Acute Pediatric Illness - Evaluation, Monitoring and Stabilization

3.0 Contact Hours

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Abstract

Every year about 150,000 children visit the Emergency Room with acute illness, out of which about 10,000 die. Pediatric emergencies consist of various types: respiratory, cardiac, endocrine, traumatic, and infectious. The most important goal for any child visiting the ER is to identify the seriously ill children. These children need immediate attention and therapeutic intervention. Early recognition and intervention reduces the morbidity and mortality in children who are acutely and seriously ill. The various clinical approaches used for evaluating a normal child are applicable to evaluating the sick child. The evaluating pediatrician should be aware of all the possible serious illnesses that could make a child critically ill.

Monitoring of an acutely ill child is done by collecting physiological data with the help of invasive and non-invasive procedures. Monitoring requirements are divided into hemodynamic, pulmonary, and neurologic monitoring which in turn could be invasive or non-invasive. Scoring systems are useful for making triage decisions and assessing the performance of an intensive care unit. Stabilization of a critical ill child includes restoration of physiological status of the cardiovascular, respiratory, central nervous and renal systems and also nutritional support.

Upon completing this course, the learner will be able to:

1. Discuss the evaluation of an acutely ill child
2. Discuss the monitoring of a critically ill child
3. Discuss the scoring systems and predictors of mortality
4. Discuss stabilizing a critically ill child

Evaluation of a sick child

The various clinical approaches used for evaluating a normal child are applicable to evaluating the sick child. The evaluating pediatrician should be aware of the all the possible serious illnesses that could make a child critically ill. Most of the acutely ill children visiting the ER would be febrile and in most of the children, it would have been caused by an acute infection.

The most important goal for any child visiting the ER is to identify the seriously ill children. These children need immediate attention and therapeutic intervention. Early recognition and intervention reduces the morbidity and mortality in children who are acutely and seriously ill. The risk of acquiring a serious illness and the cause of it will not be the same in all children. It depends upon various factors. Identifying a seriously ill child requires the following:

- Careful observation of the child
- Appropriate history taking
- Physical examination from head to foot and all various systems
- Relevant laboratory investigations

The pediatrician should also take note of the child's age. Child's age is one of the significant factors which will give a clue to the etiology. The constitutional status of a child keeps changing as he or she grows. Infections are the most common reason for a child becoming ill. Before 3 months of age, the infant is more prone to sepsis and meningitis. Group B streptococcus and gram negative organisms are also commonly encountered infections at this age. After 3 months, sepsis and meningitis are caused commonly by Streptococcus pneumoniae, Hemophilus influenza and Neisseria meningitides.

As the child grows the immune system matures and immunity is developed to these organisms. The incidence of sepsis and meningitis also decreases and more localized infections occur. After 3 years, pharyngitis is common and is caused by group A streptococci. Beyond 5 years, mycoplasma infection is common which cause respiratory infections. Urinary tract infections, which causes significant morbidity commonly occurs during childhood. But one of the significant points is that before one year of age, urinary

tract infections are more common in male infants whereas it is more common in female children after one year.

Observation

The role of observation has to be emphasized in the evaluation of a sick child. Observation helps in knowing whether the child has any serious illness. And in many instances it also gives some clue regarding the type of illness. An incessantly crying child may not be an acutely ill child. But if the child has grunting or cyanosis or a bulging fontanel, it definitely indicates the presence of serious illness. Grunting is a sign of lower respiratory problem. Cyanosis can occur in both respiratory and cardiac illness. Though bulging fontanel can occur in a normal crying child, in the presence of other signs, it may indicate meningitis.

Assessing the child's response to stimuli may provide very valuable information. The pediatrician has to see:

- How the crying child respond to parent's comforting
    - A critically ill child may not respond to comforting by even parents
- If sleeping, how soon does the child wake up with a stimulus
    - A critically ill child will not actively respond to the stimulus.
- Whether the child smiles when the pediatrician interacts with him or her.
    - The response of a normal child will be quite apparent. Sometimes the normal child will vocalize as the examiner enters the room. But other times more and more stimuli may be needed to make the child act in a normal manner. Often a fussy irritable child begins to look around and focus on the examiner when held and walked by the parent.

McCarthy's Acute Illness Observational Scales

McCarthy's Acute Illness Observational Scales are very reliable in identifying the seriously ill child. These consist of six observation items and scales.

