CONTINUING MEDICAL EDUCATION

Principles of Pediatric Emergency Care

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SUMMARY

Background: Children account for only a small percentage of pre-hospital emergency patients but are a special challenge for the treating physician.

Methods: The Medline database was selectively searched for articles appearing up to June 2009. The authors added other important literature of which they were aware.

Results: The broad spectrum of diseases, the wide age range with the physiological and anatomical changes that occur in it, and the special psychological, emotional, and communicative features of children make pediatric emergencies a special challenge for emergency physicians.

Conclusions: A mastery of basic emergency techniques including clinical evaluation of the child, establishment of venous access, airway management, resuscitation, and drug dosing is essential for the successful emergency treatment of children. We recommend classifying the common non-traumatic pediatric emergencies by four cardinal manifestations: respiratory distress, altered consciousness, seizure, and shock. Classifying these rare emergency situations in this way helps assure that their treatment will be goal-oriented and appropriate to the special needs of sick children.

Key words: emergency medical care, pediatric care, pediatric diseases, childhood accidents, emergency medical service

Cite this as: Dtsch Arztebl Int 2009; 106(45): 739–48
DOI: 10.3238/arztebl.2009.0739

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Polls among emergency physicians have revealed that delivering pre-hospital emergency care to children causes extreme emotional stress and anxiety (1). Many diagnostic and therapeutic techniques are considered to be especially difficult in children, particularly small children. Furthermore, as pediatric emergencies account for only 2% to 10% of all medical emergencies (2), it seems difficult to acquire adequate experience in a reasonable period of time merely by performing one's job as a pre-hospital emergency care physician.

Most pediatric emergencies that are dealt with by helicopter rescue services involve trauma, while two-thirds of the pediatric emergencies seen by earthbound emergency medical teams are non-traumatic. The spectrum of conditions treated is wide (3). Unusual aspects of pediatric emergencies include the challenge of communicating with ill—sometimes severely ill—children and the limited cooperation they can provide during their examination and treatment.

For this review, we identified important current studies and articles with a selective search of the literature. For some clinical conditions, national and international guidelines and/or Cochrane Reviews were available and were therefore taken into consideration.

The learning goals of this article for the reader are:

- to understand the significance of the special physiology and anatomy of the child as they affect the performance of important emergency medical techniques;
- to be able to classify pediatric emergencies by their major manifestations;
- to become conversant in the basic strategies for dealing with pediatric emergencies.

Percentage of emergency treatments

Children account for 2% to 10% of all treatments by emergency physicians.

TABLE 1

Normal values of vital signs by age^{*1}

Age group	Respiratory rate (per minute)	Pulse (per minute)	Blood pressure (mm Hg)
Neonate	30–50	80–180	60/30
Infant	20–40	80–160	96/60
Toddler	20–30	80–150	98/64
School-age child	16–24	75–110	106/68
Adolescent	12–20	50–100	114/74

^{*1}modified from (23)

Techniques

Clinical assessment and measurement of vital signs

The major changes brought about by physiological and psychological development throughout childhood can already cause difficulties in the measurement of children's vital signs. Tables of age-specific normal values for the most important parameters are thus very helpful (*Table 1*). Aside from physical examination, the initial evaluation includes an ECG, pulse oximetry, and non-invasive manual measurement of blood pressure. Clearly, measurement of the vital signs should not delay any urgent therapeutic interventions that the seriously ill child may need. Therefore, the initial assessment of the child's overall condition is of crucial importance:

- Is the child ill, or seriously ill?
- Are the airways obstructed? Is the child short of breath?
- Is the skin unusually pale, mottled, or cyanotic?
- What is the child's state of consciousness?
- Does the child make eye contact?

The respiratory rate is normally higher in children than in adults because of the greater need for oxygen in the growing child and because of a low functional residual capacity. If the respirations are more rapid than normal for the child's age, this may be because of excitement, fever, or increased respiratory drive secondary to a disease of the central nervous system, but it is usually a sign of impaired pulmonary function.

Thus, infants and small children with a relatively unstable thorax can be seen to have breathing-associated retraction in the jugular, intercostal, sternal, or epigastric areas. Another typical sign of dyspnea is flaring of the nostrils in neonates and small infants; this serves to widen the airway. Kussmaul respirations are almost always due to diabetic ketoacidosis. An abnormally low respiratory rate, which is always an alarming sign, is usually due to a disease of the central nervous system or intoxication but can also be due to hypothermia (e1, e2).

