

**CASE STUDY:
ASSESSMENT OF THE CRITICALLY ILL PEDIATRIC PATIENT**

An Infant Who is Hypovolemic

OBJECTIVES

After completion of this educational process the participant will be able to:

- A. List the seven vital signs which should be measured in every critically ill or injured pediatric patient presenting to an emergency department.
- B. Discuss normal ranges of vital signs for infants (see definitions).
- C. Determine the proper therapy to administer to a pediatric patient who presents with hypovolemia.
- D. Discuss physical examination clues which would indicate adequate response to therapy for hypovolemia. (See definitions)

HISTORY

The parents of a 5 month old infant brought him to an urban hospital emergency department because of a five day history of "spitting up, diarrhea and poor feeding." The child had been healthy until the onset of his present problem. No other family members were ill. He had vomited approximately three times and had approximately ten liquid bowel movements in the previous 24 hours. His parents estimated his fluid intake in the previous 24 hours was significantly less than half of his normal fluid intake. Upon direct questioning it was learned the infant had not wet his diaper in the previous hours and only two times in the previous 24 hours.

PRIMARY EXAMINATION

Physical examination in the emergency department by the nursing staff should include each of the seven measurements listed in table one and illustrated in figure one. To omit any of these measurements would constitute less than optimal initial physical evaluation.

The vital measurements obtained in this child were blood pressure 66/48, pulse rate 180, respiratory rate 42, rectal temperature 36° C, oxygen saturation, breathing on room air, 94%, capillary refill 5 seconds, weight 5 Kg.

To evaluate these vitals signs requires a knowledge of the normal vital signs in a five month old infant. (See Table Two)

Additional essential evaluations by the nurse include general appearance, airway patency, breathing, circulation (the ABC's), neurological status and skin signs.

A general description of this infant was a listless baby who appeared to be acutely ill. He was normally proportioned and of average size for his age. His airway was patent and he was breathing rapidly expanding his chest fully and symmetrically.

Our 5 month-old patient was sleeping in his mother's arms and did not respond to verbal stimuli. He did respond to heel pressure with a weak cry. However, when the stimulus was discontinued, he reverted to sleep.

Evaluation of his skin revealed it to be pale, peripherally mottled (see definitions) and cool to the touch.

We now have sufficient information to begin aggressive therapy. In fact initial therapy, such as administration of supplemental oxygen, should have been instituted within minutes of the infant's arrival to the emergency department. We will, however, detail the important characteristics of the secondary examination before providing details of the therapy which was instituted.

SECONDARY EXAMINATION

Proceeding from head to toe the practitioner should first evaluate the fontanelle (see definitions). Since the anterior fontanelle in the infant does not close until about the age of nine months, palpation of the "soft spot" at the junction of the parietal and frontal bones can provide important information. For example, if the fontanelle were bulging it would be an indicator of increased intracranial pressure. If sunken or depressed it would be an indicator of dehydration. Next, evaluate the mucous membranes of the mouth. Are they wet or dry? Wetness is a sign of adequate hydration, dryness a sign of dehydration. Evaluation of the neck should include an attempt to flex and extend to assess for signs of neck stiffness (resistance to motion of the neck by the infant) which could be an indicator of meningitis. This sign, i.e., stiffness, also termed meningismus, is not always present in a child with meningitis, but when present is a valuable indicator of a serious problem.

Auscultate the chest for the presence of rales, rhonchi and wheezes (see definitions). Auscultate the heart for any abnormal sounds and confirm the heart rate which is numerically noted on the monitor is the same as the heart rate determined by listening over the precordium.

Practitioners should palpate the right upper quadrant of the abdomen in any neonate infant or child who presents to an emergency department. In the 5 month old the liver edge is typically palpable one to two cm below the right costal margin. If the liver is enlarged, may be an indicator of backup of fluid from the heart into the venous system, perhaps reflecting congestive heart failure. A liver which is retracted under the costal margin is an indicator of dehydration (hypovolemia). (See Figure Two)

The central and peripheral pulses should be evaluated and graded as being 0-4+. (See Table Three) The pulses to be evaluated include the central pulses, e.g.s., the brachial and femoral pulses, and the peripheral pulses, e.g.s., the radial and dorsalis pedal pulses.

An astute practitioner will learn to compare the central with the peripheral pulses.

