Compendium

Feline Focus

Feline Pediatrics: How to Treat the Small and the Sick*

Susan Little, DVM, DABVP (Feline Practice)
Bytown Cat Hospital
Ottawa, Ontario, Canada

Most veterinarians have been presented with kittens that have failed to thrive. These patients are challenging due to their small size, their unfamiliar physiology, and the tendency for their status to deteriorate quickly. The most common general causes of illness and failure to thrive are maternal, gestational, environmental, genetic, and infectious factors.[1,2]

In much of the veterinary literature, the neonatal period is defined as the first 4 weeks of life. However, it is clinically useful to consider defined risk periods: the first 4 days of life (when many problems are related to labor and delivery or the environment); between 21 and 28 days of age (when important changes leading to neurologic and behavioral maturation take place); and weaning (4 to 6 weeks of age).[2]

Examination of Neonatal Kittens

There are many clinically relevant physiologic differences between neonatal kittens and adult cats[3] (**TABLE 1**), and very young kittens cannot be approached as small adults. Sick neonates should be examined as soon as possible, using a systematic approach that includes a complete history of the kitten, litter, and queen; examination of the kitten and queen; and diagnostic tests.[4,5] Kittens younger than 4 weeks should be examined with the queen present when possible (unless prohibited by the queen's temperament).

Start with a complete medical history for the kitten in question as well as for littermates. It may also be helpful to have a medical history for the queen, if available (e.g., illness, nutrition, vaccinations), and information about the labor and delivery, especially for kittens younger than 2 weeks. If it is not the queen's first litter, information should also be gathered on previous litters and any previous problems with labor and delivery. Investigate the kitten's home environment, noting temperature and humidity, sanitation, ventilation, population density, the presence of other pets and small children, and prevalence of infectious diseases and parasites.

Neonates should be handled gently, on a clean, warm surface. Wash your hands and wear gloves. Simple equipment will suffice for neonatal examinations: a gram scale, pediatric rectal thermometer, otoscope with infant cones, penlight, and stethoscope with an infant bell and diaphragm.

Before handling the kitten, observe its body condition and response to the environment, including alertness, posture, locomotion, and respiratory rate and character. Healthy neonates have a strong suckle reflex that is, by comparison, normally less strong than that of a healthy puppy. Normal body temperature for neonatal kittens is 97°F to 98°F (36°C to 37°C). The rectal temperature rises slowly, reaching 100°F (38°C) by about 4 weeks of age. For the first 2 weeks of life, kittens are essentially poikilothermic and lack a shiver reflex. They gradually become homeothermic after 14 days of age, but are still susceptible to environmental conditions and may become hypothermic easily.

Table 1. Physiologic Values for Neonatal Kittens

Parameter	Normal Values
Birth weight	90–110 g (0.09–0.11 kg)
Rectal temperature: newborn	97°F–98°F (36°C–37°C)
Rectal temperature: 1 mo	100°F (38°C)
Heart rate	220–260 bpm for the first 2 wk of life
Respiratory rate: newborn	10–18 breaths/min
Respiratory rate: 1 wk	15–35 breaths/min
Urine specific gravity	<1.020
Urine output	25 mL/kg/d
Water requirement	130–220 mL/kg/d
Caloric requirement	20 kcal ME/100 g/d
Stomach capacity	4–5 mL/100 g

ME = metabolizable energy.

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Table 2. Developmental Milestones for Kittens

Milestone	Age
Umbilical cord falls off	3 d
Eyelids open	7–10 d (range: 2–16 d)
Menace/pupillary light reflexes	28 d or later
Normal vision	30 d
Adult iris color	4–6 wk
Ear canals open	9 d (range: 6–17 d)
Functional hearing	4–6 wk
Crawling	7–14 d
Walking	14–21 d
Voluntary elimination	3 wk
Deciduous incisors/canines erupt	3–4 wk
Deciduous premolars erupt	5–6 wk

