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Review Article

State-of-the-art management of the acutely unwell child

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Summary
Children make up around one-fifth of all emergency department visits in the USA and UK, with an increasing trend of emergency admissions requiring intensive care. Anaesthetists play a vital role in the management of paediatric emergencies contributing to stabilisation, emergency anaesthesia, transfers and non-technical skills that optimise team performance. From neonates to adolescents, paediatric patients have diverse physiology and present with a range of congenital and acquired pathologies that often differ from the adult population. With increasing centralisation of paediatric services, staff outside these centres have less exposure to caring for children, yet are often the first responders in managing these high stakes situations. Staying abreast of the latest evidence for managing complex low frequency emergencies is a challenge. This review focuses on recent evidence and pertinent clinical updates within the field. The challenges of maintaining skills and training are explored as well as novel advancements in care.

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Introduction
One-quarter of the world's population are children aged 0–14 y, with the proportion in some countries rising to 50% [1]. Unwell children present to all healthcare settings, but a significant proportion attend emergency care. Annual attendance figures for emergency departments in England and the USA consistently report that around 20% of individuals are aged 14 y and under [2, 3]. However, not all these children are severely unwell. A variety of healthcare system and socio-economic drivers determine how and where children access services [4]. Nevertheless, data from England show an increasing trend towards emergency paediatric admissions which require intensive care. This is postulated to be due to the improved survival of very premature infants, increasing levels of socio-economic deprivation and increasing numbers of children with chronic and life-limiting illnesses [5]. The anaesthetist's role in these paediatric emergencies is broad. Dealing with the acutely unwell child is complex due to the breadth of knowledge required and the wide-ranging presenting pathology. Key skills include the recognition of a critically unwell or injured child; initiation of immediate treatment; understanding safeguarding issues; and ensuring effective communication with the child, carers and colleagues [6]. Many of the pathophysiological processes and underlying aetiologies differ from those seen in adults, varying further by age and geographical location [7]. Globally, acute illnesses leading to death include lower respiratory

infections and diarrhoea [8]. Injury is also a leading cause of death and disability worldwide in children [9], representing the most common cause of death in children aged > 12 months in the UK and the USA [10, 11]. Whilst it can be difficult to determine accurate figures on the most common emergencies, paediatric critical care transfer data from the UK and Ireland demonstrated that just over half of the severely ill transported children were infants, with the majority (78.5%) aged < 5 y. The leading causes for transfer were respiratory (44%), neurological (16.4%) and cardiovascular (15.3%). The most common diagnoses were bronchiolitis, seizures, asthma and croup [12]. As survival from congenital disorders improves, children may present with deterioration of these complex multisystem disorders, or with innocuous illnesses exacerbated by underlying reduced physiological reserves. A summary of common congenital and acquired acute paediatric presentations is shown in Table 1.

In many countries, paediatric services (including intensive care and surgery) are largely centralised, with the aim of improving and standardising care in a financially sustainable way. Paediatric care networks in the UK, Greece and the USA have centralised specialist care providers which support (and are supported by) community paediatric care. Therefore, non-specialist centres now see a significantly lower volume of paediatric surgical patients. Despite this, nearly 25% of severely injured children in the UK present to local hospitals rather than specialist tertiary services [13]. Consequently, staff outside specialist centres have increasingly less experience in the management of sick children despite often being the first responders in managing these high stakes situations. To minimise heterogeneity in care, all hospitals with emergency departments need to be able to deliver the first few crucial hours of emergency management. This review aims to provide an update on how to deliver high quality basic care, as well as advancements in the field which address issues around low case exposure and maintaining skills in different settings.

Update on `doing the basics well´

Delivery of high quality essential and basic care is of primary importance. This requires an understanding of the pathologies that might be encountered (see Table 1), recognition of potentially life-threatening conditions and identification of patients who require transfer for subspecialist care. Assessment and management of an acutely unwell child often takes an ABCDE approach, adopted by many international guidelines [7, 14]. Comprehensive descriptions are covered by advanced life support groups (e.g. the Resuscitation Council UK and European Resuscitation Council). Below we use the ABCDE

Table 1 Common causes of the acutely unwell child. Pathologies listed in order of associated frequency.

