Pediatric Clinical Pathology

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KEYWORDS

• Neonatal clinical pathology • Pediatric hematology • Urinary system
• Hepatobiliary system

KEY POINTS

- Because of variations in enzymology and functional capacity of neonatal organ systems, care must be taken when interpreting any changes in clinical chemistry values when using standard adult reference ranges.
- Although published reference ranges are provided, based on the available research in current literature it is recommended that these ranges are used only as guidelines, owing to the lack of standardization of reference intervals among reference laboratories.
- This article is not intended to provide a fully comprehensive review of all hematologic and biochemical changes that occur from birth to 6 months of age, but to help provide a practical guideline for interpretation and useful diagnostic information in determining the state of health or cause of illness in a young dog or cat.

INTRODUCTION

Neonates possess a decreased functional capacity of many organ systems and variations in enzyme levels, which improve in accordance with appropriate growth. Because of these physiologic developmental changes, care must be taken when interpreting any changes in clinical chemistry values when using standard adult reference ranges.

This article is intended to provide pertinent and applicable information about normal biochemical values in puppies and kittens younger than 6 months. The article is not intended to be a comprehensive review of small animal biochemistry and physiology, but rather aims to help provide practical guidelines for interpretation of serum biochemical results in puppies and kittens younger than 6 months.

At present there are no published sets of normal hematologic reference ranges for mixed-breed puppies and kittens younger than 6 months. Reference-value sets for closed research colonies composed of a few selected breeds are available, which help provide insight into trends in normal hematologic and biochemical values for puppies and kittens.

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HEMATOPOIETIC SYSTEM

Normal physiologic changes reflected in the complete blood count results include a decline in hematocrit in the first several weeks of life. The hematocrit of the neonate may be high at birth, but declines dramatically by 3 days of age, and continues to decrease to adult normal range by 2 to 6 months of age.[1–4] The decreased production and shortened life span of the red blood cells (RBCs) can result in increased polychromasia, nucleated RBCs, Howell-Jolly bodies, and Heinz bodies (kittens only).[5,6] The neonate RBC exhibits macrocytosis, with mean corpuscular volume decreasing to that of adults by 4 weeks of age as fetal RBCs are replaced by adult RBCs.[7] Gradual progressive climb in hematologic parameters can be detected by 2 months of age, with adult reference ranges for RBC, hemoglobin, and hematocrit usually reached by 6 months. The guidelines for evaluating a regenerative response in adult animals is likely sufficient for puppies and kittens older than 4 months (**Tables 1** and **2**). A greater regenerative response should be observed in animals younger than 4 months.[2]

White blood cell (WBC) differential analysis for puppies and kittens younger than 6 months remains within the reference interval for adult animals. For puppies, the WBC count as well as neutrophil and lymphocyte counts are relatively high at birth, decline during the first month of life, increase by the second month, and then slowly decline. For kittens, WBC as well as neutrophil and lymphocyte counts at birth are well within the adult reference range, but increase to above the adult reference range for kittens at 3 to 4 months of age, then values return to within normal adult reference ranges by about 5 to 6 months of age.[1,2] This leukocytosis, usually comprising neutrophilia and lymphocytosis, may be a physiologic response resulting from excitement and immune stimulation (**Tables 1** and **3**).

Clinical Implications

Determining the cause of an anemia in a puppy or kitten is important, and may be vital in determining a diagnosis and subsequent treatment plan. Classifying the anemia into a pathophysiologic category of regenerative, iron-deficiency, or nonregenerative based on changes in the erythrogram may be useful. Elevated reticulocytes are the preferred method for evaluation of the regenerative response in puppies and kittens. Animals younger than 4 months should have a greater reticulocyte response than that considered to be regenerative in adult dogs and cats.[2] Once the anemia has been determined to be regenerative, the total plasma or serum protein concentration can be assessed to help determine if the cause of the anemia is hemolysis or hemorrhage. The total plasma protein concentration is usually low with hemorrhage. The common causes of blood-loss anemia in puppies and kittens include inherited or acquired coagulopathies, excessive hemorrhage after trauma or surgeries, and hematophagous parasitism. The hallmark of chronic blood loss and, ultimately, iron-deficiency anemia are microcytic hypochromic RBCs (low mean corpuscular volume and low mean corpuscular hemoglobin concentration).

By contrast, regenerative hemolytic anemias tend to demonstrate normal or increased serum (or plasma) total protein. Common causes of hemolytic anemias in puppies and kittens include immune-mediated hemolytic anemia, most often attributable to neonatal isoerythrolysis, oxidative injury, and Heinz body formation (ie, a variety of foods such as onions, garlic powder, certain drugs, and plant substances); microangiopathy (ie, feline infectious peritonitis); and hemoparasites (ie, hemotropic *Mycoplasma*, *Babesia*, cytauxzoonosis).

Nonregenerative anemias are uncommon in puppies and kittens, and are usually associated with underlying illnesses such as renal failure, endocrinopathies, and