The stroke volume of a child's heart can hardly be increased at all in case of need, and the cardiac output is therefore raised, when necessary, by increasing the heart rate. Arterial pulses are often harder to palpate in children than in adults. In case of doubt, the patient's pulse can be taken by auscultation or by ECG. Tachycardia in children is usually due to excitement, fever, or hypovolemia. Persistent bradycardia always arouses the suspicion of intracranial hypertension or hypoxia; it is also seen in intoxications of various kinds (e1, e2).

When measuring a child's blood pressure, the physician should take great care to choose a blood-pressure cuff of a suitable size. It should cover two-thirds of the length of the arm and be 20% larger than the diameter of the arm. Arterial hypertension is a less common element in pediatric medical emergencies. Conversely, children in shock can maintain a normal blood pressure for a long time by means of a rapid heart rate and vasoconstriction, and thus hypotensive pressure values must be considered an alarm signal for cardiovascular decompensation. A more reliable and easily assessed parameter for volume deficiency in a child is the capillary refill time, which is checked by briefly pressing on the skin over the forehead or sternum. Refill times longer than two seconds are considered abnormal in childhood and call for prompt intervention (4).

Venous access

Obtaining venous access in a child can be a challenge, as well-nourished infants and toddlers often have no visible peripheral veins under the skin, even on a second look. Commonly used venipuncture sites are the dorsum of the hand or foot, the medial surface of the ankle, the forehead, and the scalp (e3). A distal vein should be punctured first with a small venous catheter ("small is better than nothing"), preferably 26 Gauge. If no suitable veins can be localized, the next option is a vein with a fixed anatomical relationship to the

First impression

The physician's initial assessment of the child's general condition is crucial.

Venipuncture sites

- Dorsum of hand or foot
- Medial side of ankle
- Forehead
- Scalp

TABLE 2

Appropriate diameter and length of endotracheal tube and type of laryngoscope spatula, by height of patient^{*1}

Height (cm)	58–70	70–85	85–95	95–107	107–124	124–138	138–155
Age (years)	0–1	1–2	2–3	3–4	4–7	7–9	9–12
Inner diameter of the unblocked endotracheal tube (mm)	3.5	4.0	4.5	5.0	5.5	6.0	6.5
Length from mouth (cm)	10.5	12	13.5	15	16.5	18	19.5
Laryngoscope spatula	1 straight	1 straight	2 straight	2 straight or curved	2 straight or curved	2–3 straight or curved	3 straight or curved

^{*1}modified from (24)

puncture site: the saphenous vein cranial to the medial surface of the ankle, the middle cubital vein in the crook of the arm, or the cephalic vein proximal to the first proximal interphalangeal joint. If venipuncture turns out to be impossible at all of these sites, small, superficial veins on the flexor surface of the wrist or on the trunk can be tried as well. Experienced physicians always have the option of an external jugular venous puncture, but it must be borne in mind that the Trendelenburg position is sometimes poorly tolerated and that the child must be well stabilized for a jugular venous catheter to be placed. Alternatively, the femoral vein can be punctured. A central venous catheter should never be placed in the internal jugular or subclavian vein of a child outside the hospital, as this carries a substantial risk of unintentional arterial puncture or pneumothorax. An intraosseous puncture is a much less risky way of obtaining venous access in an emergency.

The current guidelines of the European Resuscitation Council (ERC) recommend intraosseous puncture as the method of choice when attempts to secure intravenous access have been excessively time-consuming or unsuccessful (5). All of the intravenous emergency medications currently in use can be given through an intraosseous needle. Intraosseous puncture, however, is an invasive procedure fraught with potential complications and side effects, and is therefore medically indicated only in rare cases, when the patient's life would otherwise be at risk or when

resuscitation is needed (e4). The recommended strategy in pediatric emergency patients is to resort to an intraosseous approach after a maximum of three unsuccessful attempts to obtain venous access, or after 90 to 120 seconds of trying (6). The recommended first-line puncture site in children is the medial side of the proximal portion of the tibia, 1–2 cm below the tibial tuberosity (7). The use of semiautomatic puncture techniques (EZ-IO, Vidacare, San Antonio, USA) can lower the complication rate in children as in adults.