	Congenital	Acquired
Airway	• Tracheo-oesophageal fistula • Congenital tracheomalacia • Laryngeal cleft	• Croup • Inhaled foreign body • Bacterial tracheitis • Epiglottitis
Breathing	• Chronic lung disease • Congenital cystic adenomatoid malformation	• Viral respiratory infections • Viral induced wheeze/asthma • Pneumonia/parapneumonic effusions • Mediastinal mass • Air leak syndromes
Circulation	• Duct dependent systemic lesions (coarctation of the aorta, aortic stenosis, hypoplastic left heart, transposition of the great arteries) • Duct dependent pulmonary lesions (pulmonary atresia, transposition of the great arteries) • Heart failure (shunt lesions, arrhythmias) • Non duct dependent	• Sepsis • Arrhythmias • Myocarditis • Cardiomyopathy
Disability	• Inherited metabolic conditions • Vein of Galen malformation	• Neuro-infection • Epilepsy syndromes • Metabolic (including diabetic ketoacidosis) • Poisoning
Exposure	• Ichthyosis	• Skin loss syndromes (toxic epidermal necrolysis, Stevens-Johnson syndrome) • Burns

approach to review recent evidence and clinical updates. Key to all interactions is the appreciation that family-centred care should be at the forefront of paediatric practice. International guidance supports the presence of carers at the resuscitation of their child should they wish [14, 15]. Interestingly a study in paediatric intensive care did not show increased adverse events such as multiple attempts, oxygen desaturations or increased self-reported team stress levels when families were present at tracheal intubation. However, children with carers present were older and had lower mortality estimated by the PIM2 score [16]. These data may not necessarily translate to high stakes procedures, such as tracheal intubation of an acutely unwell child in the emergency department. It is crucial to aim to facilitate the presence of carers with a child, even when the child is critically unwell. Most children feel it is important parents accompany them for interhospital transfer [17], and it is also thought to mitigate parental stressors associated with transport of their critically unwell child [18].

Airway

The most common causes of serious acute paediatric illness are respiratory. The key differences between paediatric and adult airways are summarised in Table 2. Traditionally, uncuffed tracheal tubes were used in children aged < 8 y due to concerns about mucosal damage leading to complications such as post-extubation stridor and subglottic stenosis. However, uncuffed tubes have limitations including increased leak and variable first-attempt sizing accuracy. As a result, there has been a rise in popularity of low-pressure, high-volume microcuffed/cuffed tracheal tubes for children and infants (>3 kg). Compared with uncuffed tubes, cuffed tubes have a lower rate of tracheal tube exchanges and are not associated with increased postoperative stridor [19]. An Australian pilot study in infants aged < 3 months-old found those with cuffed tracheal tubes underwent fewer re-intubations for tracheal tube optimisation, had fewer episodes of atelectasis and had no increase in post-extubation stridor or diagnosis of subglottic stenosis at long term follow up [20]. The latest advanced paediatric life support guidelines from the UK, European and USA reflect this, recommending cuffed tracheal tubes, except in small infants and neonates where there is less evidence for their use [7, 14, 15]. Engelhardt et al. reported a low incidence of difficult intubation in children undergoing elective anaesthesia (0.28%), with a failed intubation rate of 0.08%. This was higher in neonates (1%) and infants (1.1%) [21]. European and American data suggest increased airway complications in younger and smaller (<10 kg) children, associated with multiple intubation attempts or short thyromental distance [21, 22]. This is also true for tracheal intubation in those children requiring transport, where there is a higher rate of tracheal intubation associated events for those aged < 12 months, with comorbidities and low weight for age [23]. The utility of apnoeic oxygenation in adults has shown conflicting results. However, in a large paediatric intensive care unit in the USA, the use of this technique within an airway management quality improvement project reduced the rate of moderate ($S_pO_2 < 80\%$) and severe ($S_pO_2 < 70\%$) desaturation events from 15.4% to 11.8% and 10.4% to 7.2%, respectively [24]. Also important to successful intubation is airway visualisation. Several videolaryngoscope manufacturers produce paediatric-sized blades [25], enabling improved visibility among team members during intubation. Whilst the incidence of difficult