An indicator of inadequate peripheral perfusion is relative weakness of the peripheral arterial pulsations when compared to the central pulses, e.g., 2+ (normal quality) femoral and 1+ (weak, thready) dorsalis pedis. (See Figure Three)

The findings of the secondary exam were as follows:

- The fontanelle was sunken.
- The mucous membranes dry.
- The neck supple, i.e., not stiff.
- The chest clear to auscultation.
- The heart sounds normal in quality and without evidence of murmur. The precordial rate of 170 corresponded to the rate displayed on the monitor.
- The liver edge was not palpable below the costal margin.
- The central pulses were 1+ quality; the peripheral pulses were 0, i.e., not palpable.

HYPOVOLEMIA

The infant we are discussing has a history and physical examination consistent with hypovolemia. Furthermore, the hypovolemia is in a moderately advanced state. Treatment should be immediately directed toward correcting the hypovolemia while at the same time considering and prophylactically treating for potential associated problems, in particular septicemia (See definitions for hypoglycemia, hypothermia and hypoxemia).

TREATMENT

Fluid Volume

Rehydration by means of administration of fluid volume is the major priority. Attempt to insert a catheter into a peripheral vein to draw blood for analysis and to initiate an IV infusion of a crystalloid solution such as normal saline or lactated Ringers solution.

Once intravenous access has been established the bolus should be 100 cc's of either normal saline or lactated Ringers solution (20 cc/Kg to this 5 Kg infant) (20 x 5 = 100). This bolus should be given rapidly over 2-3 minutes. Re-assessment should then be done if there are still signs of hypovolemia then a rapid second and/or third bolus can be given in succession. (See Tips - number 4)

Establishing intravenous access in an infant can be difficult especially for those who do it on an infrequent basis. When the veins are "collapsed" as a consequence of dehydration, the procedure can be even more difficult. So what is the practitioner to do if unable to establish a intravenous infusion within a reasonable (10-15 minutes) period of time? Consider establishing an intraosseous infusion. Detailing the method of establishing such an infusion is beyond the scope of this course. However, it is a procedure with which all emergency staff should be familiar. Essentially the procedure consists of placing a large bore needle through the bony cortex of the tibia, femur or other bone and into the marrow cavity. The marrow cavity channels directly to the vascular space. Therefore, administration of fluids and chemicals into the marrow is equivalent to injecting it into the venous system.

Maintaining, Obtaining Appropriate Glucose Levels:

Hypoglycemia is a condition in which there is low blood sugar. The infant who is stressed is particularly susceptible to the development of hypoglycemia because of low glycogen reserves which can be rapidly consumed by the stress of infection. In the absence of adequate glucose aerobic metabolism cannot occur because glucose is the "energy currency" of the cell. The result can be cell death. Central nervous system cells, neurons, are at particular risk. If the blood sugar (which should have been determined within the first few minutes after the infant's arrival to the department) is less than 60 mg/dL, the child should be treated with 0.5 Gm/Kg of glucose. Dextrose 10% should be utilized in an infant to correct the hypoglycemia not to treat the hypovolemia (use crystalloid).

Temperature Control:

Hypothermia is associated with increased morbidity and mortality. This child presented with hypothermia - note the initial temperature was 36° C - 96.8° F - and this condition could rapidly worsen, particularly as the child is uncovered for the examination. An important component of therapy is passive rewarming while simultaneously attempting IV access. Do the exam then immediately "rewrap" the infant in warm blankets. Put a stocking cap on the infant's head. The reason to do so is heat is "lost" at a rapid rate from vascular tissues. The scalp is very vascular. A room temperature comfortable for the caregiver could be, and often is, too cool for the infant. Staff should be vigilant in terms of treating hypothermia if present and if not present, preventing its occurrence.

Oxygenate:

Ensuring adequate oxygenation is a priority in this infant. Clues as to the adequacy of tissue oxygenation can be gleaned from the skin and mucous membrane color (pink?)

and capillary refill time. The best clue, in most instances, is from oxygen saturation measurement. Do what is necessary to keep the saturation at least 96%. Use a non-re-breather mask, if the infant will tolerate it, or a nasal canula. Holding an oxygen source close to the infants nose/mouth - the parent maybe the best person to do so, this is typically quite effective.

