CHAPTER 1

Introduction

Learning outcomes

After reading this chapter, you will be able to:

- Describe the focus of the PHPLS course
- Identify the important differences in children and the impact of these on the management of emergencies

Over the last two decades there has been a substantial reduction in childhood mortality across the world. This has been related to improvements in many areas such as maternal education, access to clean water, access to food, immunisation against an increasing number of infectious conditions and improved access to healthcare services. Even conditions such as human immunodeficiency virus (HIV) infections have potentially come under control with the development of highly effective antiretroviral therapeutic regimes. However, children across the world continue to suffer potentially life-threatening acute illness (sometimes on a background of chronic illness) and injury. The Pre-Hospital Paediatric Life Support (PHPLS) course is directed at training healthcare workers to recognise life-threatening illness or injury in children; to provide effective emergency intervention; and to ensure that children are directed to the appropriate place for ongoing definitive management of the condition as soon as possible. This approach is potentially applicable in many different settings across the world.

1.1 Principles

There are a number of principles that underpin this approach. Pre-hospital healthcare professionals must:

- Be reassured that acquired experience and skills are transferable to children’s illness and trauma management but be aware of the important areas of difference and your own development needs
- Adopt and rehearse a structured approach to the assessment and management of children’s illness and injury
- Ensure appropriate paediatric equipment is carried and be familiar with its use
- Include paediatric training and education in professional development and clinical governance processes

Physiological differences

Most clinical medicine is taught with the underlying assumption that adults best exemplify ‘normal’ in health. This is perhaps justified by the reality that in most parts of the world the majority of the population is made up of adults, but in poorer countries up to 40% of the population may be made up of children (depending on how children are defined). Thus it is important to highlight where children are different to adults in terms of physiology, pathophysiology and responses to various interventions (see Section 1.2). A key area of successful paediatric care is understanding that children physiologically compensate extremely well in acute illness and injury. A consequence of this is that an inexperienced practitioner may not recognise the early stages of disease or injury, and without intervention the child may deteriorate to the point of decompensation. In children decompensation is rapid and difficult to reverse; paediatric cardiac arrest represents the end of a long and missed opportunity to intervene. Thus particular attention has to be paid to timely and effective support of the respiratory and cardiovascular systems in particular.

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Children come in a range of sizes, and a consequence of this is the constant requirement to adjust all therapy, interventions and selection of equipment or consumable to the size of the particular patient (see Table 1.1).

**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 because cardiac arrest is rarely related to a sudden cardiac arrhythmia, but more commonly is a sequela of hypoxaemia and/or shock with associated organ damage, dysfunction and often irreversible decompensation (Figure 1.1). By the time that cardiac arrest occurs, there has already been substantial damage to end organs. This is in contrast to situations (more common in adults) where the cardiac arrest was 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.

**Standardised structure for assessment and stabilisation**

The use of a standardised structure for resuscitation provides benefits in many areas. Firstly it provides a structured approach to a critically ill child who may have multiple problems. The standardised approach enables the provision of a standard working environment, ensuring that all the necessary equipment is available as required. By focusing attention on life-threatening issues and dealing with these in a logical sequence it is possible to stabilise the child’s condition quickly. The use of the standardised structure enables the entire team to know what is likely to be expected of them and in what sequence.

There may well be discussion around the optimum sequence of resuscitation, but in this course a particular approach has been accepted as being reasonable, and most in keeping with the available research information. It is likely that aspects of this approach will change over time, and in fact it may be appropriate to modify the approach in particular working environments and contexts.

Once basic stabilisation has been achieved, it is then appropriate to investigate the underlying diagnoses and proceed to definitive therapy. Occasionally, definitive therapy (such as surgical intervention) may be a component of the resuscitation.
Resource management

There is increasing realisation that provision of effective emergency treatment depends on the development of teams of healthcare providers who are able to work together in a coordinated and appropriately directed way (Figure 1.2). Thus part of training in paediatric life support must focus on understanding how the human resources available for a particular resuscitation episode can be utilised most effectively.

Early transfer to appropriate teams for definitive management

It is clear that within the pre-hospital setting you are unlikely to be able to provide anything other than initial assessment and early resuscitative measures (pre-hospital critical care teams may be able to provide more than this). Definitive management will need to be provided in the most appropriate setting available. This will require decisions about where to transfer, what mode of transfer (i.e. road ambulance or helicopter) or whether to seek a retrieval team to assist. These will all depend on particular circumstances in which you find yourself.

1.2 Important differences in children

Children vary in weight, size, shape, intellectual ability and emotional response. 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, exhibit limited emotional responses and are dependent upon adults for all their needs. Fourteen or more years later at the other end of childhood, the adolescent may be a 50 kg, 160 cm tall person who looks physically like an adult, is often exhibiting a high degree of independent behaviour but who may still require support in ways that are different to 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 9.5 kg by the age of 1 year. After that time weight increases more slowly until the pubertal growth spurt.