Table 2 Anatomical and physiological differences associated with the paediatric airway.

Anatomical or physiological differences	Aspects to consider
Large occiput in infants	Encourages neck flexion and head movement May require a shoulder roll or head ring for optimal positioning and stabilisation
Shorter trachea	Small distance between the larynx and the carina leading to a narrow margin between bronchial intubation and inadvertent extubation Confirmation of tube position, establishing stability before transfer and careful securing of tracheal tubes are essential
Low functional residual capacity and high metabolic rate	Children, especially infants, tolerate apnoea poorly Likely require ventilation through a rapid sequence induction anaesthetic Adequate pre-oxygenation is often difficult to achieve due to distress and movement
Tendency to bradycardia	Consequence of hypoxia and increased vagal response to laryngoscopy
Easy insufflation of stomach during bag mask ventilation and high impact of abdominal competition	Potential need for nasogastric tube/suction catheter decompression of the stomach

laryngoscopy (Cormack–Lehane grade ≥ 3) is higher in infants compared with older children [21, 22], a 2018 Cochrane meta-analysis of videolaryngoscopy-assisted intubation in neonates concluded there was insufficient evidence to recommend its use for neonatal intubation [26]. Garcia-Marcinkiewicz et al. compared standard blade videolaryngoscopy with direct laryngoscopy in infants and demonstrated increased first attempt success and reduced complications (including oesophageal intubation) in the videolaryngoscopy group [27]. When comparing standard and hyperangulated videolaryngoscopes, increased intubation success was observed in infants < 5 kg with a standard blade, with no difference observed between the blades above this weight [28]. Paediatric difficult airway guidelines emphasise the importance of minimising the number of airway instrumentations [29, 30]. The guidelines from the USA endorse limiting to one direct laryngoscopy attempt, with consideration of using a standard blade videolaryngoscope in lieu of that attempt. The guidelines also advocate the use of peri-intubation nasal oxygen. In a `cannot intubate, cannot ventilate´ scenario without ENT support available, UK guidelines recommend the use of 14–16 G cannula cricothyroidotomy in the 1–8 y age group, in contrast to scalpel cricothyroidotomy in adult guidelines [29]. The guidance from the USA is less prescriptive, supporting `invasive techniques´ which cover all forms of cricothyroidotomy/tracheostomy/rigid bronchoscopy and extracorporeal membrane oxygenation [30].

Breathing

Supplementary oxygen must be carefully considered in the acutely unwell child. Whilst life-saving when used to avert hypoxia, hyperoxia is associated with worse outcomes. The relationship between hyperoxia, bronchopulmonary dysplasia and retinopathy in premature neonates is long established. Recent evidence now demonstrates hyperoxia is associated with increased mortality in critically ill children [31]. Revised paediatric life support guidelines now advise titrating oxygen therapy to S_pO_2 94–98%, avoiding sustained S_pO_2 100% except in pulmonary hypertension or carbon monoxide poisoning [7, 14, 15]. Following a pilot study in 2018 [32], the first randomised controlled trial (RCT) comparing conservative with liberal oxygenation targets in critically ill children (OXY-PICU) is currently underway. Paediatric studies support the use of high-flow nasal oxygenation in bronchiolitis, asthma, obstructive apnoea, pneumonia, respiratory distress and for post-extubation support [33]. Accepted practice is a flow rate of 1–2 $l.kg^{-1}.min^{-1}$ in children < 10 kg, with a further increase of 0.5 $l.kg^{-1}.min^{-1}$ > 10 kg, titrating F_IO_2 to achieve saturation targets as described above. High-flow nasal cannulae reduce the need to escalate care in infants with bronchiolitis compared with low-flow oxygenation [34, 35]. This is not, however, associated with decreased length of stay or duration of oxygen therapy, suggesting that whilst reducing respiratory workload, high-flow nasal cannula therapy does not modify the disease process. A study by Ramnarayan et al. directly compared high-flow nasal cannula with CPAP, in both acute illness (step-up trial) and within 72 h of tracheal extubation following a period of invasive ventilation (step-down trial) [36]. The recently published step-down trial data found high-flow nasal cannulae to be inferior to CPAP, with a longer time from randomisation to liberation from all forms of support, increased 180-day mortality and no significant difference in reintubation rates at 48 h [36]. The step-up trial is due to be published later this year.

