a high ratio, lose heat more rapidly and consequently are relatively more prone to hypothermia. At birth, the head accounts for 19% of BSA; this falls to 9% by the age of 15 years.

Figure 1.5 Differences in children
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Physiological

Respiratory

The infant has a relatively greater metabolic rate and oxygen consumption. This is one reason for an increased respiratory rate. However, the tidal volume remains relatively constant in relation to body weight (5–7 ml/kg) through to adulthood. The work of breathing is also relatively unchanged at about 1% of the metabolic rate, although it is increased in the preterm infant.

In the adult, the lung and chest wall contribute equally to the total compliance. In the newborn, most of the impedance to expansion is due to the lung, and is critically dependent on the presence of surfactant. The lung compliance increases over the first week of life as fluid is removed from the lung. The infant's compliant chest wall leads to prominent sternal recession when the airways are obstructed or lung compliance decreases. It also allows the intrathoracic pressure to be less 'negative'. This reduces small airway patency. As a result, the lung volume at the end of expiration is similar to the closing volume (the volume at which small-airway closure starts to take place).

The combination of high metabolic rate and oxygen consumption with low lung volumes and limited respiratory reserve means that infants in particular will desaturate much more rapidly than adults. This is an important consideration during procedures such as endotracheal intubation.

At birth, the oxygen dissociation curve is shifted to the left and P_{50} (PO_2 at 50% oxygen saturation) is greatly reduced. This is due to the fact that 70% of the haemoglobin (Hb) is in the form of fetal haemoglobin (HbF); this gradually declines to negligible amounts by the age of 6 months.

The immature infant lung is also more vulnerable to insult. Following prolonged respiratory support of a preterm infant, chronic lung disease of the newborn may cause prolonged oxygen dependence. Many infants who have suffered from bronchiolitis remain 'chesty' for a year or more.

Cardiovascular

The infant has a relatively small stroke volume (1.5 ml/kg at birth) but has the highest cardiac index seen at any stage of life (300 ml/min/kg). Cardiac index decreases with age and is 100 ml/min/kg in adolescence and 70–80 ml/min/kg in the adult. At the same time the stroke volume increases, the heart gets bigger and muscle mass relative to connective tissue increases. As cardiac output is the product of stroke volume and heart rate, these changes underlie the heart rate changes seen during childhood. In addition, the average infant is only able to increase their heart rate by approximately 30% versus the adult who may be able to increase heart rate under stress by up to 300%.

As the stroke volume is small and relatively fixed in infants, cardiac output is principally related to heart rate. The practical importance of this is that the response to volume therapy is blunted when normovolaemic because stroke volume cannot increase greatly to improve cardiac output. By the age of 2 years, myocardial function and response to fluid are similar to those of an adult.

Systemic vascular resistance rises after birth and continues to do so until adulthood is reached. This is reflected in the changes seen in blood pressure.

Immune function

At birth the immune system is immature and, consequently, babies are more susceptible than older children to many infections such as bronchiolitis, septicaemia, meningitis and urinary tract infections. Maternal antibodies acquired across the placenta provide some early protection but these progressively decline during the first 6 months. These are replaced slowly by the infant's antibodies as they grow older. Infants may be particularly susceptible to infectious diseases in the period between the waning of maternal antibodies and development of their own antibodies (sometimes in response to immunisation). Breastfeeding provides increased protection against respiratory and gastrointestinal infections.

Psychological

Fear

Children vary enormously in their intellectual ability and their emotional response. A knowledge of child development assists in understanding a child's behaviour and formulating an appropriate management strategy. Particular challenges exist in communicating with children. Many situations that adults would not classify as fearful, engender fear in children. This causes additional distress to the child and adds to parental anxiety. Physiological parameters, such as pulse rate and respiratory rate, are often raised because of it, and this in turn makes clinical assessment of pathological processes such as shock more difficult.

Fear is a particular problem in the pre-school child who often has a 'magical' concept of illness and injury. This means that the child may think that the problem has been caused by some bad wish or thought that they have had. School-age children and adolescents may have fearsome concepts of what might happen to them in hospital because of ideas they have picked up from adult conversation, films and television.