If the birth date is unknown, attempt to establish an estimated age for the kitten by using body weight and inspection of the dentition. The typical kitten birth weight is 90 to 110 g (range: 80 to 140 g), although there is considerable variation by and within breed.[6] Normal kittens gain 50 to 100 g/wk (10 to 15 g/d) and should double their birth weight before 2 weeks of age. Low birth weight is a common cause of mortality, with kittens weighing under 75 g at birth at highest risk. The first deciduous teeth to appear are the incisors and canines at 3 to 4 weeks of age. The premolars erupt at about 5 to 6 weeks of age. The dental formula for deciduous teeth is 2(I3/3, C1/1, P3/2) = 26; there are no deciduous molars. Developmental milestones may also be helpful in estimating age (**TABLE 2**), although delayed development may occur in kittens with low birth weight and poor weight gain. Examples include uncoordinated walking by 21 days and coordinated walking by 28 days.

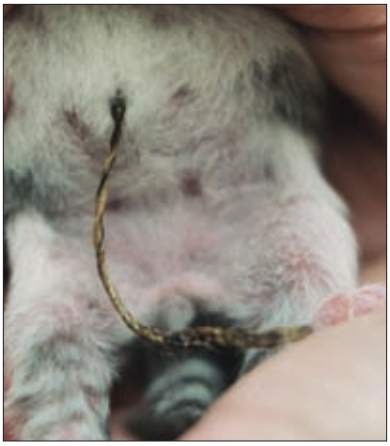

Figure 1. The normal umbilical cord is dry, with no redness, swelling, or discharge at the umbilicus, and falls off at about 3 to 4 days of age.

Inspect the neonate for gross anatomic abnormalities, such as cleft palate or lip, umbilical hernia or infection (**FIGURE 1**), open fontanelle, limb deformities (**FIGURE 2**), chest wall deformities, and nonpatent urogenital or rectal openings (**FIGURE 3**). Kittens younger than about 3 weeks cannot eliminate urine and feces voluntarily. Evaluate a kitten's micturition and defecation reflexes using a cotton ball moistened with mineral oil or warm water to stimulate the anogenital area. Diarrhea is present in about 60% of sick neonatal kittens and may cause significant fluid loss. Hematuria or pigmenturia may be signs of urinary tract infection, trauma, or neonatal isoerythrolysis (**FIGURE 4**). Neonatal isoerythrolysis may be a common problem in some breeds (e.g., British shorthair, Cornish rex, Devon rex) with a high percentage of individuals with blood type B. **BOX 1** lists selected common congenital defects in neonatal kittens that are apparent around the time of birth.

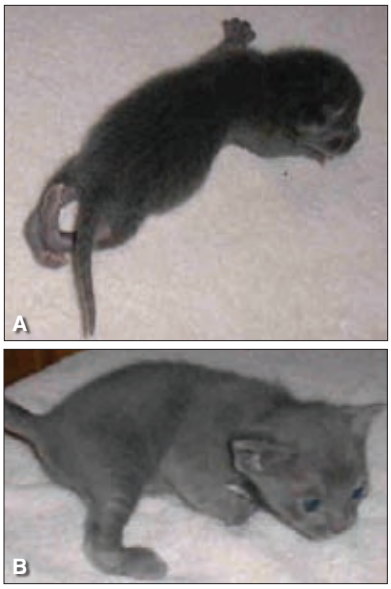

Figure 2. Tarsal hyperextension in a Korat kitten. (**A**) Tarsal hyperextension and metatarsal rotation in a newborn Korat kitten. (**B**) The same kitten at a few weeks of age. Correction of the tarsal hyperextension is already evident as the kitten learns to crawl. *Photos courtesy of Carine Risberg*

The eyes should be inspected for abnormalities of the globe or eyelids and for neonatal ophthalmia (before the eyes open) or conjunctivitis (after the eyes open). A menace reflex and pupillary light responses do not appear until 28 days of age or later. A divergent strabismus may be present and is normal until about 8 weeks of age unless hydrocephalus is present. Evaluation of the fundus is difficult until about 6 weeks of age.