Observation items:

- Quality of cry
- Reaction to parent stimulation - This is about looking for the effect on crying when held, patted on the back, jiggled on the lap or carried

- State variation – This is going from awake to asleep or asleep to awake
- Color
- Hydration – Looking for moisture in skin, eyes and mouth
- Response to social overtures – This is about the response to being held, kissed, hugged, touched, talked to and comforted

Each of these items is graded in normal, moderate impairment and severe impairment. A normal finding is scored as 1, moderate impairment as 3 and severe impairment as 5. The best possible score for the six items is 6 and the worst score is 30.

- The chance of a serious illness is 1-2% if the total is less than or equal to 10
- The chance of a serious illness increases by 10 fold if the score is more than 10

But the limitation of this scoring system is that it cannot be used in infants less than 3 months as the infant would not have developed the skills required to score on some of these items.

History taking

History taking is complex. Parents should provide information on specific symptoms. The questions should be pertaining to the acute illness. Organ specific questions should be asked.

For example:

- Respiratory system – Ask about fast breathing, cyanosis, retraction, and wheezing which may indicate pneumonia
- Musculoskeletal system – Ask about swelling and movement of the limbs. In septic arthritis, the child will have swelling of the joint and won't be moving that limb (pseudo-paralysis)

Some of the children might be having recurrent episodes of acute illness. This indicates that the child is having some underlying chronic problem which is predisposing them to the recurrent episodes of illnesses. For example, children who are positive for HIV will have an immunodeficient state which will predispose them to various recurrent

infections. Questions should be asked to assess the physiological status of the child and also about the complications that are anticipated. For example, in children presenting with tachypnoea and fever in whom bronchiolitis is diagnosed, the possibility of developing dehydration is there. So questions to assess the hydration status should be asked, such as wet diapers, tears, or awakeness.

Physical examination

The physical examination follows the same sequence for the well child. The components of the physical examination that are more bothersome to the child are completed last. The first step is to make the sick child as comfortable as possible. It is best to seat the child on the parent's lap. The older child may be seated on the examination table. This is followed by checking the vital signs.

- Pulse - In the presence of fever or if the child is in shock, the heart rate will be increased

- Respiration – Increased respiratory rate and other symptoms like stridor, expiratory wheezing, grunting, or coughing may indicate serious infection

- Blood pressure – Hypotension may indicate a serious infection

- Temperature – Most of the children who present as a seriously ill child would have serious infections and the associated fever.

This is followed by a general examination from head to foot. Most often the infections causing serious illness in children are viral in nature and these are invariably associated with nasal discharge. The other external 'markers' of viral infection can also be seen in the form of skin rashes or organism specific findings like a slapped cheek appearance of a Parvo virus infection may be seen. Cutaneous perfusion should be assessed by warmth and capillary refill time. When the child is not crying, the anterior

fontanel should be palpated. A bulging fontanel indicates the intracranial pressure is, high which most commonly occurs in meningitis.

Sometimes there will paradoxical irritability. When there is meningitis, there will be neck rigidity. Any attempt to move the neck will make the child cry. Similarly, in septic arthritis, the affected limb is kept still and the child does not move it. Any attempt to move it makes the child cry. The head to foot examination is followed by examination of the individual systems.

The cardiovascular and the respiratory system examination should be done when the baby is calm and not crying since the findings of auscultation may be missed if the child is crying. In the respiratory system, assessment is performed in terms of adequacy of air entry into the lungs, equality of breath sounds, and evidence of adventitial breath sounds, especially wheezes, rales, and rhonchi. The conducted sounds due to obstruction in the nose have to be differentiated. In the cardiovascular examination, pericardial friction rub, loud murmurs, or distant heart sounds may indicate an infectious process involving the heart. In the central nervous system examination, if meningitis is suspected then both Kernig's and Brudzinski's signs may be sought. In children younger than 18 months, meningeal signs may not always be present with meningitis. While examining the abdomen the diaper is removed. The abdomen is inspected for distention. Auscultation is performed to assess adequacy of bowel sounds, followed by palpation. In addition to focal tenderness, palpation may elicit involuntary guarding or rebound tenderness. These findings indicate peritoneal irritation, as is seen in appendicitis. The inguinal area and genitals are then sequentially examined. In the febrile child, inguinal adenitis or a strangulated hernia may be the cause of fever.