Airway

The child's airway has a number of special characteristics that need to be considered by physicians taking care of respiratory emergencies. The larynx is higher and the tongue relatively larger than in adults, and both can thus make mask ventilation more difficult. Infants and toddlers are positioned in minimal extension (the "sniffing position"), as more pronounced reclination of the head can lead to airway obstruction (8, 9). School-age and preschool children are best intubated with the aid of a straight Miller-type laryngoscope spatula, with which the relatively soft, U-shaped epiglottis can be raised—i.e., the spatula is introduced under the epiglottis, so that the epiglottis comes to lie on top of it.

Orotracheal intubation is preferred in emergency situations, although a nasotracheally introduced tube is easier to fix in place and is at lesser risk of becoming dislodged if the trachea is relatively short. The suitable

Intraosseous vascular access

In the treatment of pediatric emergencies, it is recommended that vascular access should be obtained by the intraosseous route after a maximum of three unsuccessful puncture attempts or 90 to 120 seconds of trying.

Special considerations in respiratory emergencies

- High position of the larynx
- Large tongue
- Infants and toddlers should be positioned in minimal extension

Algorithm for unexpectedly difficult intubation of a child. In serious emergency situations, intubation must be the goal; mask ventilation is used to gain time until the patient can be intubated.

tube size can be derived from the formula, “inner diameter (mm) = (age in years/4) + 3 (blocked tubes) or + 4 (unblocked tubes)” (8), or else it can be read off of a table (Table 2). In practice, estimation of the tube size from the diameter of the patient’s little finger has been found to be quite practical. The narrowest spot of the child’s airway is directly under the cricoid cartilage. Therefore, if a blockable tube is used, it should be blocked cautiously, preferably with measurement of the cuff pressure, to avoid serious injury to the larynx and trachea.

A child in respiratory distress under emergency conditions should be considered not to have an empty stomach, and the emergency intubation should be performed with rapid sequence induction. The current guideline of the German Society for Anesthesiology and Intensive Care Medicine (Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin, DGAI) stresses the central importance of avoiding hypoxia and thus recommends ventilating by mask until the muscle relaxant has taken effect, not using cricoid pressure, and not giving depolarizing muscle relaxants (10). As a general principle, the position of the tube and the patient’s ventilatory status must be controlled and continually monitored in patients of any age, and capnography should be used for this purpose in the pre-hospital setting as well.

Securing the airway of a neonate, infant, or small child requires special knowledge and manual skills (8). Difficult airways are a much greater challenge to manage in children than in adults (Figure). If intubation

proves unexpectedly difficult, the patient should be ventilated by mask to prevent hypoxia. Fiber-optic intubation is not available for use in the pre-hospital emergency situation, however, and thus mask ventilation should be continued during transport, or else other, alternative supraglottic techniques for securing the airway will have to be applied. If mask ventilation is impossible and oxygenation cannot be maintained by pulling the tube back into the pharynx or using a laryngeal mask, coniotomy should be considered as a last resort (e6). A puncture coniotomy is performed with a 14 Gauge venous canula, which can then be connected to the ventilation bag either through a 3.5 mm endotracheal tube connector or through a 10 mL syringe and a blocked tube.

Resuscitation

The recommendations for cardiopulmonary resuscitation in childhood were last updated in 2005 (5). The changes that were made in this update were less a reflection of new medical knowledge than of an attempt to simplify the recommendations to make them resemble the adult algorithms more closely, thus enabling more effective resuscitation even in the hands of less experienced rescuers.

The most important change is that the age limit of eight years has been dropped; the only remaining distinction is between children and adolescents from puberty onwards, for whom the adult algorithms apply. The recommended ratio of chest compressions to respirations is 15:2 for two rescuers or 30:2 for a single rescuer. If the patient has obviously aspirated a foreign body that cannot be expelled by coughing, chest or abdominal compressions are recommended.

Manual defibrillation is performed with 4 J/kg of body weight (BW). Automatic external defibrillators (AED’s) cannot be used in infants, but can be used in all older children. The dosage of epinephrine for pediatric resuscitation is 10 µg/kg BW as an intravenous or intraosseous bolus and 100 µg/kg BW intratracheally (5).