> Knowledge allays fear and it is important to explain things as clearly as possible to the child in language they understand

Play can be used to help with explanations (e.g. applying a bandage to a teddy first), and also helps to maintain some semblance of normality in a strange and stressful situation. Parents must be allowed to stay with the child at all times (including during resuscitation if at all possible); importantly, they too must be supported and fully informed at all times.

Communication

Infants and young children either have no language ability or are still developing their speech. This causes difficulty when symptoms such as pain need to be described. Even children who are usually fluent may remain silent in healthcare settings when unwell or injured. Information has to be gleaned from the limited verbal communication and from the many non-verbal cues (such as facial expression and posture) that are available. Older children are more likely to understand aspects of their illness and treatment and so be reassured by adequate age-appropriate communication.

> Children with developmental differences due to pre-existing conditions such as autism, chromosome abnormalities or cerebral palsy may require different means of communication

1.4 Structured approach to paediatric emergencies

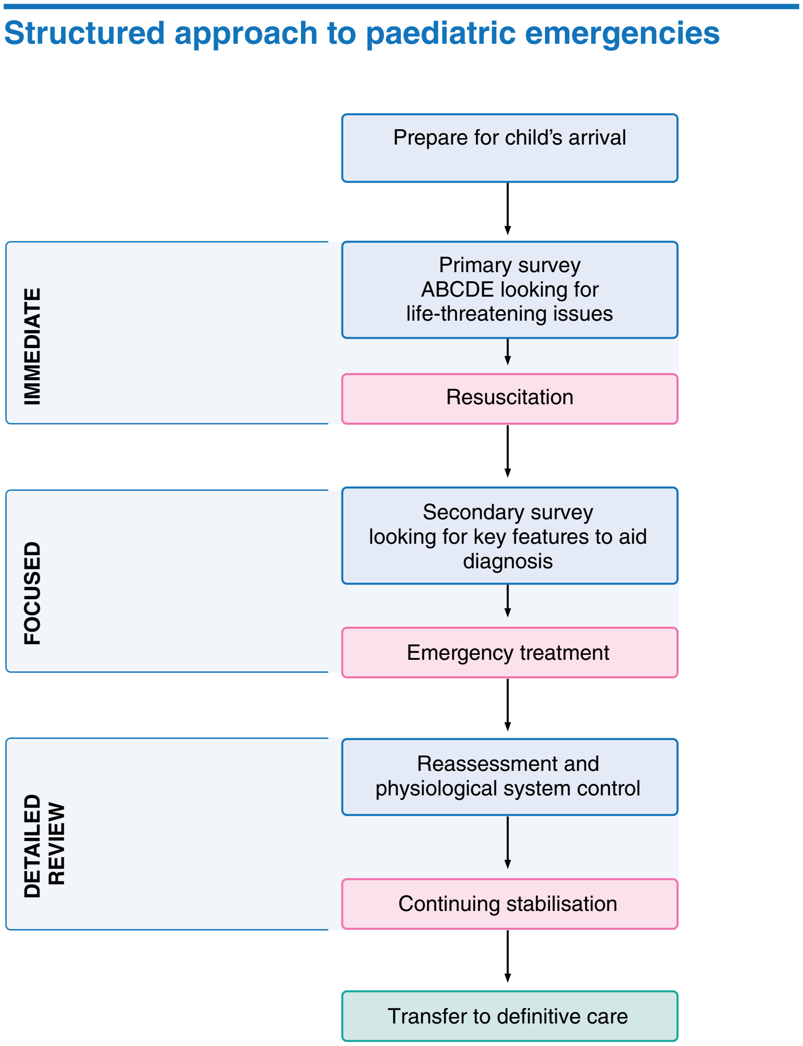

Figure 1.6 Structured approach to paediatric emergencies

A structured approach to paediatric emergencies will enable a clinician to manage emergencies in a logical and effective fashion and assist in ensuring that vital steps are not forgotten even in unfamiliar or infrequent emergency situations (Figure 1.6). This allows:

- Identification of life-threatening situations: closed or obstructed airway, absent or ineffective breathing, or absent pulse or shock requiring immediate interventions which comprise resuscitation
- Following resuscitation, looking for key features which signpost likely working diagnosis
- Initiation of emergency treatment
- Stabilisation and transfer for definitive care

Remember to utilise newer techniques such as point of care ultrasound (POCUS) if practitioners have the skill set to do so (see Appendix I).