Examination of the ear and the throat is done last. This is the most uncomfortable part of the examination for the child. But this part of the examination should not be missed or avoided as this may give important clues to the diagnosis such as an enanthem of hand, foot and mouth disease caused by Coxsackie virus or may even show an enlarged inflamed tonsil.

Sometimes a repeat examination might be needed. A child may be crying incessantly due to the illness or even due to stranger anxiety. A bulging anterior fontanel

could be either due to meningitis or simply due to crying. In this situation a repeat examination when the child is calm will point towards the exact cause.

A careful observation, a detailed history and a complete physical examination will identify the serious illness in more than 90% of the children. But sometimes other data might be needed which include the already discussed age and also the temperature and relevant laboratory investigations. In febrile children, the higher the fever, the greater the risk for serious illness.

Laboratory infection may provide vital clues. In bacterial infection, the total white blood cell count may be increased. In the differential count, there will be predominance of neutrophils. A urinalysis and urine culture should be considered when the source of fever is not apparent, especially in females and uncircumcised males younger than 2 yr of age and all boys younger than 1 yr of age—the highest risk groups. An elevated C-reactive protein value may also distinguish bacterial from viral infections.

In the end, all the data collected should be evaluated. This will help in determining how to further proceed.

- If the child is more than 3 years and the physical examination and laboratory tests are normal, the child may be followed expectantly.
- If on the other hand any of these is abnormal, it is suggestive of serious illness and more specific investigations should be done. For example, a chest x-ray has to be taken if pneumonia is suspected.
- If the child is less than 3 months, a complete septic work up should be done

Monitoring of an acutely ill child

Monitoring of an acutely ill child is done by collecting physiological data with the help of invasive and non-invasive procedures. The non-invasive procedures involve continuous monitoring of heart rate and respiratory rate or intermittent monitoring of blood pressure and arterial blood gas analysis. Non-invasive monitoring is associated with fewer complications allowing for greater patient comfort at a reduced expense. Invasive monitoring requires special expertise in the insertion of catheters and nursing care in their maintenance and has potential serious complications (e.g., infections, thrombosis, bleeding). It is widely used in unstable critically ill patients.

Monitoring devices

The various monitoring devices used in the monitoring of an acute ill child include the following:

Non-invasive monitoring

- Cardio respiratory chest leads - Heart rate, rhythm, respiratory rate are measured
- Pulse oximetry - Continuous SaO_2 monitoring done
- Capnography - End-tidal CO_2 using breath-by-breath analysis
- Sphygmomanometer – Blood pressure measured
- Electroencephalogram - Continuous monitoring of cranial electrical activity

Invasive monitoring

- Central venous access - Allows for CVP determinations and administration of vasoactive agents and hypertonic solutions
- Pulmonary artery catheter - Allows for measurements of cardiac output, SVO2, pulmonary artery pressure
- Jugular bulb catheter - Measures SVO_2 at the jugular bulb. Cerebral oxygen extraction can be calculated

Monitoring requirements are divided into hemodynamic, pulmonary, and neurologic monitoring which in turn could be invasive or non-invasive.

Hemodynamic monitoring

Hemodynamic monitoring is indicated in any patient admitted to the pediatric intensive care unit (PICU) who is in shock, has respiratory failure, or has sustained an acute neurologic insult. The variables that are monitored are:

- Heart rate
- Blood pressure
- Central Venous Pressure and pulmonary capillary wedge pressure (PCWP)
- Right atrial and left atrial pressures (in postoperative cardiovascular patients)

Pulmonary monitoring

The monitoring requirements for patients who require significant respiratory support include blood gas determination, either from arterial or, less frequently, capillary and venous blood gases. The variables and the devices used are:

- Blood gas analysis
- End-tidal CO_2 ($EtCO_2$) analysis by capnography
- Oxygen saturation by Pulse oximetry

Neurophysiologic monitoring

Neurologic monitoring involves careful clinical observation accompanied by highly technical non-invasive devices (e.g., electroencephalography, evoked potentials, near infra-red spectroscopy), or invasive catheters placed to monitor intracranial pressure (ICP). The monitoring includes-