Reassessment and Continuing Treatment:

Frequent reevaluation of vital signs is important. (See Figure Two.) At a minimum pulse rate, cardiac rhythm and oxygen saturation should be measured on a continuous basis, and blood pressure, respiratory rate and core temperature measured at frequent periodic intervals. Ideally core temperature is monitored continuously with an indwelling rectal probe. Capillary refill and skin signs are evaluated on an "as needed" basis but no less frequent than every half hour. Also periodically reevaluate the level of consciousness and pulse quality. If this infant's condition is "simply" a viral infectious process affecting primarily the gastrointestinal tract without underlying septicemia (see definitions), he could respond promptly and even dramatically to crystalloid infusion. However it could, and almost certainly will, be necessary to repeat the fluid infusion at least one, two, or more times.

Continuing Rehydration:

Normal total body fluid volume in a 5 Kg child is about 3,500 cc's. This infant presented with moderate dehydration indicative of a 10-15% fluid deficit. Assuming it is a 10% deficit it would mean this 5 Kg infant, who has a total fluid volume of approximately 3,500 cc's, has a deficit of 350 cc's (10% of 3,500). Therefore he would potentially require three to four 100 cc's (20 cc's x 5 Kg) fluid boluses to correct his deficit. To assess the adequacy of hydration reevaluate blood pressure, pulse rate (it should be below 160), skin signs (no longer pale, cool, mottled), pulse quality (adequate and equivalent central and peripheral pulses), or mucous membrane wetness and level of consciousness (returning to normal interactivity/responsiveness).

Outcome:

This infant was treated with four 100 cc boluses of normal saline. He "perked up" considerably, becoming responsive to verbal stimuli and later awake. Within two hours he was interactive with his mother. His blood pressure increased to 78/44, his pulse rate decreased to 154, his respiratory rate to 32, his skin signs were normal his mucous membranes moist and his brachial, radial, femoral and dorsalis pedis pulses 2+ (normal).

Because of the potential of underlying sepsis he was administered a broad spectrum antibiotic. Blood, urine and stool were obtained for culture. He was transferred to a

regional pediatric center where he was admitted to the intensive care unit. By the second day he was feeding and was discharged home after four days. Blood, urine and stool cultures did not demonstrate evidence of pathogens. It was presumed his underlying disease process was caused by a virus.

DEFINITIONS

- Crystalloid - A solution of sterile water containing certain elements such as sodium and chloride; e.g.s, normal saline and lactated Ringers solution.
- Fontanelle - The "soft spot" which can be palpated in the spaces between the skull bones. The fontanelles are typically "closed" by the age of nine months.
- Hypo - Means too little or low; volemia refers to volume. Thus, hypovolemia is defined as low or inadequate volume of fluid in the blood vessels, i.e., arteries, veins and capillaries. When the condition of hypovolemia is present, there will also be inadequate fluid volume within the cells.
- Infant - Age 29 days to one year.
- Mottled - Patchy areas of skin which have a mosaic pattern of abnormal coloration, usually a brown-red appearance.
- Perfusion - Blood flow.
- Rales - Abnormal lung sounds heard during the inspiratory phase of breathing/ventilation.
- Rhonchi - Coarse rales.
- Septicemia - Microorganisms in the blood stream.
- Wheezes - Musical quality sound sometimes heard during expiration when the bronchioles are narrowed, i.e., air is being "forced" through narrowed tubes.

TIPS

1. Weight - there are 2.2 lbs in a Kg.
2. Temperature – A change of one degree centigrade = A change of 1.8° Fahrenheit.
3. Wet diaper - always ask the caregivers to estimate the number of times an ill infant has wet his diaper in the previous 24 hours and when he/she last wet the diaper. The response, if accurate, will represent a clue to the degree of dehydration. The dehydrated infant has decreased urine output and fewer wet diapers.
4. Never administer an intravenous bolus of 5% dextrose and water or any dextrose solution to correct dehydration. To do so could cause a dangerously low serum sodium (dilutional hyponatremia). The result could be central nervous system dysfunction, perhaps manifested by seizures. Hyperglycemia could also occur resulting in worsening of the hypovolemic condition by means of the glucose molecule "carrying" water out through the kidney.

FIGURE ONE

Seven measurements to be obtained in every critically ill or injured infant.