Throughout this book, in the virtual learning environment (VLE) and on APLS courses, the same structure will be used so that the clinician will become familiar with the approach and be able to apply it to any clinical emergency situation.

1.5 Preparation

If warning has been received of the child's arrival then preparations can be made:

- Ensure that appropriate help is available: critical illness and injury need a team approach
- Work out the likely drug, fluid and equipment needs

For unexpected emergencies, ensure that all areas where children may be treated are stocked with the drugs, fluid and equipment needed for any childhood emergencies.

1.6 Teamwork

A well-functioning team is vital in all emergency situations. Success depends on each team member carrying out their own tasks and being aware of the tasks and the skills of other team members. The whole team must be under the direction of a team leader. Scenario practice by teams who work together is an excellent way to keep up skills, knowledge and team coordination in preparation for the 'real thing'. See Chapter 2 on non-technical skills.

1.7 Communication

Communication with the ill or injured child and their family has been discussed previously. Communication is no less important with clinical colleagues. When things have gone wrong, investigations have identified that an issue in communication has often been involved. Structured communication tools may be useful in ensuring that all relevant information is conveyed to all the teams involved in the child's care. Contemporaneous recording of clinical findings, of the child's history and of test results and management plans seems obvious but in the emergency situation may be overlooked. A template for note taking can be found in Chapter 8.

1.8 Triage

Triage is the process whereby each child presenting with potentially serious illness or injury is assigned a clinical priority. It is an essential clinical risk management step, and also a tool for optimisation of resource allocation in any emergency.

In the UK, Canada and Australia, five-part national triage scales have been agreed. Such a scale is shown in Table 1.1. While the names of the triage categories and the target times assigned to each name vary from country to country, the underlying concept does not.

Table 1.1 Triage scale

Number	Colour	Name	Maximum time to clinician
1	Red	Immediate	0 min
2	Orange	Very urgent	10 min
3	Yellow	Urgent	60 min
4	Green	Standard	240 min
5	Blue	Non-urgent	N/A

Triage is used to identify children who require urgent intervention.

Accuracy of triage and assigning a priority is an important basis for any triage system. However, there are instances when even for lower acuity patients the management may be deemed urgent, for example in an epidemic it may be important to get potentially uninfected children away from possible infection as soon as possible but the assessed triage priority will not change, just the action post triage. Never forget the need for repeated triage/reassessment – children can deteriorate rapidly and if there is no reassessment process, this may be missed.

Remember also that being triaged green does not mean that a child does not have a serious problem that requires specialist attention. It simply means the risk has been assessed and it would be acceptable for that child to wait for definitive management.

It is important to make sure that the family understands the nature of the triage process (and why they will see other children receiving treatment who arrived after their child).

Triage decision making

There are many models of decision making, each including: identification of a problem, determination of the alternatives and selection of the most appropriate alternative.

Discriminators are factors normally expressed as a word or short statement that allow patients to be allocated to one of five clinical priorities as in the algorithm in Figure 1.7. They can be general or specific. The former apply to all patients irrespective of their presentation and include life threat, pain, haemorrhage, conscious level and temperature and appear across the priorities (e.g. very hot, hot and warm). Specific discriminators tend to relate to key features of particular conditions, for example an asthmatic child 'unable to talk in sentences'. Thus severe pain is a general discriminator, but cardiac pain and pleuritic pain are specific discriminators.

