Review of Serum Chemistry Interpretation in Neonatal Foals

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Interpretation of serum chemistry results in foals can be very confusing because reference ranges are usually based on adult samples, and many values are increased in foals compared with adults. Understanding the expected differences in serum chemistry results between foals and adult horses improves the recognition of abnormalities and facilitates making an accurate diagnosis. Author’s address: PO Box 1843, Georgetown, KY 40324; e-mail: bwaldridge@earthlink.net. © 2013 AAEP.

1. Introduction
Reference ranges for many serum chemistry values in adult horses cannot reliably diagnose disease in foals.1–4 Placental abnormalities may influence clinicopathologic results in neonates during the first few days of life.1 Most hepatic indices in foals are significantly different from adult horses, especially during the neonatal period. Ideally, age-specific reference ranges should be used in foals, but it is difficult to sample a large enough population of clinically normal foals and few laboratories are able to generate age-specific references. Whenever possible, the reference ranges in this report have been obtained from clinically healthy foals.

2. Hepatic Indices
Sorbitol dehydrogenase and aspartate transaminase are reliable indicators of hepatocellular disease in foals.2,5 Sorbitol dehydrogenase and aspartate transaminase have more narrow standard deviations in foals, and their normal reference ranges are closer to those of adults. Serum alkaline phosphatase (ALP) activity is highest during the first 2 to 8 weeks of life2,3,6,7 and remains elevated for 8 weeks7 to at least 90 days.6 There is a wide individual variation and large standard deviation of ALP activity in foals, which limits its effectiveness to diagnose hepatobiliary disease.2 Hank et al8 measured activity of specific ALP isoenzymes and determined that 80% to 92% of total ALP activity is from bone. However, Dumas and Spano9 reported that increased ALP activity in foals is mainly of hepatic origin. Although the contribution of the various ALP isoenzymes to total ALP activity remains unclear, most of the increased ALP activity in foals is attributed to increased osteoblastic activity and bone formation in young, growing animals.2,3,6,8
Gamma glutamyltransferase (GGT) activity in foals ranges from 1.5 to 3 times normal adult values for the first 3 to 4 weeks of life.2,10 Gamma glutamyltransferase activity in foals is most increased from adult horses at 7 to 21 days of age.5 Similar to ALP activity, there is a normal wide individual variation in GGT activity between foals, which restricts its
diagnostic use to identify hepatic disease.\textsuperscript{2} Although mare colostrum contains a low amount of GGT, postsuckle GGT activity in foals is not associated with serum immunoglobulin G concentration\textsuperscript{10} and cannot be used to determine colostrum intake.\textsuperscript{9} Hepatic GGT activity is increased in young animals and may account for some of the increased GGT activity in foals.\textsuperscript{2,10}

Neonatal hyperbilirubinemia is normal during the first 2 to 3 weeks of life.\textsuperscript{4–6} Bilirubin concentration is highest in young foals and reduces to normal adult horse ranges by 7 to 14 days of age.\textsuperscript{5,6} Both total and unconjugated bilirubin concentrations in foals are increased over adult values from birth through 7 to 14 days postpartum.\textsuperscript{6} Neonatal hyperbilirubinemia may be the result of immature hepatic function or hemolysis of fetal erythrocytes.\textsuperscript{3,4,6} The ability of the fetal liver to excrete bilirubin is minimal, and bilirubin must be excreted across the placenta by the fetus.\textsuperscript{6} Foals less than 5 days of age have less hepatic glucuronyl transferase activity than adults and therefore a slower rate of bilirubin uptake and conjugation.\textsuperscript{4} Increased direct bilirubin concentration in foals 2 days of age or less may be due to a lack of bilirubin transport proteins.\textsuperscript{3}

Serum bile acid concentration is highest at birth and gradually declines for at least 6 weeks postpartum.\textsuperscript{6} Serum bile acid concentration in foals may be elevated because of increased hepatic production, decreased excretion, differences in gastrointestinal flora, or enhanced intestinal absorption. Hepatic uptake of serum bile acid and excretion into bile require active transport, which may not be fully functional in foals.

Triglyceride concentration in foals tends to be highest during the first 2 weeks of life and moderately increased for up to 6 weeks of age.\textsuperscript{5,6} Triglyceride concentrations in foals may decrease as hepatic function matures and triglycerides are used to synthesize other lipoproteins.\textsuperscript{8} Triglycerides can be very elevated in foals that have recently nursed, as the result of digestion of fat in mare’s milk.

3. Renal Function

Increased creatinine concentration in newborn foals is usually caused by placental pathology and/or fetal stress rather than renal disease.\textsuperscript{1} Placental pathology appears to affect serum blood urea nitrogen (BUN) concentration less than creatinine, probably because urea is a smaller and more diffuse molecule.

Spurious hypercreatininemia in foals <2 days of age is defined by serum creatinine concentration >5 mg/dL, and creatinine concentration decreases by ≥50% in the first 24 hours of treatment and each day until it is within normal range by 72 hours.\textsuperscript{12} Serum creatinine concentration in foals with spurious hypercreatininemia normalizes regardless of fluid administration, including foals that are only nursing free-choice. Seventy-one percent of foals affected by spurious hypercreatininemia were also diagnosed with neonatal encephalopathy in one report.\textsuperscript{12} It is unknown if placental abnormalities predispose newborn foals to spurious hypercreatininemia.

Blood urea nitrogen concentration is near normal adult ranges at birth, declines during the first 48 hours of life, and remains low until 1 to 18 weeks of age.\textsuperscript{4,7,13} Very young foals may be azotemic, but renal indices and plasma osmolality should decrease as the foal nurses and fluid intake expands plasma volume and stimulates diuresis.\textsuperscript{13} Increased BUN concentration often occurs when foals are in a catabolic state and using endogenous protein as an energy source.\textsuperscript{1} Deamination of protein results in increased urea production and excretion. Low BUN concentration in growing foals may be the result of increased amino acid utilization for protein synthesis.\textsuperscript{3}

4. Electrolytes

At birth, both total and ionized calcium concentrations are 25% to 30% higher than in adult horses.\textsuperscript{1} Hours after birth, blood calcium concentration is approximately 20% lower than in adults and then gradually returns to normal limits in the first few days of life. Edwards et al\textsuperscript{12} reported that serum calcium concentration decreased significantly during the first 48 hours of age and returned to normal ranges by 7 days.

Inorganic phosphorus concentration is elevated from birth until at least 18 weeks of age.\textsuperscript{3} Schmitz et al\textsuperscript{4} found that serum inorganic phosphorus concentration was initially slightly higher than expected adult ranges and peaked between 2 to 3 weeks of age. Serum inorganic phosphorus concentration then gradually decreased but remained above normal adult ranges at 6 months of age. Hyperphosphatemia is apparently related to skeletal ossification and osteoblastic activity.\textsuperscript{4,13}

5. Conclusions

Interpretation of serum chemistry values in neonatal foals can be complicated when normal ranges from adult horses are used. Comparison of reference ranges from textbooks and between different laboratories and serum chemistry analyzers is not always reliable. Ideally, the normal expected ranges used in foals are stratified by age and are based on a large sample of healthy foals. However, this is often not possible, and knowing the inherent differences in serum chemistry values between foals and adult horses helps to determine if an abnormality is significant.

References