Worldwide, lower respiratory tract infection remains a leading cause of death and in settings with advanced healthcare models these patients often have associated comorbidities, with repeated admissions to emergency care [5, 8]. In contrast to adults, where sepsis is the leading cause of acute respiratory distress syndrome, viral respiratory infection is the most common underlying condition for paediatric acute respiratory distress syndrome [37]. The estimated incidence of paediatric acute respiratory distress syndrome in advanced healthcare settings is 2.0–12.8 per 100,000 person years, with a mortality of 18–27% [38]. Consensus guidelines produced by the Paediatric Acute Lung Injury Consensus Conference provide clinicians with a definition that incorporates oxygen saturation and the oxygen saturation index (in the absence of measured PaO_2) that may reduce the incidence of missed diagnoses [39]. These guidelines also offer recommendations for therapeutic options and provide current and robust evidence for paediatric ventilation strategies, with relevant interventions in the emergency setting (see Table 3).

Circulation

Over the last 30 y, antenatal diagnosis of congenital heart disease and the advent of perinatal pulse oximetry screening have reduced the number of critical congenital cardiac diagnoses made postnatally [40]. A 5-year retrospective review of a single US Emergency Department's admissions identified one case of previously undiagnosed cardiac disease per 4838 paediatric emergency department visits [41]. While prevalence is low,

Table 3 Paediatric Acute Lung Injury Consensus Conference recommendations for the management of paediatric acute respiratory distress syndrome [39]. Level of agreement determined by a modified Delphi approach.

	Recommendation	Level of agreement
Ventilatory support	Patient specific tidal volumes in context of disease severity • Poor lung compliance: 3–6 $ml.kg^{-1}$ predicted body weight • Better lung compliance: 5–8 $ml.kg^{-1}$ predicted body weight	Weak
	Inspiratory plateau pressure limitation • Compliant chest wall: 28 cmH_2O • Reduced chest wall compliance: 29–32 cmH_2O	Weak
	Elevated PEEP: 10–15 cm H_2O titrated to oxygenation and haemodynamics with close monitoring of both	Weak
	Cuffed endotracheal tube	Strong
	S_pO_2 88–92% when PEEP optimised to ≥ 10	Strong
	Permissive hypercapnia	Strong
	pH 7.15–7.3	Weak
Respiratory adjuncts	Suctioning to maintain a clear airway	Strong
Non respiratory adjuncts	Effective targeted sedation to tolerate mechanical ventilation	Strong
	Minimal, effective neuromuscular blockade if sedation inadequate for mechanical ventilation	Strong

PEEP, positive end expiratory pressure.

children presenting acutely with cardiac disease may require transport to centres with specialist cardiac services. These patients are often more severely unwell than general critical care patients and require early and aggressive resuscitation due to associated morbidity and mortality [42]. A multidisciplinary team approach with the most experienced clinicians is recommended. Table 4 suggests simultaneous work streams that allow rapid assessment and treatment by the team.