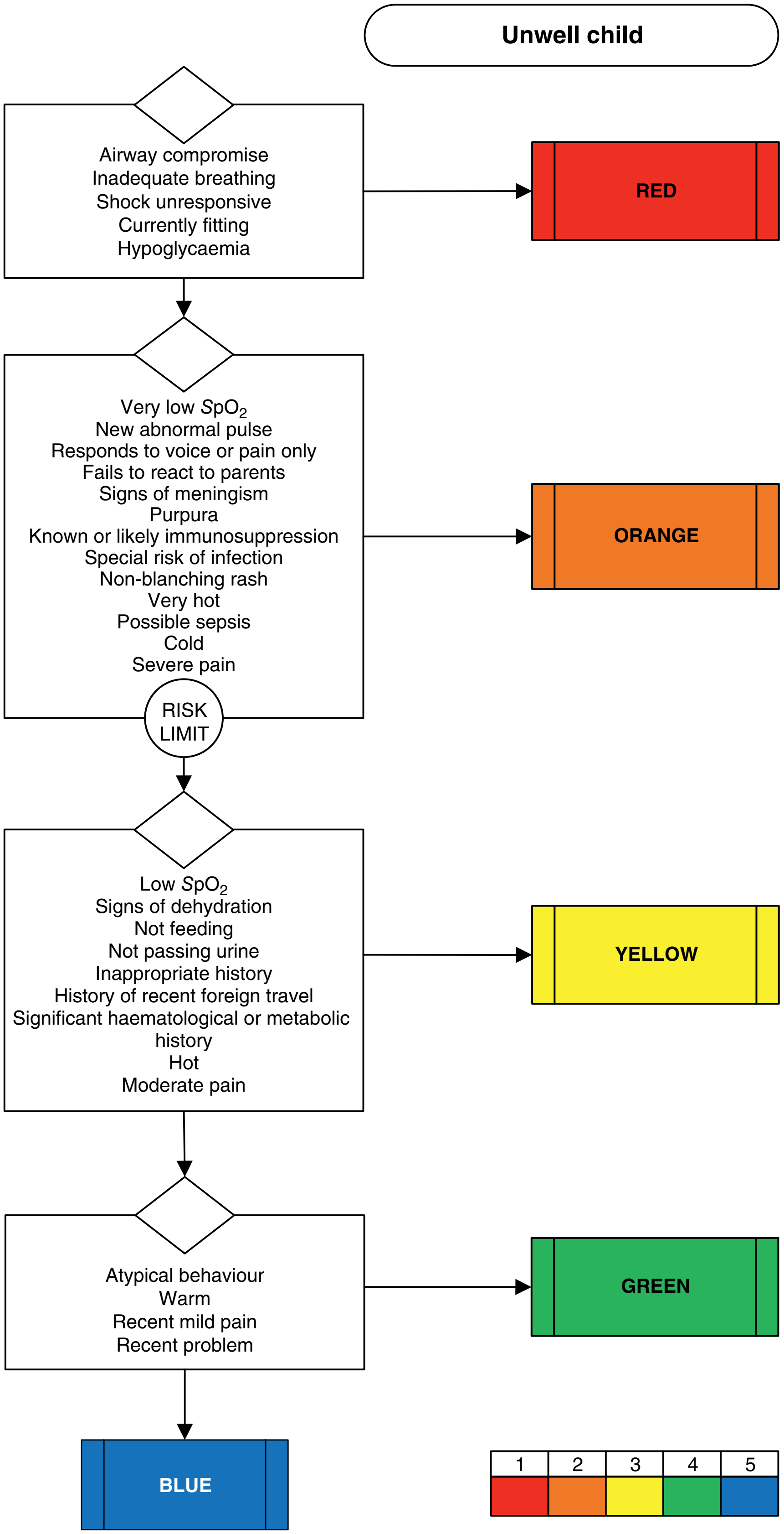

Figure 1.7 Paediatric triage for an unwell child

Secondary triage

It may not be possible to carry out all the assessments necessary at the initial triage encounter – this is particularly so if the workload of the department is high. In such circumstances, the necessary assessments should still be carried out, but as secondary procedures by the receiving healthcare professional. The actual initial clinical priority cannot be set until the process is finished. More time-consuming assessments (e.g. blood glucose estimation and peak flow measurement) are often left to the secondary stage.

1.9 Summary

This chapter has given an overview of management of paediatric emergencies, outlining the structured approach which is central to APLS. Subsequent chapters will focus in depth on the elements of the ABCDE approach in both the ill and the injured child.