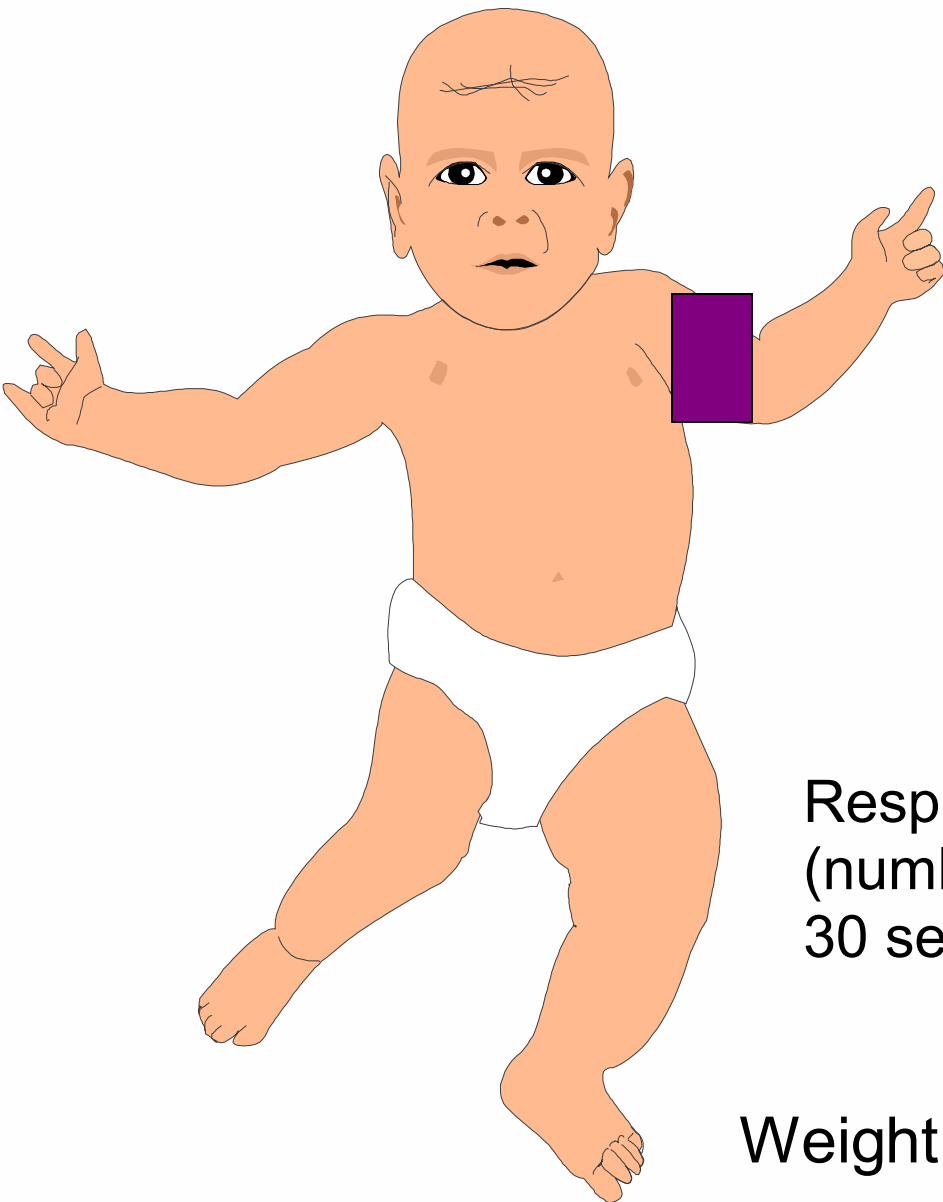
MONITOR

- Temperature 36° C
- Pulse 170
- O₂ Sat 97%
- BP 70/40

Capillary Refill
5 seconds

Respiratory rate
(number of breaths in
30 seconds X 2) = 44

Weight = 5Kg

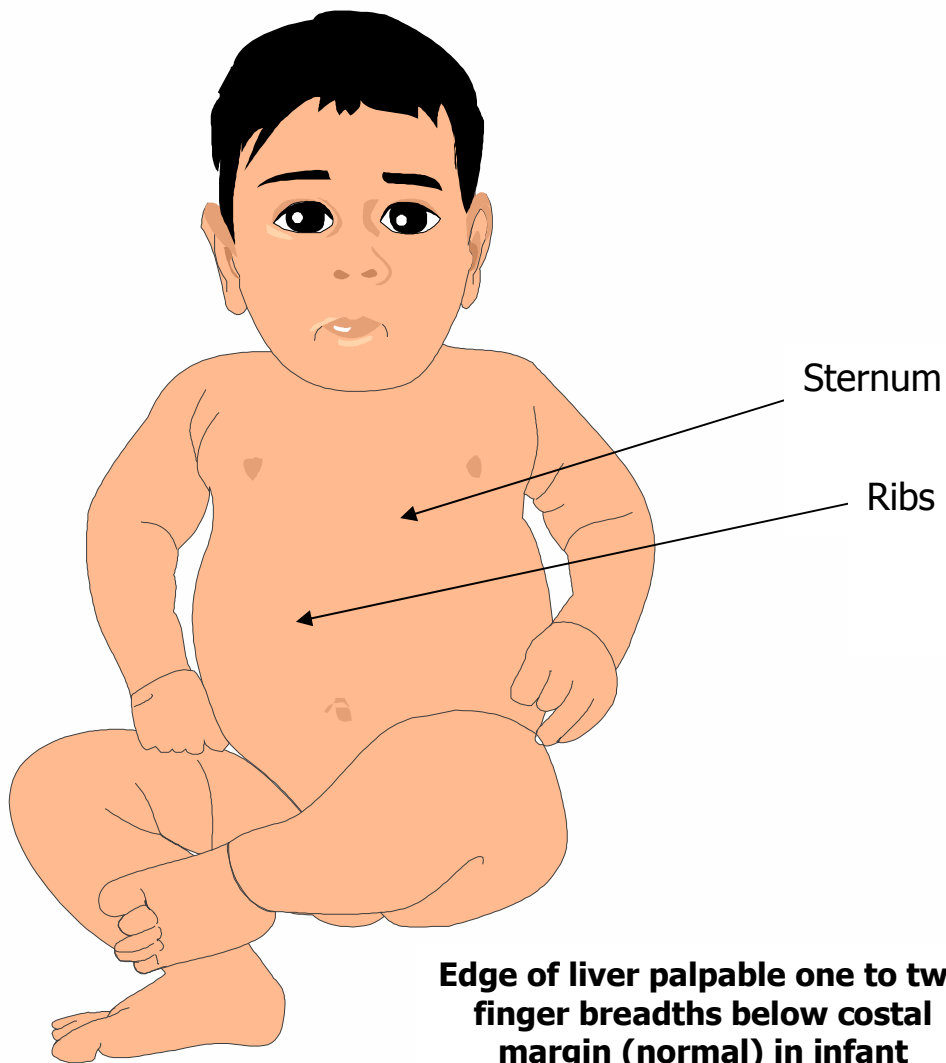


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FIGURE TWO

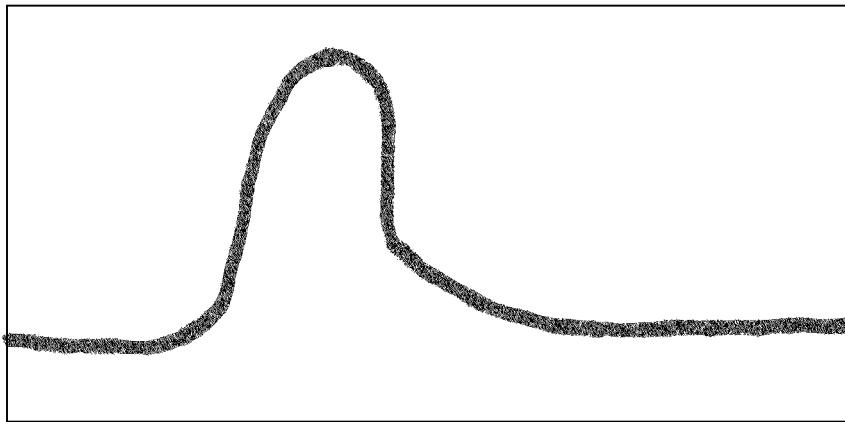
Examining the infant for liver size



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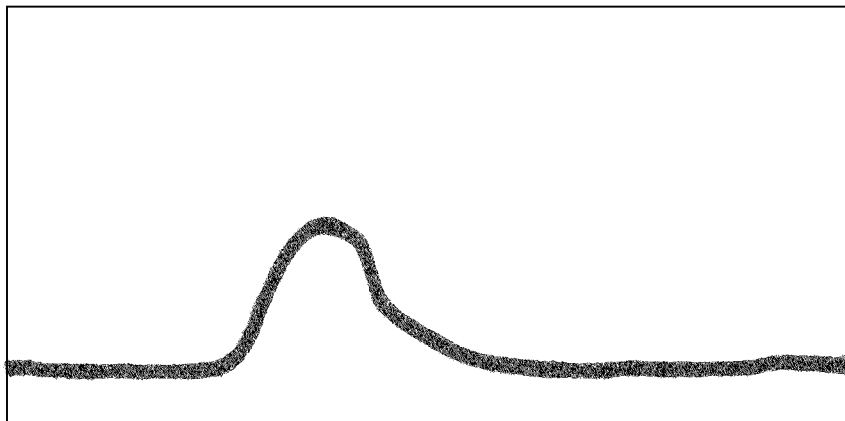
FIGURE THREE

- a. The wave form of a normal pulse, note the height and breadth of the form and the area under the curve



2+

- b. The wave form of a weak, “thready” pulse



1+

Note the decreased height, breadth and area under the curve as compared to the normal pulse

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TABLE ONE

Vital Signs to Measure in All Pediatric Patients

- Blood Pressure in mmHg
- Pulse Rate in beats/minute
- Respiratory Rate in breaths/minute
- Core Temperature - See chart below
- Oxygen Saturation in percent
- Capillary Refill in seconds
- Weight in Kilograms

TEMPERATURE CONVERSION CHART

(One degree centigrade (Celsius) = 1.8 degrees Fahrenheit)

<u>Centigrade</u>		<u>Fahrenheit</u>
34°	=	93.2°
35°	=	95.0°
36°	=	96.8°
37°	=	98.6°
38°	=	100.4°
39°	=	102.2°
40°	=	104.0°
41°	=	105.8°

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Table Two