Sepsis remains a leading cause of morbidity and mortality worldwide. A global epidemiology study estimated the prevalence of paediatric sepsis at 8.2%, with the most common underlying causes being respiratory (40%) and bloodstream (19%) [49]. Despite evidence that hospital sepsis deaths occur within the first 24–72 h of admission [50, 51], and the availability of guidelines from the Surviving Sepsis Campaign since 2004, morbidity and mortality remains high [49]. The new

Table 4 Work streams for rapid assessment and management of the acutely unwell child with cardiac disease [43–48].

Work stream 1	Work stream 2	Work stream 3
Intravenous access and fluids	Respiratory support +/− tracheal intubation	Medication
Peripheral access often difficult Intra-osseous access can bridge to definitive central access Judicious fluid resuscitation of 5–10 $ml.kg^{-1}$ over 15–30 min Regular assessment for signs of fluid overload or resolution of shock	Cardiogenic shock due to heart failure ○ non-invasive and invasive ventilation may support circulation ○ unloads respiratory pump ○ reduces metabolic demand for oxygen ○ allows redistribution of essential cardiac output In the failing heart ○ invasive ventilation reduces left ventricular transmural pressure and left ventricular afterload Undertake tracheal intubation with extreme caution ○ use cardiostable drugs to a maximum dose of ketamine 1–2 $mg.kg^{-1}$ or fentanyl 1–2 $\mu g.kg^{-1}$	Postnatal duct dependent congenital heart disease ○ may present with obstructive shock ○ high dose prostaglandin may restore patency of the ductus arteriosus (initial 7–10 days) ○ prostaglandin doses above 15 $ng.kg^{-1}.min^{-1}$ are associated with a higher incidence of apnoea ○ likely require mechanical ventilation from combination of apnoea, acidosis and haemodynamic compromise Vasoactive medications to assist circulation ○ adrenaline, milrinone and noradrenaline (depending on the patient physiology) ○ may be administered safely peripherally in the initial resuscitation period

2020 Surviving Sepsis campaign international guidelines for the management of septic shock and sepsis-associated organ dysfunction in children provide guidance on fluids and vasoactive medications [52]. Fluid recommendations differ based on the availability of paediatric intensive care. For systems with paediatric intensive care, 40–60 $ml.kg^{-1}$ in bolus fluid (10–20 $ml.kg^{-1}$ per bolus) are suggested over the first hour, titrated to clinical markers of cardiac output, with continuous re-assessment. Should signs of fluid overload (hepatomegaly, pulmonary congestion) develop at any stage, this should be discontinued. In settings without paediatric intensive care, it is advised that maintenance fluids be started but no boluses given if the infant/child is not hypotensive. If hypotension is present, up to 40 $ml.kg^{-1}$ (10–20 $ml.kg^{-1}$ per bolus) over the first hour should be titrated to clinical markers of cardiac output (and discontinued if signs of fluid overload develop). Maitland et al. [53], conducted a RCT in a low-resource African setting that showed bolus fluid in the first hour of resuscitation increased mortality compared with maintenance fluids. Further analysis of the study concluded that, in this setting, the incidence of children presenting with severe febrile illness and fulfilling the World Health Organization definition for shock or hypotension was low. However, even in the children who met those criteria, there was a trend towards increased mortality, suggesting fluid management should be less focused on bolus and more on ensuring maintenance in a resource-limited setting [54]. The guidelines recommend fluid resuscitation be with balanced/buffered crystalloids rather than 0.9% saline solution in the first 72 h of admission for sepsis, based on observational studies which showed a reduction in mortality in children (OR 0.79; 95%CI 0.65–0.95) [55, 56]. In children with septic shock, adrenaline or noradrenaline are advocated as first-line vasoactive medications rather than dopamine, although dopamine may be substituted if these are not available. This guidance change follows the publication of two small studies [57, 58]. Ramaswamy et al. found adrenaline superior to dopamine in reversing fluid-refractory hypotensive cold shock within the first hour of resuscitation (41% vs. 13%, OR 4.8; 95%CI 1.3–17.2) and Ventura et al. reported peripheral dopamine to be associated with increased mortality compared with peripheral/intraosseous adrenaline in children with fluid-refractory septic shock. Vasoactive medications can be administered safely via peripheral or intraosseous access whilst central venous access is sought [48].