The pinnae should be inspected for evidence of trauma, parasites such as ear mites, and skin disease. The ear canals are not easy to

Figure 3. This female kitten has an imperforate anus and an anovaginal fistula. *Photo courtesy Dr. Rosalyn MacDonald*

Figure 4. Pigmenturia is evident in urine on a cotton ball from a kitten with neonatal isoerythrolysis (*left*) compared with normal urine (*right*).

inspect with an otoscope until after 4 weeks of age. The neonate's haircoat should be clean and shiny. Healthy neonatal kittens may have somewhat hyperemic mucous membranes until 7 days of age (although hyperemia may also be a sign of dehydration), whereas sick neonates often have pale, gray, or cyanotic mucous membranes. Kittens with cyanotic mucous membranes have a poor prognosis.

The cardiovascular system undergoes dramatic changes as the heart takes over the functions previously performed by the fetomaternal circulation. One important physiologic difference between neonates and adults is the higher neonatal heart rate. The normal neonatal heart rate can be >200 bpm (range: 220 to 260 bpm). The normal respiratory rate is 15 to 35 breaths/min. Functional murmurs may be present in neonates due to anemia, hypoproteinemia, fever, or sepsis. Innocent murmurs not associated with disease are more common in puppies than kittens; murmurs present after 4 months of age should be investigated. Congenital heart disease may be associated with murmurs that are loud and accompanied by a precordial thrill. The most common congenital heart diseases in kittens are tricuspid valve dysplasia and ventricular septal defect.[7]

Box 1. Selected Common Congenital Defects in Neonatal Kittens

Eyes and Ears
- Glaucoma
- Colobomas
- Microphthalmia
- Corneal dermoids
- Congenital nystagmus

Neurologic
- Hydrocephalus
- Cerebellar hypoplasia
- Deafness

Skin and Musculature
- Hypotrichosis
- Umbilical hernia
- Gastroschisis/schistosoma (abdominal hernia)

Cardiac
- Patent ductus arteriosus
- Atrioventricular defects

Skeletal
- Radial hemimelia
- Polydactyly
- Syndactyly
- Flat chest kitten syndrome
- Pectus excavatum ("funnel chest")

Urogenital
- Renal aplasia/hypoplasia
- Ambiguous genitalia/pseudohermaphroditism

Endocrine
- Congenital hypothyroidism/dwarfism

Gastrointestinal
- Cleft palate
- Atresia ani/anogenital fistula

Box 2. Minimum Database for Sick Neonatal Kittens

- Packed cell volume and total solids: use microhematocrit tubes and refractometer
- Complete blood cell count: measure white blood cell count from one drop of whole blood placed directly into Unopette; obtain differential from blood smear
- Blood urea nitrogen: use whole blood on reagent strip
- Blood glucose: use one drop of whole blood in glucometer (note: results from these machines tend to be low)

Abdominal palpation can be performed with care; in the first few days of life, abdominal pressure during palpation may induce regurgitation of stomach contents and aspiration. A full abdomen is normal in a well-fed kitten, but an enlarged abdomen in an ill kitten may indicate aerophagia. The normal liver and spleen may not be palpable; the kidneys are frequently palpable. The stomach may be palpable if it is full. The intestinal tract is palpable as fluid-filled bowel loops that should be freely movable and nonpainful. The normal urinary bladder is also palpable, movable, and nonpainful.

Diagnostics

For venipuncture, position the kitten in dorsal recumbency with the forelegs drawn back toward the abdomen and the head and neck extended. Draw blood from the jugular vein using a 1-mL syringe with a 25- or 26-gauge needle. Slow aspiration of blood is essential to avoid collapsing the vein. A small volume (0.5 mL) of blood can be used for the most critical tests (**BOX 2**).

Blood chemistry and hematology values for neonates differ from those for adults (**TABLE 3** and **TABLE 4**); most values normalize to adult levels by 4 months of age.[8–10] Urine is collected for chemistry, sediment, and specific gravity analysis by stimulating the perineum; cystocentesis should be performed with great care in the very young because the bladder wall is easily damaged and because umbilical vasculature may still be patent and can be traumatized. Urine specific gravity is 1.020 or lower in the first few weeks of life; adult values are reached by about 8 weeks of age.[11] A fecal sample should be examined for common intestinal parasites such as *Giardia* and *Isospora* spp and roundworms using zinc sulfate centrifugation, a direct saline smear, and a *Giardia* fecal antigen test. Kittens as young as 2 weeks may be treated with pyrantel pamoate (5 to 10 mg/kg PO every 2 weeks).