Normal Vital Signs for a 6 month-old infant

- Blood Pressure - greater than 70 systolic
- Heart Rate 80-160
- Respiratory Rate 20-40
- Rectal Temperature 37.0° - 37.5° C or 98.6° - 99.7° F
- Oxygen Saturation equal to or greater than 96% (breathing room air)
- Capillary Refill two or less seconds
- Weight six to eight (6-8) kilograms or 13.2 - 17.6 pounds

Table Three

Assigning a numerical value to the quality* of the pulse

- 4+ Pulse - the pulse is visible to the eye without palpation
- 3+ Pulse - the pulse is bounding
- 2+ Pulse - the pulse is normal
- 1+ Pulse - the pulse is weak or thready
- 0+ Pulse - the pulse is not palpable

* Quality equals fullness and intensity - see figure one

Table Four

The Four "Hypos:

- Hypovolemia - Low fluid volume
- Hypoglycemia - Low blood sugar (< 60 mgm dL)
- Hypothermia - Low core temperature
- Hypoxemia - Low oxygen level in the blood

SUMMARY

The above case reflects the importance of prompt and thorough primary and secondary assessments which led to timely institution of oxygen and fluid replacement therapy to correct the hypoxemia and hypovolemic shock. One should always remember when confronted with hypovolemia, the potential of associated hypoxemia, hypoglycemia and hypothermia. They are termed by us the four "hypos" (see table four). When one "hypo" is present search for the other three. If present, correct, if not present, prevent.

This case study "Assessment of the Critically Ill Pediatric Patient: An Infant Who is Hypovolemic" has been jointly developed by Dr. Gary McCalla and the late Dr. John L. McDonald.

This case study was a work-in-progress for REACH's late Medical Director, John L. McDonald, MD, when he passed away in late 2000. REACH's current Medical Director, Gary McCalla, MD, uncovered the file in Dr. McDonald's office and took the initiative to complete the case study. Doctors McCalla and McDonald hope to stimulate enhancement of problem-solving techniques for physicians, nurses and medics when challenged by critically ill pediatric patients and offer valuable education to all medical professionals so they may continue to "do what is right for the patient."

We would welcome any questions or comments about this case study. We would also welcome any suggestions relevant to developing a case study from an interesting case involving your unit and REACH.

Let us hear from you. Should you desire to read previously published case studies and the opportunity to receive additional CEUs, visit our website at www.reachair.com. You can do so online.

Gary McCalla, MD
Medical Director
REACH Air Medical Services

CASE STUDY

POST TEST

ASSESSMENT OF THE CRITICALLY ILL PEDIATRIC PATIENT

QUESTIONS: choose **all** correct answers.