The recommendations for the emergency first aid of neonates were also updated in the 2005 guidelines (5). Some of the basic principles of neonatal resuscitation can also easily be applied in pre-hospital emergency situations. The neonate is very sensitive to cold and can generate heat endogenously only by raising its oxygen consumption. Often, apnea or hypopnea is initially present and can be relieved with gentle stimulation

Airway management

If intubation is unexpectedly difficult, revert to mask ventilation to prevent hypoxia.

Resuscitation

Chest compression for ventilation

- One rescuer: 30:2
- Two rescuers: 15:2

(rubbing the back) (11). If mask ventilation is still needed despite this measure, low oxygen concentrations should be established as soon as possible in order to avoid damaging effects that can be seen in asphyctic children (12). If the child must be intubated, the emergency physician may be tempted to use the smallest possible tube, but this leads to a much higher airway resistance, and critical overinflation may be the result. A 3.5 mm inner diameter (ID) tube fixed at 10 cm from the corner of the mouth suffices for a mature neonate. The autoregulation of cerebral perfusion is markedly impaired or nonexistent in asphyctic children, and it follows that hyperventilation—which leads to cerebral vasoconstriction—should be rigorously avoided. Finally, an accidentally avulsed umbilical cord (in precipitate labor) should be immediately tied or clamped to prevent major blood loss.

Medications

There are many special pharmacokinetic considerations in childhood, relating to (among other things) volumes of distribution, protein binding, metabolic rates, and the degree of permeability of the blood-brain barrier (13). Simply scaling the adult dose downward according to the child's body weight is, therefore, not necessarily appropriate for the child's actual needs, even though this remains the usual rule in practice, because few relevant pharmacokinetic studies have been performed in children. Various tables and reference works are available for this purpose. The child's body weight can be estimated by the formula, "body weight (kg) = $2 \times \text{age (years)} + 8$." The *e-Table* provides an overview of the dosages of medications that are currently given in the pre-hospital treatment of pediatric emergencies.

Clinical manifestations

Aside from trauma, which will not be discussed any further here, most pediatric emergencies can be categorized by their main clinical manifestations as belonging to one of four types:

- Respiratory distress
- Altered consciousness
- Seizure
- Shock.

Respiratory distress

Respiratory emergencies in childhood are characterized by two cardinal manifestations, dyspnea and stridor. The type of stridor can already give an important clue

to the differential diagnosis. An obstruction in the extrathoracic portion of the trachea causes inspiratory stridor, while an obstruction in its intrathoracic portion causes expiratory or combined stridor (14).

The most common cause of inspiratory stridor of sudden onset is pseudocroup (15). The triad of a barking cough, hoarseness, and inspiratory stridor characteristically arises in a small child in the aftermath of an upper respiratory infection. The clinical features of pseudocroup are so typical that this entity is actually easy to distinguish from croup (epiglottitis), which it supposedly closely resembles: epiglottitis is characterized by inspiratory stridor, marked dysphagia, and high fever in a very sick child and has now practically disappeared, thanks to widespread *Haemophilus influenzae* B vaccination. Treatment with steroids (systemic and inhaled) and inhaled epinephrine leads to rapid resolution of mucosal swelling (e7). The therapeutic benefit of warm or cold, moist air is debated in the literature (16).

High-grade obstruction of the smaller airways with expiratory stridor is usually an expression of bronchial asthma or bronchiolitis. Status asthmaticus is only rarely the initial manifestation of bronchial asthma, tending rather to arise when pre-existing asthma decompensates. Dyspnea and obstruction dominate the clinical picture; hypoxia and hypercapnia arise late in its course. Warning signs of impending decompensation include silent obstruction and neurological signs (agitation or somnolence). Oxygen administration and medical stabilization of the patient with inhaled beta₂-mimetics, epinephrine, steroids, and (if necessary) theophylline before transport are essential (e9). If intubation is necessary, barbiturates, opiates, and succinylcholine should be avoided and ketamine should be used instead, in order not to worsen bronchoconstriction. Similar therapeutic principles apply to bronchiolitis (which is almost exclusively caused in infants by respiratory syncytial viruses [RSV]): in this situation, epinephrine is usually the most effective drug, as the bronchioli possess no smooth muscle and therefore no point of attack for inhaled beta₂-mimetics (e10–e12).