- Continuous electroencephalogram (EEG) – This is monitoring of the brain's electrical activity
- Evoked potentials – These enable evaluation of a variety of sensory pathways that include visual evoked responses (VEPs), brain-stem auditory evoked potentials (BSAEPs), and somatosensory evoked potentials (SSEPs)
- Bispectral Index (BIS) – This is used to monitor the neurologic status of both sedated and unsedated critically ill patients
- Radionuclide imaging – This may provide some useful information regarding cerebral blood flow
- Invasive neurologic monitoring – This involves intracranial pressure monitoring and jugular bulb catheterization

Scorings Systems and Predictors of Mortality

Scoring systems are useful for making triage decisions and assessing the performance of an intensive care unit. These are of limited use in predicting the outcome of the illness. The various scoring systems used in the pediatric intensive care unit are categorized as:

- Organ specific scores (examples given below)
    - Glasgow Coma Scale
    - Croup score
- Scores based on mechanism of injury
    - Pediatric Trauma Score
    - Injury Severity Score
- Pediatric scoring systems
    - Pediatric Index of Mortality (PIM)
    - Physiologic Stability Index (PSI)
    - Pediatric Risk of Mortality (PRISM)

Prism III is used nowadays. It is based on 17 physiologic variables subdivided into 26 ranges. It has a consistently strong relationship between the number of malfunctioning organ systems at 12 and 24 hr and the mortality risk in a given PICU. A PICU that performs a periodic self-assessment using PRISM can determine if its performance is on par with a reference population.

Pediatric Trauma Score takes into account a child's size, the accessibility of the airway, the systolic blood pressure, the level of consciousness, and the presence or absence of wounds and fractures. Below a certain cutoff, transfer to a dedicated trauma center is recommended.

The Glasgow Coma scale has three parameters – eye opening, motor response and verbal response. This scoring system is used in drowsy or comatose patients. The integrity of the CNS is assessed with this scale.

Other scoring systems are rarely used.

Stabilization of a critically ill child

Pediatric emergencies

Every year about 150,000 children visit the ER with acute illness, out of which about 10,000 die. Pediatric emergencies are of various types: respiratory, cardiac, endocrine, traumatic, and infectious. However, most pediatric arrests are respiratory, not

cardiac. Respiratory arrests are more common in children with pre-existing chronic lung disease or those who become acutely ill with shock or airway compromise. Respiratory emergencies could be upper airway obstruction, lower airway obstruction or pneumonia. Cardiopulmonary arrests in a hospital setting are usually initially respiratory arrests and are often predictable. Apnea usually precedes bradycardia with poor perfusion. A number of factors contribute to the physiologic instability of infants and young children like temperature, fluid requirements, airway, cardiac output and glucose metabolism.

Emergency personnel should have an approach that will allow them, in the best interest of the patient, to refrain from initiating or terminating resuscitations when efforts are futile. The most common life-threatening illnesses in children are those involving respiratory, cardiac or neurologic failure. Identifying the cause of various organ failures may take considerable time, but treatment of the physiologically unstable child must begin immediately.

Observation begins with determination of the alertness of the patient, including response to stimuli, spontaneous vocalization or movement, and muscle tone. In basic life support, this is assessed by asking, "Are you all right?" This is followed by assessment of the vital signs and other basic indicators of the physiologic state.

Resuscitation

The goal in pediatric resuscitation is to maintain adequate oxygenation and perfusion of blood throughout the body while steps are taken to stabilize a child and establish long-term homeostasis. An orderly sequence of events should be instituted, beginning with the ABCs: airway, breathing, and circulation.

Many pediatric patients undergoing resuscitation recover to a substantial degree. Hospitalized children with acute life-threatening conditions often recover spontaneous circulation after an arrest. Children with a respiratory arrest, a short duration of CPR and a pulse present at the time of apnea have the best chance of survival. The majority of survivors have no change in their neurologic function compared with their pre-arrest status. If a patient is asystolic on arrival at the hospital or in the advanced stages of a

chronic disease process before receiving acute medical care, the chances for a successful resuscitation decline dramatically.

Respiratory support

The most common cause of obstruction of airway in the absence of a foreign body is the tongue falling back. Head tilt, chin lift or jaw thrust if the cervical spine is unstable and it is confirmed by looking for the rise and fall of the chest, listening at the nose and mouth for breathing, and feeling air exiting the child's airways. This should be done in less than 10 seconds. If a foreign body is seen, it should be removed.