1. Normal systolic blood pressure in mmHg for an infant is:
 - A. Greater than 70
 - B. Greater than 90
 - C. Greater than 110
 - D. Less than 50

2. Normal pulse rate in an infant is:
 - A. Greater than 210,
 - B. 110 - 180
 - C. 80 - 160
 - D. 40 - 120

3. Normal respiratory rate in an infant is:
 - A. 20-40
 - B. Greater than 60
 - C. Less than 10
 - D. 16 – 20

4. Normal oxygen saturation in an infant breathing room air is:
 - A. 100%
 - B. less than 92%
 - C. less than 80%
 - D. Greater than 96%

5. Normal capillary refill in an infant is:
 - A. Two or less seconds
 - B. Four or less seconds
 - C. Six or less seconds
 - D. Eight or less seconds

6. The anterior fontanelle of an infant is typically closed by the age of:
 - A. Two months
 - B. Four months
 - C. Six months
 - D. Nine months

7. The proper initial quantity of crystalloid to be administered to a pediatric patient who is hypovolemic is:
 - A. 5 cc's per Kg
 - B. 10 cc's per Kg
 - C. 15 cc's per Kg
 - D. 20 cc's per Kg

8. A crystalloid which could be administered as a bolus to a hypovolemic child for purposes of rehydration is:
 - A. 5% dextrose in water
 - B. 10% dextrose in water
 - C. 5% dextrose and 1/4 normal saline
 - D. normal saline

9. Hypoglycemia is commonly present in an infant who is stressed because he or she has:
 - A. High glycogen reserves
 - B. Low glycogen reserves
 - C. Too much insulin produced by the pancreas
 - D. Too little insulin produced by the pancreas

10. The liver in an infant is normally palpable:
 - A. 1-2 cm below the right costal margin
 - B. Not palpable
 - C. 3-4 cm below the left costal margin
 - D. Only if the child is dehydrated

11. Normal blood sugar in mg/dL in an infant is:
 - A. Greater than 60
 - B. Greater than 80
 - C. Greater than 120
 - D. Less than 30

12. Normal pulse quality should be classified on the 0-4 scale as:
 - A. 0 (zero)
 - B. 1+
 - C. 2+
 - D. 3+

13. Signs of poor peripheral perfusion associated with hypovolemia include skin which is:
 - A. Flushed
 - B. Warm
 - C. Mottled
 - D. Pink

14. A central pulse is:
 - A. Radial
 - B. Posterior tibial
 - C. Femoral
 - D. Dorsalis pedis

15. A sign of altered neurologic function in an infant is:
 - A. Crying loudly
 - B. Non responsive to loud verbal stimulus
 - C. Prompt response to pain
 - D. Desire to be held by parents

16. One Kilogram equals:
 - A. 1.0 pound
 - B. 1.8 pounds
 - C. 2.2 pounds
 - D. 2.7 pounds

17. Hypothermia is:
- A. Low core temperature
 - B. Low blood sugar
 - C. High blood sugar
 - D. High core temperature
18. Hypoglycemia can result in:
- A. Neuronal death
 - B. Pancreatitis
 - C. Liver failure
 - D. Bronchospasm
19. Septicemia is:
- A. High core temperature
 - B. Presence of microorganisms in the blood
 - C. Presence of microorganisms in the cerebrospinal fluid
 - D. Presence of microorganisms in the urine
20. When septicemia is a potential diagnosis an infant should promptly be administered intravenously:
- A. Potassium supplementation
 - B. Anti-seizure therapy
 - C. Antibiotics
 - D. Sedation
21. An infant may be defined as:
- A. 24 hours to 27 days of age
 - B. 28 days to three months of age
 - C. 29 days to one year of age
 - D. One year to three years of age
22. A bulging fontanelle is a sign of:
- A. Dehydration
 - B. Low blood sugar
 - C. Increased intracranial pressure
 - D. Decreased intracranial pressure

23. When auscultating the chest wheezes are typically heard during:

- A. Inspiration
- B. Expiration
- C. Shock
- D. Septicemia

24. Hypo means:

- A. Too little
- B. Too much
- C. An infection
- D. Not nervous

25. Hypoxemia means:

- A. Low oxygen level in the blood
- B. Normal oxygen level in the blood
- C. High oxygen level in the blood
- D. No oxygen level in the blood