An important differential diagnosis of either inspiratory or expiratory stridor is foreign-body aspiration. The actual aspiration event is seldom observed; the clinical signs are coughing and/or shortness of breath, in the absence of fever or a history of asthma. If the airway is critically obstructed, thoracic compressions are indicated in children under 1 year old, thoracic or

Rule of thumb for calculation of body weight in kg

$$2 \times \text{age (years)} + 8$$

Cardinal manifestations of pediatric emergencies

- Respiratory distress
- Altered consciousness
- Seizure
- Shock

BOX

Poisoning Treatment Centers in Germany, Austria, and Switzerland

- Berlin, Poison Emergency Center Berlin, tel. +49 - 30 / 1 92 40
- Bonn, Poison Information Center of Friedrich-Wilhelms University of the Rhine, tel. +49 - 2 28/2 87 32 11
- Erfurt, Joint Poison Information Center of the States of Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt, and Thuringia, tel. +49 - 3 61/73 07 30
- Freiburg, University Children's Clinic, Poison Information Center, tel. +49 - 7 61/1 92 40
- Göttingen, Northern Poison Information Center, Georg-August University, tel. +49 - 5 51/1 92 40
- Homburg/Saar, Poisoning Information and Advice Center of the University Clinics, tel. +49 - 68 41/1 92 40
- Mainz, Poisoning Advice Center of Johannes Gutenberg University, tel. +49 - 61 31/1 92 40
- Munich, Poison Emergency Center and Mobile Antidote Center, tel. +49 - 89/1 92 40
- Nuremberg, Toxicological Intensive Care Unit, tel. +49 - 9 11/3 98 24 51
- Vienna, Poison Information Center, General Hospital, tel. +43 - 14 06 43 43
- Zurich, Swiss Toxicological Information Center, tel. +41 - 44 251 51 51

abdominal compressions (the Heimlich maneuver) in older children (5). If these maneuvers do not suffice to expel the foreign body, the patient can be intubated and the foreign body can be pushed forward into a main stem bronchus, from which it can be subsequently extracted bronchoscopically.

Altered consciousness

Among the many disease states that are associated with altered consciousness in children, most are also characterized by accompanying signs that point the way to the correct diagnosis: fever (sepsis, meningitis,

heatstroke), circulatory centralization (shock), and trauma. Emergency situations in which altered consciousness is the sole abnormality are less common. One such situation is hypoglycemia, which mainly arises as the result of insulin treatment for diabetes mellitus, after a prolonged period without food intake, or in a variety of congenital metabolic disturbances. Hypoglycemia can be properly diagnosed from the clinical history and the accompanying autonomic signs. Persistent, severe hyperglycemia can lead to altered consciousness and seizures. Whenever hypoglycemia is suspected in an alert child, glucose should be given rapidly in the form of sweetened drinks. If the child's consciousness is already altered, 1 mL of 20% glucose solution per kg of body weight (i.e., 0.2 g glucose/kg BW) is given intravenously and followed by a continuous glucose infusion to prevent rebound hypoglycemia.

Symptomatic hyperglycemia in childhood is almost always due to diabetic ketoacidosis. In 25% of all cases, this occurs as the first manifestation of diabetes; it can also occur in patients with known diabetes who are inadequately treated (e.g., non-compliant adolescents). As this is a life-threatening condition conferring a risk of permanent harm, particularly if cerebral edema arises, it should be diagnosed rapidly (17). There is characteristically a history of polydipsia, polyuria, weight loss, and diminished performance in school, while physical examination reveals Kussmaul respirations and ketone breath. The children are often dehydrated. Once the diagnosis has been confirmed by blood sugar measurement, treatment should be initiated immediately: in the pre-hospital setting, the patient is given volume replacement with NaCl 0.9% (15–20 mL/kg BW IV over 15 minutes). Solutions containing potassium, such as Ringer's solution or Ringer's lactate, should not be given; an initial insulin bolus should not be given either (18).

Finally, intoxications can occur at any age and can lead to altered consciousness depending on the substance that has been ingested. In preschool and school-age children, poisoning is usually accidental and generally involves the ingestion of plants or medications. In adolescents, the common substances of intoxication are usually medications and alcohol, often taken with suicidal intent. If the clinical picture is unusual, it is recommended that the patient should be treated symptomatically and that further aid should be sought, even in the early pre-hospital phase, from one of the supraregional poison information centers (*Box*).