Cardiovascular support

As resuscitation proceeds and ventilation is started, support of the circulation should be provided to sustain adequate blood flow to deliver oxygen to the tissues. Circulation is assessed by checking the pulse. If there is no pulse or if the pulse is less than 60 beats/min with poor perfusion, chest compressions must be given. The effectiveness of chest compressions is determined by the presence of a palpable pulse. If resuscitation is to continue and spontaneous heart rate and respirations have not returned, then the patient should be intubated, vascular access established, and administration of resuscitative drugs initiated. In the field with a pulseless child, an automatic external defibrillator may be available and should be used in children older than 8 years of age if ventricular fibrillation is present.

Shock

Shock is an acute syndrome, characterized by inadequate circulatory provision of oxygen, so that the metabolic demands of vital organs and tissues are not met. If inadequate tissue perfusion continues, various endocrine, vascular, inflammatory, metabolic, cellular, and systemic responses occur and the patient becomes more physiologically unstable. The specific pattern of response and related pathophysiology, clinical manifestations, and treatments varies with the etiology of shock. Untreated shock will lead to irreversible tissue injury and death. The types of shock include –

- Septic shock

- Cardiogenic shock
- Distributive shock
- Hypovolemic shock
- Obstructive shock

In most patients with early shock, a fluid bolus of 20 mL/kg of normal saline or lactated Ringer solution should be given rapidly. If it is not possible to insert an intravenous catheter into a peripheral vein within 90 seconds or within three attempts, an intraosseous needle should be inserted to administer fluids. After this infusion, the patient is reassessed to determine if more fluid is required or other forms of therapy should be initiated. If, after fluid resuscitation, the patient continues to demonstrate poor perfusion and shock, vasoactive agents are needed.

Respiratory stabilization

Respiratory failure is the primary diagnosis in close to 50% of children admitted to PICU. It is a common cause of cardiopulmonary arrests in children. The four principal derangements are hypoventilation, diffusion impairment, intrapulmonary shunting, and ventilation-perfusion mismatch. Children with impending respiratory failure due to lung disease have respiratory distress characterized by rapid breathing, exaggerated use of accessory muscles, and intercostal, supraclavicular, and subcostal retractions. Respiratory arrest or repeated apnea requires immediate respiratory support. Severe shock also may require mechanical ventilation, even if arterial blood gases are within acceptable range, because patients need increased oxygen delivery to vital organs.

Renal stabilization

Renal function is often significantly affected by critical illness that does not involve intrinsic renal disease. Renal failure in children is most commonly caused by shock, sepsis, hypoxia, or nephrotoxic medications. Although oliguria is common in the PICU and may be associated with poor outcomes, often only additional fluids or low doses of diuretics are needed for correction. Renal blood flow and function usually improve when renal perfusion pressure is increased during shock by the infusion of

vasopressors. Dopamine at doses of 1–3μg/kg/min often improves urine output and natriuresis. Rarely, renal replacement therapies are required. Continuous venovenous hemofiltration (CVVH) is the modality of choice for renal replacement therapy in critically ill children.

Neurologic stabilization

Acute neurologic deterioration can be life-threatening. The clinician must act quickly to stabilize the child with an evolving neurologic picture to quickly reverse the process and avoid further permanent injury to the brain. The initial event produces the "primary injury" to the brain that gives rise to the typical signs and symptoms. Failing to recognize the primary events from the clinical manifestations, the child may be at significant risk for further injury referred to as "secondary injury." Preservation of global neurologic function, prevention of secondary cerebral edema, and optimizing regeneration are important particular concerns to the intensive care physician. The basics of neurologic stabilization include the ABCs of resuscitation and maintenance of adequate oxygenation and perfusion. The decision to intubate the trachea and institute mechanical ventilation is determined by the need to control the airway and the presence or absence of protective airway reflexes. The manifestations like increased intracranial tension seizures should be managed with appropriate drugs.

Nutritional stabilization

Critically ill children need nutritional support to decrease the negative nitrogen balance resulting from excessive catabolism. Glucose infusion of 3–5 mg/kg/min is given to inhibit the breakdown of endogenous protein. Generally, 70% of calories should be derived from carbohydrates and 30% from lipids. Amino acids should be provided in reasonable amounts, in any form (1.5 g/kg in older children, 2.0 g/kg in infants). It is often difficult to deliver adequate calories to critically ill children because of enteral intolerance or restrictions in fluid volumes, but the caloric goals should be attainable within the first week of hospitalization. Enteral feeding or parenteral feeding (if gastrointestinal cannot be used) should provide the required calories.