Disability

Traumatic brain injury is a common global cause of death and disability in children. Children sustain different patterns of head injury to adults due to differing anatomy and physiology, and clinical management should reflect this. The common mechanisms for traumatic brain injury in children vary with age. There are two peaks in childhood presentation, in those aged < 2 y and in adolescents [59]. In all patients aged < 14 y, falls are the leading cause, with transport-related injuries (road traffic accidents, bicycles) increasing in the 4–8-year-old age group and abusive head trauma more common below the age of 2 y [60]. Presenting clinical features with a high predictive value for abusive head trauma in patients aged < 3 y are apnoea and retinal changes. Seizures, long bone and rib fractures show association with abusive head trauma that fails to reach statistical significance [61]. With the development of major trauma centres, there has been a change in the location of care for patients with traumatic brain injury, necessitating the transfer of patients to such centres. Most of these transports in the UK are undertaken by anaesthetists, with the support of paediatric colleagues and in close collaboration with the nearest paediatric critical care centre [62]. Prevention of secondary brain injury is key to minimising morbidity and mortality. The Brain Trauma Foundation published guidelines for the management of paediatric severe traumatic brain injury in 2019 [63]. Interventions where the anaesthetist is central to preventing secondary brain injury are summarised in Table 5. Young children are prone to hypoglycaemia and cerebral oedema; therefore, maintenance fluids should be restricted to 50–60% of normal values [64] using glucose-containing isotonic saline solution. Hyperglycaemia is often seen in response to severe traumatic brain injury. Although persistent post-traumatic hyperglycaemia is associated with worse outcomes, a larger body of evidence suggests that the risk of severe hypoglycaemia associated with tight glucose control conveys harm in the absence of any mortality benefit [65]. The scalp is highly vascularised and can be a source of significant blood loss subcutaneously; in a neonate or infant this can contribute to significant haemodynamic compromise, which can be hidden in the absence of an exposed laceration. The CRASH-3 trial collaborators showed a reduction in mortality from 14% to 12.5% (RR 0.78; 95%CI 0.64–0.95) with mild to moderate injury (Glasgow Coma Scale < 13 but > 3) in adults who received tranexamic acid within 3 h of injury [66]. No similar RCTs have been carried out in paediatric populations. However, in a traumatic combat setting, tranexamic acid has been shown

Table 5 Summary of management of paediatric severe traumatic brain injury with associated level of recommendations [63].

Intervention		Recommendation	Level of recommendation
Prevention of hypoxia	Ventilation	Hyperventilation is not recommended within first 48 h for ICP control	3
	Cerebral perfusion pressure	Maintain at 40–50 mmHg	3
	ICP control (sedation)	Routine ICU sedation recommended Avoid bolus sedation in ICP spikes	3
	ICP control (hyperosmolar therapy)	Hypertonic saline 3% for intracranial hypertension, 2–5 $ml.kg^{-1}$ over 10–20 min	2
Prevention of increased oxygen demand	Temperature control	Prophylactic moderate (32–33 °C) hypothermia is not recommended to improve overall outcomes	2
	Seizure control	Prophylactic treatment reduced post traumatic seizures within 7 days	3

Recommendation level: 1, recommendations were based on high-quality body of evidence; 2, recommendations were based on moderate-quality body of evidence; 3, recommendations were based on a low-quality body of evidence.
ICP, intracranial pressure.

to reduce mortality [67]. The use of tranexamic acid in paediatric traumatic brain injury has been incorporated into the Royal College of Paediatrics and Child Health guidance on major trauma [68].