Foreign-body aspiration

Foreign-body aspiration is an important differential diagnosis of both inspiratory and expiratory stridor.

Most important physical findings in children with altered consciousness

- Fever
- Circulatory centralization
- Trauma

TABLE 3

Clinical assessment of the severity of dehydration^{*1}

Parameter	Minimal or no dehydration <5% weight loss	Mild to moderate dehydration 5–10% weight loss	Severe dehydration ≥10% weight loss
General condition, state of consciousness	Good, awake	Restless, irritable, or tired	Apathetic, lethargic, unconscious
Thirst	Normal	Thirsty, drinks avidly	Drinks poorly or not at all
Mucous membranes (mouth, tongue)	Moist	Dry	Dried out
Capillary refill	Normal (<2 sec)	Prolonged (>2 sec)	Prolonged (>2 sec)
Urine production	Normal or decreased	Decreased	Minimal
Skin turgor	Skin folds snap back immediately	Slow (<2 sec)	Slow (>2 sec)
Pulse	Normal	Normal to elevated	Tachycardia
Respiratory rate	Normal	Normal to intensified	Deep, acidotic breathing
Eyes	Normal	Sunken	Deeply sunken
Tears	Present	Diminished	Absent
Fontanel	Normal	Mildly sunken	Sunken

^{*1}modified from (20, 25)

An attempt should always be made to secure a sample of the responsible substance (parts of plants, medication packages).

Seizure

Epileptic seizures account for a large percentage of emergency medical interventions in children; most cases are of febrile seizures. Febrile seizures are common and usually harmless (19), but the rarer differential diagnoses, including meningitis, traumatic brain injury, and severe dehydration, should always be borne in mind (e13). The treatment consists of the rectal administration of diazepam (5 mg for children weighing less than 15 kg, 10 mg for children weighing more than 15 kg); if the seizure does not stop within 5 minutes, rectal diazepam should be repeated before diazepam or clonazepam is given intravenously (*e-Table*). Although a rapidly rising fever triggered the seizure, the administration of antipyretic drugs (ibuprofen, paracetamol) is

often forgotten in practice. Moreover, the dehydration that accompanies severe febrile illnesses requires effective treatment. The new occurrence of a focal epileptic seizure in a child calls for prompt diagnostic imaging.

Shock

Children, like adults, can go into shock as the result of a number of common conditions including trauma, burns, infection, gastroenteritis, and anaphylactic reactions (e14). If too much time elapses before shock is correctly diagnosed and effectively treated, the body's compensatory mechanisms can fail, bringing the child into acute danger (4). The cardiac output falls before arterial hypotension occurs, and the latter is thus a late warning sign. It follows that shock in a child must always be treated before the child becomes hypotensive.

The most common type of shock in childhood is hypovolemic shock, caused, e.g., by persistent fluid loss

Epileptic seizures

Most epileptic seizures in childhood are febrile seizures.

Shock

The most common type of shock in childhood is hypovolemic shock.

in gastroenteritis. The severity of dehydration can be assessed rapidly (*Table 3*). Older children with mild dehydration can be treated on an outpatient basis, but infants that are even mildly dehydrated should be cared for in the hospital. Each 1% of dehydration corresponds to a fluid loss of about 10 mL per kilogram of body weight. Crystalloids such as NaCl 0.9% or Ringer's solution are used for intravenous rehydration (10–20 mL/kg BW over 60 minutes, or else a bolus of 20 mL/kg BW over 15–30 minutes). If the patient is anuric, solutions that contain potassium should be used with caution.

Septic shock in children takes a variable course. Hypodynamic, “cold” shock with elevated peripheral resistance and a low cardiac output is much more common than in adults. The treatment of septic shock depends on a number of considerations and should be carried out in accordance with the current international guidelines (20, 21).

Under the heading “shock,” we will also briefly consider sudden infant death (SID) and related acute life-threatening events (ALE) (e15). Although numerous risk factors for these events have been identified, their precise pathophysiology is still mostly unclear (e16). In case of death, meticulous physical examination and history-taking, the drawing of a blood culture, and an autopsy are absolutely essential (22). A child who has had an ALE, even if he or she has completely recovered, must be admitted to the hospital for work-up.