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. Clearly 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 formula or reference guides are available, e.g. the Joint Royal Colleges and Ambulance Liaison Committee (JRCALC) page per age handbook or the page per age resource included in the Appendix to this manual. 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 here will provide you with an approximate weight (Table 1.1). This will allow you to then 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 it to be able to use it quickly and accurately under pressure. When arriving at an incident, you should quickly review the child’s size to check if it is much larger or smaller than predicted. If you have a child that looks particularly large or small for their age, you can go up or down one age group.

As the child’s weight increases with age the size, shape and proportions of various organs also change (Figure 1.3).

Physiological differences in different sized children include the following.

**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 pre-term infant.

The infant’s compliant chest wall leads to prominent sternal and subcostal 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).

Table 1.1 Normal ranges

<table>
<thead>
<tr>
<th>Age</th>
<th>Guide weight (kg)</th>
<th>RR At rest Breaths per minute 5th–95th centile</th>
<th>HR Beats per minute 5th–95th centile</th>
<th>BP Systolic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>5th centile</td>
<td>50th centile</td>
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<tr>
<td>Birth</td>
<td>3.5</td>
<td>25–50</td>
<td>120–170</td>
<td>65–75</td>
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<tr>
<td>1 month</td>
<td>4.5</td>
<td></td>
<td></td>
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<tr>
<td>3 months</td>
<td>6.5</td>
<td>25–45</td>
<td>115–160</td>
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<tr>
<td>6 months</td>
<td>8</td>
<td>20–40</td>
<td>110–160</td>
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<td>12 months</td>
<td>9.5</td>
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<tr>
<td>18 months</td>
<td>11</td>
<td>20–35</td>
<td>100–155</td>
<td>70–75</td>
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<td>2 years</td>
<td>12</td>
<td>20–30</td>
<td>100–150</td>
<td>70–80</td>
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<tr>
<td>3 years</td>
<td>14</td>
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<td>90–140</td>
<td>80–130</td>
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<td>4 years</td>
<td>16</td>
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<td>80–135</td>
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<td>8 years</td>
<td>25</td>
<td>15–25</td>
<td>70–120</td>
<td>80–90</td>
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<tr>
<td>9 years</td>
<td>28</td>
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<td>10 years</td>
<td>31</td>
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<td>14 years</td>
<td>50</td>
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<td>60–110</td>
<td>100–120</td>
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<tr>
<td>Adult</td>
<td>70</td>
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</tbody>
</table>

BP, blood pressure; HR, heart rate; RR, respiratory rate.
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.

The immature infant lung is also more vulnerable to insult. Following prolonged respiratory support of a pre-term infant, chronic lung disease of the newborn may cause prolonged oxygen dependence. For example, infants who have suffered from bronchiolitis can remain ‘chesty’ for a year or more. Table 1.1 shows respiratory rate by age at rest.

**Figure 1.3 Differences in children**

**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 the amount of 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 Table 1.1.

Normal systolic pressures are also shown in Table 1.1.

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 (Table 1.1).

**Immune function**

At birth the immune system is immature and, consequently, infants are more susceptible than older children to many infections such as bronchiolitis, sepsicaemia, 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 he or she grows older, sometimes in response to immunisation. Breastfeeding provides increased protection against respiratory and gastrointestinal infections.

**Psychological**

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 and as far as possible easing their fear of the circumstances they find themselves in.

**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 when unwell or in pain. 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.

**Fear**

Many clinical situations 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.

Children can be irrational and tend to be more fearful in the presence of injury and illness. Medical examination and intervention will be scary to the majority of children. Adolescents will have different health beliefs and need careful communication to engage in healthcare. Knowledge dispels fear and it is therefore important to explain things as clearly as possible to the child. Explanations must be phrased in a way that the child can understand. Play can be used to do this in younger children (e.g. applying a bandage to a teddy first), and also helps to maintain some semblance of normality in a strange and stressful situation. Finally, parents must be allowed to stay with the child at all times (including during resuscitation if at all possible); their absence from the child’s bedside will only add further fears, both to the child and to the parents themselves. Importantly, parents too must be supported and fully informed at all times.

**1.3 Summary**

The Pre-Hospital Paediatric Life Support course is focused on providing training for healthcare professionals in the recognition and management of life-threatening illness in children; in recognition and initial management of important underlying conditions; and appropriate referral to teams that are able to provide definitive intervention. In this process it is also essential to remember the needs of the child’s family and to support the clinical team.

You should also be aware that there are some important differences in children:

- Absolute size and relative body proportions change with age
- Observations of children must be related to their age
- Therapy in children must be related to their age and weight
- The special psychological needs of children must be considered