Neonatal physiology in animals: A short discussion

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Abstract
The term “neonate” is derived from the Latin word natus (to be born) and refers to a newborn during the first weeks of life during the physiologic transition. Although strictly speaking it should encompass the entire period until the transition is complete for all organ systems, by convenience it is usually defined as the first 3 to 4 weeks of life in most domestic species. Since neonates are not miniature adults, their physiology is unpredictably different from adults and hence needs a detailed study to know it.

Keywords: Adaptation, neonatal, physiology, postnatal

Introduction
The mechanics of birth require a change in the newborn for extrauterine survival by attaining homeostasis with regards to respiratory gas exchange, along with circulatory and other related modifications. Such modifications depend on a complex change in major organ system, which although transition, usually takes place within the first 6-10 hours of life or may take many weeks for adaptation. The neonate possesses glycogen stores which are depleted shortly after birth and makes adequate nourishment from nursing vital. Fasting, even in the minimal sense can result in hypoglycemia apart from other causes like endotoxemia, septicemia, portosystemic shunts, and glycogen storage abnormalities. If the neonate is clinically fit and has an adequate swallowing and other related reflexes, then oral fluid and glucose replacement may be preferable, provided the animal is not clinically compromised. Just like in the humans, the caloric requirement of neonates of animals is also age (in days) depended, and though mother’s/dam’s milk is always superior, yet commercially manufactured milk replacement formulas are also available for them in case of necessity.

Gastrointestinal System
There is a rapid increase in development of the gastrointestinal tract (GIT) to about 80% in length and 30% in diameter in the first 10 days of life with maturation being incomplete until after weaning. It takes at least 24 hours for gastric acid secretion to occur in most of the species, but in the rat, this acid secretion occurs only after the first 18 days of birth (until weaning). Among numerous extracellular trophic signals, nutrients present in amniotic fluid, colostrum and fresh milk are mainly responsible for initial GIT development. Although nutrition is perhaps the most potent trophic stimulus of GIT growth, extracellular signals like hormones, mammary secretions, microbes, secretions from autocrine or paracrine mechanisms etc. from surrounding cells influences the cells of the fetal and neonatal GI tract and liver. The microbes which are present in the intestinal gut plays a critical role in development of mucosal immune function, while growth factors in colostrum augment the proliferation of the commensal enteric bacteria, and may also play a major function in initiating or augmenting immunity development of certain species of animals which are otherwise poorly expressed in the neonates. In some species certain immune functions that are initially absent in neonates are replaced by factors in colostrum, as in the equine, wherein neutrophils become mature killing cells only after exposure to substances present in the colostrum.

Fluid Physiology
During the last few days of gestation fetal blood pressure increases significantly (by 20% in fetal lambs) although fetal blood pressures are still much lower than adult blood pressure (Greenough and Milner, 2005) [3].
As the result of these fluid shifts drawing from the fetal fluids or maternal circulation and accumulating in the fetal interstitium all neonates are born fluid overloaded to one degree or another and thus have higher fluid requirements than adults (Maureen, M. M., 2009) [6]. Generally, dehydration in neonates may mainly occur when a normal intake of food is not balanced by a sufficient intake of water, or when diarrhoea and vomiting occurs leading to excessive losses of fluid and certain electrolytes. The whole body lymph flow rates are significantly greater in the neonatal period than later in life, and are higher from the lungs in some anesthetized newborn animals than their adults.

Renal system
Elimination of drugs by metabolic processes have prolonged half lives in the neonate animals (except in the horse) as they have little liver metabolic capacity. Though the neonate of horse is born naive, the foal rapidly develops drug metabolic capability over the first 1 to 3 days of its life such that it functions as an adult after 3 days of age (Short, 1984) [8], while other species typically requires 4 to 5 weeks to reach drug metabolic maturity.

Calves, foals and pigs have considerable excretory renal function at birth, while puppies and kittens require about 2 to 3 weeks to approach adult values due to immature glomeruli and nephrons (Zoetis and Hurtt, 2003a) [10]. In normal lambs, foals and calves nephrogenesis is complete by birth and GFR reaches adult levels in days. In the dog nephrogenesis continues for at least 2 weeks after birth (Evan et al., 1979; Grundy, S.A., 2006) [1, 5]. Neonates have decreased protein binding due to lower albumin levels, with a lower affinity for drugs and an increased permeability of the blood-brain barrier.

Nervous system
The neonates have immature central and peripheral nervous systems and immature neuromuscular junctions, such that less general/local anesthetic is required to produce anesthesia/local block than in adults.

Circulatory system
The cardiovascular system of the neonates undergoes dramatic alterations during the neonatal period as the fetomaternal circulation is lost and the neonatal heart assumes the role of maintaining the circulatory homeostasis. In the newborn lamb, cardiac output is four times greater than in the adult animal. Functional closure of the ductus arteriosus is thought to occur in almost half of neonates by 24 hours and in 90% by 48 hours. At the time of birth, there is a shift in the site of erythropoiesis (from yolk sac to liver, spleen and finally bone marrow), and the fetus alters its globin synthesis pattern by switching from making HbF (foetalHb) to HbA (adult Hb). In fact, HbF is a relatively recent evolutionary adaptation, found only in primates.

Respiratory system
In the intrauterine life, gas exchange is performed through the placenta by the umbilical cord, while in the extraterine life, the lungs are responsible for blood oxygenation. Kittens, calves, and humans have relatively few alveoli at birth whereas lamb lungs are quite well developed (Zoetis and Hurtt, 2003b) [11], while cardiopulmonary adaptations to extraterine life are one of the most important physiological changes that must occur for calf survival (Nagy, 2009) [7]. Inflation of the lungs occurs by the gasping reflexes in the newborn opens up the pulmonary vascular bed and pulmonary blood flow increases considerably which causes a change in the pressure relationship within the cardiovascular system, producing the functional closure of the foramen oval, ductus arteriosus and ductus venous (Grove-White, 2000) [4]. But until the first inflation occurs, the animal suffers a slight respiratory acidosis, which causes minor metabolic acidosis that is considered to be normal characteristic in recently delivered calves (Grove-White, 2000) [4]. The first breath is the most visible sign of the neonate’s health and it is known that cold stimulates breathing and a high cardiac output supplies the high metabolic demand of extra-uterine life. Stimulation of the genital or umbilical region induces reflex respiration in the neonatal puppy and may be clinically used to stimulate respiration in the immediate neonatal period (Grundy, S.A., 2006; Fox, M.W., 1964) [5, 2] which generally require adequate medical treatment which undergo pathological labour/dystocia (Vannucchi et al., 2012) [9].

References