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INTERPRETING PEDIATRIC LABORATORY DATA

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OBJECTIVES

After completing this chapter, the reader should be able to

- Define the various pediatric age group terminology
- Discuss general pediatric considerations as they relate to blood sampling
- Describe how pediatric reference ranges are determined
- Discuss the age-related physiologic differences that account for variations by age in the normal reference ranges for serum sodium, potassium, bicarbonate, calcium, phosphorus, and magnesium
- List common pediatric causes of abnormalities in the electrolytes and minerals listed above
- Explain why age-related differences in serum creatinine and kidney function tests occur
- Discuss the age-related differences that occur in serum albumin, liver enzyme tests, and bilirubin
- Describe what is meant by the physiologic anemia of infancy and explain how it occurs

The interpretation of laboratory data in the pediatric patient population can be complex. Compared to adults, the pediatric population is much more dynamic. Alterations in body composition, organ function, and physiologic activity accompany the normal processes of maturation and growth that occur from birth through adolescence. These alterations can result in different normal reference ranges in pediatric patients for various laboratory tests. Pediatric patients not only have different normal laboratory values compared to adults, but also normal laboratory values may differ in various pediatric age groups. It is important for the clinician to understand the reasons for these different, commonly accepted reference ranges and to use age-appropriate reference ranges when providing pharmaceutical care to pediatric patients.

The measurement of substances in neonates, infants, and young children is further complicated by the patient's smaller physical size and difficulty in obtaining blood and urine samples. The smaller blood volume in these patients requires blood samples to be smaller; thus, special microanalytical techniques must be used. Additionally, in the neonate, substances that normally occur in higher amounts in the blood—such as bilirubin, lipids, and hemoglobin—may interfere with certain assays. This chapter will briefly review pertinent general pediatric principles and focus on the different age-related factors that must be considered when interpreting commonly used laboratory data in pediatric patients.

GENERAL PEDIATRIC CONSIDERATIONS

Knowledge of pediatric age group terminology is important to better understand age-related physiological differences and other factors that may influence the interpretation of pediatric laboratory data. These terms are defined in **Table 21-1** and will be used throughout this chapter.^{1,2}

The interpretation of any patient's laboratory data must be viewed in light of the patient's clinical status. This includes the patient's symptoms, physical signs of disease, and physiologic parameters, such as respiratory rate, heart rate, and blood pressure. For example, an elevated PaCO₂ from an arterial blood gas may be clinically more significant in a patient who is extremely tachypneic (perhaps indicating impending respiratory failure) compared to a patient whose respiratory rate is mildly elevated. Thus, it is important to know the relative differences in physiologic norms that occur in the various pediatric age groups.

Normal respiratory rates are higher in neonates and young infants compared to children, adolescents, and adults. The average respiratory rate of a newborn is 60 breaths/min at one hour after birth, but 30–40 breaths/min at greater than six hours after birth. Mean respiratory rates of infants and young children <2 years of age (25–30 breaths/min) continue to be higher than in children 3–9 years of age (20–25 breaths/min) and adolescents (16–20 breaths/min).¹

Normal heart rates follow a similar pattern with higher heart rates in neonates and young infants, which then slowly decrease with increasing age through adolescence. For example, the mean heart rate of a newborn is 120–160 beats/min and that of a one-month-old infant is 145 beats/min, while the mean heart rate for a one-year-old is 120 beats/min and that of a 12-year-old is 85 beats/min.³

TABLE 21-1. Definition of Age Group Terminology^a

Gestational age (GA)	The time from conception until birth; more specifically, GA is defined as the number of weeks from the first day of the mother's LMP until the birth of the baby; GA at birth is assessed by the date of the LMP and by physical and neuromuscular examination (e.g., New Ballard Score)
Postnatal age (PNA)	Chronological age since birth
Postmenstrual age (PMA)	Postmenstrual age is calculated as gestational age plus postnatal age (PMA = GA + PNA)
Neonate	A full-term newborn 0–28 days PNA; some experts may also apply this terminology to a premature neonate who is >28 days PNA but whose PMA is ≤42–46 wk
Premature neonate	Neonate born at <37 wk GA
Full-term neonate	Neonate born at 37 wk 0 days to 41 wk 6 days (average ~40 wk) GA
Infant	1 mo (>28 days) to 12 mo of age
Child/children	1–12 yr of age
Adolescent	13–18 yr of age
Adult	>18 yr of age

LMP = last menstrual period.