Flea infestations should be treated aggressively, as they can cause life-threatening anemia. Young kittens can be bathed in pet-safe shampoo followed by thorough drying and combing of the haircoat. Water-based pyrethrin sprays labeled for use in kittens may also be used. Nitenpyram is labeled for use in kittens at least 4 weeks of age and weighing at least 2 lb (0.9 kg). Most other flea control products are labeled for use in kittens from 8 weeks of

Table 3. Normal Hematology Values for Kittens From Birth to 8 Weeks[a]

Differential	Age			
	2 Weeks	*4 Weeks*	*6 Weeks*	*8 Weeks*
PCV (%)	33.6–37.0	25.7–27.3	26.2–27.9	28.5–31.1
RBCs ($\times 10^6/\mu L$)	5.05–5.53	4.57–4.77	5.66–6.12	6.31–6.83
WBCs ($\times 10^6/\mu L$)	9.10–10.24	14.10–16.52	16.08–18.82	16.13–20.01
Neutrophils ($\times 10^6/\mu L$)	5.28–6.64	6.15–7.69	7.92–11.22	5.72–7.78
Lymphocytes ($\times 10^6/\mu L$)	3.21–4.25	5.97–7.15	5.64–7.18	8.02–11.16
Monocytes ($\times 10^6/\mu L$)	0.0–0.02	0.0–0.04	0	0.0–0.02
Eosinophils ($\times 10^6/\mu L$)	0.53–1.39	1.24–1.56	1.22–1.72	0.88–1.28

PCV = packed cell volume, *RBCs* = red blood cells, *WBCs* = white blood cells.

[a]Adapted from Moon P, Massat B, Pascoe P. Neonatal critical care. *Vet Clin North Am Small Anim Pract* 2001;31:343-367.

Table 4. Normal Serum Chemistry Values for Kittens From Birth to 8 Weeks[a]

Chemistry	Age				
	2 Days	*1 Week*	*2 Weeks*	*4 Weeks*	*8 Weeks*
Albumin (g/dL)	1.6–2.6	2.0–2.5	2.1–2.6	2.4–2.9	2.4–3.0
ALP (U/L)	275–2021	126–363	116–306	97–274	60–161
ALT (U/L)	12–84	11–76	10–21	14–55	12–56
Bilirubin (mg/dL)	0–0.7	0–0.6	0–0.2	0–0.3	0–0.1
Calcium (mg/dL)	8.6–12.7	10.0–13.7	9.9–13.0	10.0–12.2	9.8–11.7
Cholesterol (mg/dL)	80–175	119–213	137–223	173–253	124–221
Creatinine (mg/dL)	0.5–1.1	0.3–0.7	0.4–0.6	0.4–0.7	0.6–1.2
GGT (U/L)	0–5	0–5	0–4	0–1	0–2
Glucose (mg/dL)	75–154	105–145	107–158	117–152	94–143
Phosphorus (mg/dL)	4.1–10.5	6.7–11.0	7.2–11.1	6.7–9.0	7.6–11.7
Total protein (g/dL)	3.9–5.8	3.5–4.8	3.7–5.0	4.5–5.6	4.8–6.5
Urea (mg/dL)	24–71	16–36	11–30	10–22	16–33

ALP = alkaline phosphatase, *ALT* = alanine aminotransferase, *GGT* = γ-glutamyltransferase.

[a]Adapted from Levy J, Crawford P, Werner L. Effect of age on reference intervals of serum biochemical values in kittens. *J Am Vet Med Assoc* 2006;228:1033-1037.

age, although, anecdotally, selamectin has been used in kittens as young as 6 weeks of age. Ear mite (*Otodectes*) infestations are best treated with topical ivermectin. One product (Acarexx, Boehringer Ingelheim) has been demonstrated as safe in kittens as young as 4 weeks of age.

Testing for FeLV and FIV is an important part of both wellness care and investigation of illness (**TABLE 5**). Recommendations for FeLV and FIV testing in kittens have been recently published[12,13] and should be reviewed.