Overview

Knowledge of basic working techniques and typical clinical signs enables the physician to proceed with confidence when treating pediatric emergencies. The fact that important physiological parameters change in major ways in the first few years of life is fundamental to the assessment of life-threatening conditions. Vascular access plays a key role in emergency medical care and is often relatively difficult when the patient is a severely ill child. In the emergency situation, therefore, the option of intraosseous access should always be thought of early.

With respect to the airways, too, the physician must know about the special anatomy and physiology of the child. Important considerations here are the use of unblocked tubes and of modified rapid-sequence induction. Medication doses are usually calculated according to the child's body weight, which can be estimated by the rule of thumb “body weight (kg) = 2 × age (years)

+ 8.” There are many different types of pediatric illness, but pediatric emergencies can be usefully classified into five main categories, depending on their dominant clinical feature: trauma, respiratory distress, altered consciousness, seizure, and shock.

Conflict of interest statement

The authors declare that they have no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

Manuscript received on 20 July 2009, revised version accepted on 17 September 2009.

Translated from the original German by Ethan Taub, M.D.

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Overview

Knowledge of basic working techniques and typical clinical signs enables the physician to proceed with confidence when treating pediatric emergencies.

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FURTHER INFORMATION ON CME

This article has been certified by the North Rhine Academy for Postgraduate and Continuing Medical Education.

Deutsches Ärzteblatt provides certified continuing medical education (CME) in accordance with the requirements of the Medical Associations of the German federal states (Länder). CME points of the Medical Associations can be acquired only through the Internet, not by mail or fax, by the use of the German version of the CME questionnaire within 6 weeks of publication of the article. See the following website: cme.aerzteblatt.de

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The solutions to the following questions will be published in issue 1–2/2010.

The CME unit “Perspectives on the Pathophysiology and Treatment of Sudden Idiopathic Sensorineural Hearing Loss” (issue 41/2009) can be accessed until 20 November 2009.

For issue 49/2009 we plan to offer the topic “Lung Cancer.”

Solutions to the CME questionnaire in issue 37/2009: Dietlein et al.: “The Medical and Surgical Treatment of Glaucoma.”

Solutions: 1d, 2c, 3e, 4b, 5a, 6b, 7e, 8d, 9d, 10a

Please answer the following questions to participate in our certified Continuing Medical Education program. Only one answer is possible per question. Please select the answer that is most appropriate.

Question 1

Which of the following normal values of the vital signs is correct for a 5-year-old girl?

- a) Respiratory rate 5/min
- b) Pulse 100/min
- c) Blood pressure 60/40 mm Hg
- d) Blood glucose 35 mg/dL
- e) Capillary refill time >2 sec

Question 2

You are an emergency physician called to see a one-year-old boy who is apathetic and drinks poorly (pulse 160/min, respiratory rate 40/min, skin turgor time >2 sec, anuric). He has been suffering from gastroenteritis for three days. How do you assess the situation?

- a) No risk, an outpatient visit to the family physician the next day will suffice
- b) Low risk, minimal dehydration, hospital admission unnecessary
- c) High risk, severe dehydration, begin rehydrating immediately, hospital admission essential
- d) Low risk, no danger to life, but a pediatrician should be consulted on an outpatient basis
- e) Intermediate risk, mild dehydration, hospital admission necessary

Question 3

Which vascular access route should not be used in the pre-hospital treatment of pediatric emergencies because of its excessive risk?

- a) Peripheral venipuncture on the dorsum of the hand or foot
- b) Peripheral venipuncture on the medial surface of the ankle
- c) Intraosseous access to a long bone at a site appropriate for the patient's age
- d) Central venous catheterization of the subclavian vein
- e) Peripheral venipuncture on the scalp

Question 4

With what size unblocked endotracheal tube (inner diameter, in mm) should a three- to four-year-old boy be intubated?

- a) 3
- b) 8
- c) 5
- d) 7
- e) 6.5

Question 5

How much adrenaline should be given IV per kilogram of body weight during the cardiopulmonary resuscitation of a child?

- a) 5 µg/kg BW
- b) 10 µg/kg BW
- c) 15 µg/kg BW
- d) 20 µg/kg BW
- e) 25 µg/kg BW

Question 6

In the German-speaking countries, which disease most commonly causes inspiratory stridor in children?