Exposure

Children are more susceptible to hypothermia than adults, particularly those with a high ratio of surface area such as preterm and low birth weight infants, and is associated with poor outcomes including death. Mitigating against hypothermia includes ensuring the internal environment is warm by eliminating draughts and prewarming surfaces [69], and guaranteeing children are dry and kept wrapped, especially the head, in prewarmed blankets. These measures, alongside external heating devices are useful when transporting critically ill children. Application of a polyethylene plastic bag to the torso and lower extremities in very low birthweight neonates reduces moderate hypothermia rates compared with standard thermoregulation protocols [70]. In certain circumstances therapeutic hypothermia is utilised in neonates, for example to treat asphyxia, where 72 h of moderate hypothermia is associated with improved neurodevelopment outcomes [71]. Neurodevelopmental outcomes following out-of-hospital cardiac arrest in paediatric patients remains poor however, and induced hypothermia has been explored in this context. Both THAPCA IH (therapeutic hypothermia after cardiac arrest in-hospital) and THAPCA OH (out-of-hospital) multicentre studies failed to show survival benefit with good neurological outcomes following cardiac arrest with moderate therapeutic hypothermia (32–34 °C) compared with normothermia. Pooling of these two trials also failed to show significant improvement in survival with favourable neurobehavioural outcomes [72]. Following changes to guidance in adult life support, the International Liaison Committee on Resuscitation Paediatric Life Support task force conducted an updated evidence review in 2021 on post-arrest temperature management in children. This recommended that for infants and children who remain comatose following return of spontaneous circulation after out-of-hospital or in-hospital cardiac arrest, active control of temperature be used to maintain a central temperature ≤ 37.5 °C (weak recommendation and moderate certainty evidence) [73]. Recently, emphasis has shifted from hypothermia to the role of temperature control in critical illness. Fever is an evolutionary response that accelerates immune responses [74]. In common childhood diseases such as malaria, varicella and rhinovirus, avoidance of antipyretics is associated with more rapid recovery. Overall, there is a paucity of evidence regarding temperature control in critically unwell children. However, a recent multicentre pilot RCT compared the feasibility of the application of permissive (fever > 39 °C) vs. restrictive (fever > 37.5 °C) thresholds for antipyretic administration with ventilated patients, and demonstrated no difference in ICU stay or mortality [75]. Currently, the National Institute for Health and Care Excellence recommends avoidance of antipyretics solely to reduce fever in children.

It would be remiss to write about the acutely unwell child without covering safeguarding. Whilst trends in child mortality by homicide or assault have decreased over the last 160 y in England and Wales, crimes against children since 2000 have increased and child maltreatment remains a public health problem worldwide [76, 77]. All staff need to be trained in recognising and responding to suspected child abuse or neglect [78]. Where there are safeguarding or child protection concerns, it is essential that healthcare professionals act in the best interests of the child. There are agreed national competences for all healthcare staff which should be regularly updated as part of mandatory training. Local training updates should ensure staff are aware of escalation policies and anaesthesia departments should have at least one anaesthetist with additional competencies. Systems should be in place to identify children who frequently attend and individual-specific protection documents need to be easily accessible in emergency settings [79].