Necropsy is underutilized as a diagnostic tool for multicat environments such as shelters or catteries. Necropsy results may provide information necessary to save remaining littermates or a future litter. For the best results, the whole body should be submitted (refrigerated, not frozen) to a qualified pathologist. If necessary, freezing is preferable to autolysis.

Basic Therapeutics

Rapid identification of illness and prompt intervention are the keys to success when treating ill kittens. Often the exact cause of a kitten's illness is not apparent at the time of presentation, and therapy must be focused on supportive care. Initial therapy may include supplemental warmth, hydration, glucose administration, and nutritional support.[14,15] Awareness of physiologic differences between neonatal and adult cats is important, and information about these differences should be reviewed.[3]

Severe hypothermia occurs when the kitten's rectal temperature is <94°F (34.4°C) and is associated with depressed respiration, impaired function of the immune system, bradycardia, and ileus. Hypothermic kittens should be rewarmed slowly, over 2 to 3 hours or more, to a maximum rectal temperature that is age appropriate. Warming too rapidly may cause increased metabolic demand, resulting in dehydration, hypoxia, and loss of cardiovascular integrity. An incubator or oxygen cage is a good way to accomplish rewarming, but hot water bottles and heating lamps can also be used with very careful monitoring. For severely hypothermic kittens, fluids warmed to 95°F to 98°F (35°C to 37°C) may be administered via the intravenous (IV) or intraosseous (IO) route (depending on age). Never attempt to feed a hypothermic kitten, as aspiration pneumonia due to gastrointestinal hypomotility and regurgitation is a significant risk. Monitor closely for recurrence of hypothermia after rewarming.

Clinical hypoglycemia occurs when the blood glucose level is <3 mmol/L (50 mg/dL) and is a common problem for sick neonates due to kittens' immature liver function and rapid depletion of glycogen stores. Hypoglycemia may be caused by vomiting, diarrhea, sepsis, hypothermia, or inadequate nutritional intake. Kittens with

Table 5. Common Pathogens of Kittens

Clinical Problem	Common Pathogens
Upper and lower respiratory tract disease	Feline herpesvirus-1
	Feline calicivirus
	Bordetella bronchiseptica
	Mycoplasma spp
	Chlamydophila spp
Gastrointestinal tract	Panleukopenia (parvovirus)
	Coliform bacteria
	Tritrichomonas foetus
	Giardia spp
	Isospora spp
	Ancylostoma spp
	Toxocara spp
Systemic disease	FeLV
	FIV
	Feline infectious peritonitis
	Toxoplasma spp
	Gram-positive bacteria (e.g., *Streptococcus* spp, *Staphylococcus* spp)
	Gram-negative bacteria (e.g., *Escherichia coli, Salmonella* spp)

hypoglycemia will be weak and lethargic and may be anorectic. If the kitten is not hypothermic or dehydrated, periodically administer 5% to 10% dextrose orally by gastric tube at 0.25 to 0.50 mL/100 g body weight until the kitten is stronger and normoglycemic (**FIGURE 5**). Then begin feedings of kitten milk replacer if a lactating foster queen is not available. Critically ill neonates may require a bolus infusion of 12.5% dextrose IV or IO (0.1 to 0.2 mL/100 g or more), followed by a constant-rate infusion of 1.25% to 5% dextrose in a balanced electrolyte solution to prevent rebound hypoglycemia.[8,16] Hypertonic dextrose solutions should not be administered subcutaneously because tissue sloughing may occur.

Dehydration occurs easily in neonatal kittens with hypoxia, hypothermia, diarrhea, vomiting, or reduced fluid intake. Neonates have poor compensatory mechanisms and immature kidney function. Daily urine output in kittens 1 month of age is 25 mL/kg compared with 10 to 20 mL/kg in adult cats.[8] Neonates also have higher fluid requirements than adults for reasons such as higher total body water (about 80% of body weight, compared with 60% in adults), greater ratio of surface area to body weight, higher metabolic rate, and less body fat. Hydration status may be difficult

Figure 5. Weak, hypoglycemic kittens, or litters of orphan kittens, can be easily fed using a gastric tube. A size 5-French soft red rubber feeding tube is used for the smallest kittens.

to assess in the youngest patients. Skin turgor is not always a reliable test of hydration for kittens younger than 6 weeks because their skin contains less fat and more water than adult skin. The kitten's mucous membranes should be moist and either slightly hyperemic or pink. Pale mucous membranes and a decreased capillary refill time indicate at least 10% dehydration. Neonatal urine is normally colorless and clear; in dehydrated kittens, the urine may be darker with a specific gravity >1.020.