- a) Pseudocroup
- b) Bronchiolitis
- c) Bronchial asthma
- d) Foreign-body aspiration
- e) Epiglottitis

Question 7

Which of the following is an important special consideration for securing the airway of a child?

- a) Low-lying larynx
- b) Small tongue
- c) Minimally extended position of the head ("sniffing position")
- d) Hard, U-shaped epiglottis
- e) Easy anatomy for intubation

Question 8

Ventricular fibrillation is rare in childhood. When it occurs, what energy is necessary for defibrillation?

- a) 2 J/kg BW
- b) 4 J/kg BW
- c) 8 J/kg BW
- d) 10 J/kg BW
- e) 20 J/kg BW

Question 9

Which medication is used to treat seizures in children?

- a) Diazepam
- b) Theophylline
- c) Suprarenin
- d) Adenosine
- e) Morphine

Question 10

Which of the following is a reliable and easily assessed parameter of volume deficiency in a child?

- a) Elevated respiratory frequency
- b) Fever
- c) Capillary refill time
- d) Agitation
- e) Pallor

eTABLE

Overview of the dosing of medications currently used in pre-hospital pediatric emergency medicine

Emergency medication	Dose [mg/kg BW]	Neonate (3.5 kg) [mg]	Infant (10 kg) [mg]	Toddler (20 kg) [mg]	School-age child (40 kg) [mg]
Resuscitation					
Epinephrine (in CPR) IV	0.01	0.035	0.1	0.2	0.4
Atropine (in CPR) IV	0.02	0.07	0.2	0.4	0.8
Amiodarone IV	5	15	50	100	200
Calcium chloride (10%) IV	0.25	0.875	2.5	5	10
Circulatory stabilization and treatment of cardiac arrhythmias					
Adenosine IV	0.2	0.7	2	4	8
Magnesium sulfate (50%) IV	0.1	– 1	1	2	4
Atropine for bradycardia IV	0.01	0.035	0.1	0.2	0.4
Treatment of hypoglycemia					
Glucose 20% IV	200 (1 mL)	700 (3.5 mL)	2000 (10 mL)	4000 (20 mL)	8000 (40 mL)
Treatment of epileptic seizure					
Clonazepam IV	0.1	0.35	1	2	4
Phenobarbital IV	10	35	20	40	80
Diazepam p.r.	0.5	– 1	5	10	10
Treatment of anaphylaxis					
Dimethidene IV	0.1	0.35	1	2	4
Cimetidine IV	5	15	50	100	200
Ranitidine IV	1	3.5	10	20	40
Prednisolone IV	5	20	50	100	200
Induction and maintenance of anesthesia					
Thiopental IV	5–10	25	75	150	250
Propofol IV	3–5	15	50	100	200
Etomidate IV	0.3	1	3	6	12
Ketamine S IV	3	10	30	60	120
Midazolam IV	0.1	– 1	1	2	4
Fentanyl IV	0.005	0.02	0.05	0.1	0.2
Alfentanil IV	0.01	0.04	0.1	0.2	0.4
Rocuronium IV	0.5	2	5	10	20
Analgesia					
Piritramide IV	0.05	0.2	0.5	1	2
Morphine IV	0.05	0.2	0.5	1	2
Paracetamol p.r.	30	125	125	250	500
Metamizole IV ^{1,2}	10	– 1	100	200	400
Opioid antagonist					
Naloxone IV	0.05	0.2	0.5	1	2
Treatment of airway obstruction					
Salbutamol inhalation ³	0.12–0.25	– 1	1 (4 drops)	2.5 (10 drops)	5 (20 drops)
Epinephrine inhalation ³		2.4 (0.6 mL)	4.8 (1.2 mL)	4.8 (1.2 mL)	4.8 (1.2 mL)
Theophylline IV ⁴	5	– 1	50	100	200
Prednisolone IV	5	17.5	50	100	200

¹ unfavorable side-effect profile in neonates; ² as a bolus infusion; ³ in 2 or 4 mL (for toddlers and school-age children) NaCl 0.9%; ⁴ over 20 min, then 10 mg/kg BW per day;
CPR = cardiopulmonary resuscitation