Advancements in maintaining support and training for low case exposure

It is important to acknowledge that healthcare education and healthcare systems at large are centred around the treatment of adults. However, a large proportion of paediatric emergencies will initially be dealt with outside of a paediatric specialist setting with variable paediatric capabilities in terms of personnel, knowledge and skills and availability of appropriate protocols and equipment, often referred to as 'paediatric readiness' [80, 81]. Additionally, non-specialist centres often have low paediatric volume and therefore lack experiential expertise [82]. This care variation is further influenced by regional differences in skill distribution, for example, rural areas may have limited availability of paediatric emergency physicians [83]. It is, therefore, incumbent on clinical teams in the emergency setting to maintain a degree of comfort and competence in the initial assessment and stabilisation of the unwell child. Appropriate training, conducted at the correct intervals, is key to the consistently successful management of emergencies [84]. Optimal training should cover multiple performance domains including information management, technical skills, non-technical skills and interaction with the broader work system, such that clinicians are equipped with both the knowledge of `what to do´ and also `how to get it done´ within their specific work environment. Interdisciplinary in-situ and system-focused simulation can be useful in this regard [85, 86]. Technology-assisted training modalities, including virtual reality and augmented reality are starting to show promise [87]. These modalities may help democratise access to high-quality training, particularly in locations that do not currently have access to more expensive manikin simulation facilities, or have the capability to conduct synchronous interdisciplinary simulation. Although medical knowledge is crucial to individual performance, it is impossible for any clinician to have expertise in all domains and increased cognitive load is inversely associated with impaired knowledge recall [88]. As such, clinicians should consider employing tools that facilitate access to information.

The most recent European paediatric life support guidance supports the use of decision aids that provide precalculated dose advice for drugs and equipment [7]. Numerous apps exist that may facilitate recall of protocols and guidelines, as well as equipment sizing and weight-based medication dosing. Examples include SPA Pedi Crisis®, CNMC Paediatric Emergency Guide and ITDCS Paediatric Emergencies. These should be first used electively during routine clinical practice and simulation training, to ensure familiarity with the app structure and user interface. Despite the appeal of interactive technologies, low-technology solutions also have a role including the Broselow Tape, PAWPER tape and Mercy method to estimate patient weight, medication doses and suggested equipment sizes [89]. Although the field of telemedicine is still in its infancy, a recent systematic review suggests that telemedicine applied to paediatric emergency care may have a positive impact on therapeutic decision-making, diagnostic accuracy, cost reduction and patient satisfaction [90]. It is possible that general and subspecialty paediatric expertise may be readily available in real time in locations without immediate access to these, including the prehospital realm. Other important aspects of improving care include establishing supportive networks between specialist paediatric and generalist emergency departments. One such initiative is TREKK (Translating Emergency Knowledge for Kids, https://trekk.ca), a pan-Canadian initiative that evaluated learning needs of clinicians and parents, alongside unknown learning needs to prioritise important topics used to created curated evidence-informed resources for clinicians and families [91]. Another exciting field in development is that of machine learning and artificial intelligence assistants. Artificial intelligence algorithms have been shown to predict the onset of sepsis in children and neonates more efficiently than either real-time electronic screening algorithms or clinical recognition [92, 93]. Machine learning algorithms may also help risk-stratify febrile infants. If used to rule out severe illness (in this case, bacteraemia), machine learning and artificial intelligence could help reduce unnecessary diagnostic procedures, hospitalisations and antibiotic administrations, in addition to helping identify at-risk patients requiring immediate intervention [94]. Human factors and ergonomics are key in emergency management, particularly when events of high acuity and low frequency are concerned. For example, seemingly minor errors in dose calculations can lead to significant overdosing in small children, and patient identification is harder in a population which often cannot advocate for themselves [95]. Here, health technologies are not necessarily `safer´; devices such as drug and intravenous pumps cannot always be used interchangeably between adult and paediatric settings and with the smaller market for these devices, financial drivers innovating safer paediatric equipment are not always present. Staff must be experienced in using paediatric equipment and ideally there should be similar equipment in all centres within a geographical region to ensure instant familiarity when staff move hospitals (such as for UK doctors in training).

In conclusion, managing an acutely unwell child can be complex, with anaesthetists playing a key role in the team. Practice is diverse, encompassing varied physiological responses, multiple pathologies and often complex underlying comorbidities. A systematic approach to management, ensuring initial care is delivered in a timely fashion, is vital for ensuring good outcomes. Developments in training, cognitive aids, knowledge sharing and addressing human factors are vital to keep a workforce `paediatric ready´ to deal with these important emergencies.

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