If the kitten is normothermic and not in shock or cardiovascular collapse, warmed subcutaneous (SC) fluids can be administered, although absorption is slow in young kittens. If there is no gastrointestinal dysfunction, warmed oral fluids may be given. These approaches are especially useful in the youngest and smallest patients (younger than 4 weeks). If the kitten is moderately to severely dehydrated and large enough to facilitate IV therapy, IV fluid administration is the most effective. A mini-set (60 drops/mL) is used with a fluid or syringe pump or a burette. The cephalic or jugular vein can be catheterized with a 24-gauge, ¾-inch or 22-gauge, 1-inch catheter. Lactated Ringer solution is ideal for rehydration because lactate can be used as an energy source and 1.25% to 5% dextrose can be added if necessary.

Warmed fluids may be given as a slow IV bolus of 1 mL/30 g body weight (30 to 45 mL/kg), followed by a maintenance infusion of 80 to 120 mL/kg/d (8 to 12 mL/100 g/d) plus any ongoing losses.[11,16] It is important to monitor fluid therapy closely; it is easy to overhydrate young kittens due to their immature renal tubular function. Hydration status can be monitored by several methods, but weighing the kitten every 6 to 8 hours on an accurate gram scale is useful and easily accomplished. Serial packed cell volume/total protein measurements may also be used. Electrolyte and glucose status should be monitored.

If it is difficult to achieve IV access, an alternative route for administration of fluids must be employed. The intraperitoneal route should be used cautiously in neonatal kittens due to the risk

Figure 6. Conjunctivitis due to feline herpesvirus is common in young kittens. Clinical signs include fever, sneezing, and bilateral nasal and ocular discharge.

of inducing peritonitis or damaging blood vessels. IO access using the trochanteric fossa of the proximal femur is the best alternative to IV access in larger kittens; blood, fluids, and medications can be administered in this way, particularly in kittens about 4 weeks of age and older.[11] Use a 20- to 22-gauge, 1-inch spinal needle or 18- to 25-gauge hypodermic needle as a catheter. Flow rates of up to 11 mL/min can be achieved by gravity. Use of cold fluids, too large a volume in a short time, or hypertonic or alkaline solutions will cause pain. IV access should be established as soon as possible. Complications of IO administration include infection, extravasation of fluids, and bone and soft tissue trauma. Practical considerations, such as tolerance of stress, may dictate the use of SC fluid administration, at least initially. Careful monitoring of fluid absorption is required when the SC route is used.

Blood transfusions may be necessary in some sick neonatal kittens, particularly those with anemia due to fleas or intestinal parasites. Indications for blood transfusions are weakness, tachycardia, pale mucous membranes, and a hematocrit <15%. Blood from a compatible typed donor is diluted 9:1 with a citrate anticoagulant and given using a millipore blood filter via the IV or IO route at a rate of 20 mL/kg over a minimum of 2 hours.[11]

Immunity

Kittens receive almost all their passive immunity during the first 18 hours of life (before gut closure) with the ingestion of colostrum; there is little or no transplacental transfer of immunoglobulins in cats.[17] The serum IgG nadir is reached at about 4 weeks of age due to catabolism of maternal IgG and correlates with a period of vulnerability to infection[18,19] (**FIGURE 6**). IgG levels then steadily increase as the kitten's own adaptive immunity develops.

Failure of passive transfer can occur in kittens that have not ingested colostrum during the first critical hours. Correction of failure of passive transfer can be accomplished by SC injection of serum from an adult cat with a compatible blood type that has been screened for infectious diseases. The only study in the literature used 15 mL/100 g body weight, divided into three doses over 24 hours.[18] The minimum amount necessary is unknown. Kittens with uncorrected failure of passive transfer start to produce IgG at about 4 weeks of age; they are therefore most vulnerable to infection from birth to at least 4 weeks of age.

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