^aThe term *postconceptional age* (PCA; age since conception) is no longer recommended for use in clinical pediatrics.² However, this term may be found in pediatric literature. Traditionally, PCA was defined as GA + PNA. Because the exact time of conception is not generally known (except in cases of assisted reproductive technology) and GA is calculated as above (according to the mother's LMP), PMA is considered a more accurate term to use. When PCA is used in the pediatric literature, it should be defined within the article where it is used.

Source: Reproduced, with permission, from reference 1.

In pediatric patients, normal blood pressure values vary according to age, gender, and percentile height of the patient.^{4,5} Blood pressures are lower in neonates and increase throughout infancy and childhood. For example, typical blood pressures for a full-term newborn would be in the range of 65–95 systolic and 30–60 diastolic. The normal blood pressure (blood pressure <90th percentile) for a one-year-old girl of average height (50th percentile height) would be <100/54, while that of a 15-year-old girl of average height would be <123/79. Blood pressures are slightly different for girls compared to boys and are higher in taller children. Appropriate references should be consulted to obtain normal blood pressure values when providing clinical care to pediatric patients.^{1,4,5}

In addition to age-related physiologic differences in respiratory rates, heart rates, and blood pressures, age-related changes in body composition (e.g., fluid compartments), cardiac output, organ perfusion, and organ function also exist. These age-related changes may result in different normal laboratory values for pediatric patients compared to adults. For example, age-related changes in fluid compartments affect normal laboratory values for serum electrolytes, as discussed in the Serum Electrolytes and Minerals section below. Being aware of the normal laboratory values for age is important for proper monitoring of efficacy and toxicity of pediatric drug therapy.

Pediatric Blood Sampling

The smaller physical size of pediatric patients makes it more difficult to obtain blood samples. In general, venipuncture techniques used in adults can be utilized in older children and adolescents. However, vacuum containers used for blood sampling may collapse the small veins of younger children and are not recommended in these patients.⁶ Capillary puncture (also called *microcapillary puncture* or *skin puncture*) is used in patients with small or inaccessible veins. Thus, it is the blood

sampling method of choice for premature neonates, neonates, and young infants. Because this method also helps preserve total blood volume, it may also be beneficial to use in infants and small children who require multiple blood tests.⁷

The physical sites that are used for capillary puncture include the heel, finger, great toe, and ear lobe.^{6,7} The preferred site in neonates is the medial or lateral portion of the plantar surface of the heel. The medial surface of the great toe may also be used. The central area of the foot is avoided because of the risk of damage to the calcaneus bone, tendons, nerves, and cartilage. Heel sticks (capillary puncture of the heel) are often used in neonates and younger infants, while fingersticks may be used in children and adults. The earlobe is never used for capillary puncture for neonates and infants but may be used as a “site of last resort” in older children and adults.⁷

Because capillary and venous blood are similar in composition, the capillary puncture method may be used to obtain samples for most chemistry and hematology tests.⁷ However, differences may occur between venous and capillary blood for certain substances such as glucose, calcium, potassium, and total protein. For example, glucose concentrations may be 10% higher when the sample is collected by capillary puncture compared to venipuncture.⁶ In addition, improper capillary puncture sample collection may result in hemolysis or introduction of interstitial fluid into the specimen. This may result in higher concentrations for potassium, magnesium, lactate dehydrogenase, and other substances. Therefore, using the proper procedure to collect blood by the capillary puncture method is essential. It is also important that the site of capillary puncture be warmed prior to sample collection, especially for blood gas determinations.⁶ Complications of capillary puncture include infection, hematoma, and bruising.

The size of the blood sample is an important issue to the pediatric clinician. Compared to adults, pediatric patients have