Neonatal Resuscitation
Improving the Outcome

Autumn P. Davidson, DVM, MS

KEYWORDS

• Neonatal resuscitaion • Prenatal • Parturient • Postpartum

KEY POINTS

- Prudent veterinary intervention in the prenatal, parturient, and postpartum periods can increase neonatal survival by controlling or eliminating factors contributing to puppy morbidity and mortality.
- Postresuscitation or within the first 24 hours of a natural delivery, a complete physical examination should be performed by a veterinarian, technician, or knowledgeable breeder.
- Adequate ingestion of colostrum must occur promptly postpartum for puppies and kittens to acquire passive immunity.

The neonatal period can be defined as the first 2 weeks of postpartum life. Average reported neonatal mortality rates (greatest during the first week of life) vary, ranging from 9% to 26%. Prudent veterinary intervention in the prenatal, parturient, and postpartum periods can increase neonatal survival by controlling or eliminating factors contributing to puppy morbidity and mortality. Poor prepartum condition of the dam, dystocia, congenital malformations, genetic defects, injury, environmental exposure, malnutrition, parasitism, and infectious disease all contribute to neonatal morbidity and mortality. Optimal husbandry has an impact on neonatal survival favorably by managing labor and delivery to reduce stillbirths, controlling parasitism and reducing infectious disease, preventing injury and environmental exposure, and optimizing nutrition of the dam and neonates. Proper genetic screening for selection of breeders minimizes inherited congenital defects. The quality of labor (length, ease of the birth process, and quality of obstetric manipulation) has an impact on neonatal survival for up to 2 weeks postpartum. Proper neonatal resuscitation technique has a great impact on early neonatal survival. Neonatal resuscitation becomes necessary if the dam is anesthetized for a cesarean section, rejects the neonates or is ambivalent about immediate postpartum care, or is debilitated. Intervention for resuscitation of neonates after vaginal delivery should take place if a dam's actions fail to stimulate

Veterinary Medical Teaching Hospital Small Animal Clinic, Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, 1 Shields Avenue, Davis, CA 95616, USA; Pet Care Veterinary Hospital, East Campus, 2425 Mendocino Avenue, Santa Rosa, CA 95403, USA
E-mail address: apdavidson@ucdavis.edu

Vet Clin Small Anim 44 (2014) 191–204
http://dx.doi.org/10.1016/j.cvsm.2013.11.005 **vetsmall.theclinics.com**
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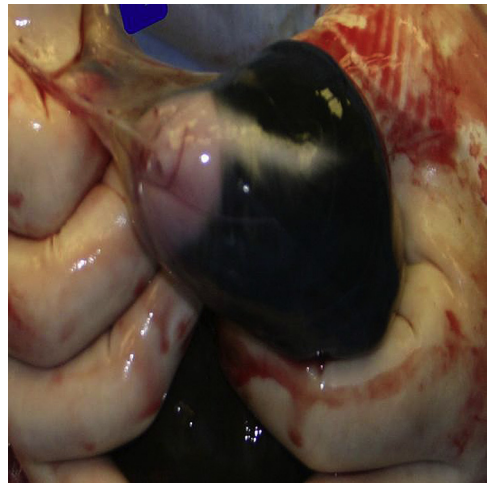

Fig. 1. Removal of fetal membranes from neonatal muzzle.

respiration, vocalization, and movement within 1 minute of birth. Increased veterinary participation in the resuscitation process can also be helpful if dystocia has contributed to poor postpartum condition of either the neonates or the dam.

Optimal neonatal resuscitation after birth (if the dam fails to do so) or cesarean section involves the same ABCs as any cardiopulmonary resuscitation. Spontaneous breathing and vocalization at birth are positively associated with survival through 7 days of age. Neonates delivered anesthetized via cesarean section often do not initiate respiration spontaneously. First, prompt clearing of airways (A = airway) by removing the fetal membranes from the face followed by gentle suction with a bulb syringe or aspirator should occur (Figs. 1–3). Removal of airway fluids is facilitated by lowering a neonate's head below the thorax (Fig. 4). Gentle but brisk drying and stimulation of the neonate with a small warm towel to promote respiration (B = breathing) and avoid chilling are performed (Fig. 5). Neonates should not be swung to clear airways as described in the veterinary and layman literature, because of the potential for cerebral hemorrhage from concussion. The use of doxapram as a respiratory stimulant is unlikely to improve hypoxemia associated with hypoventilation and is not recommended.

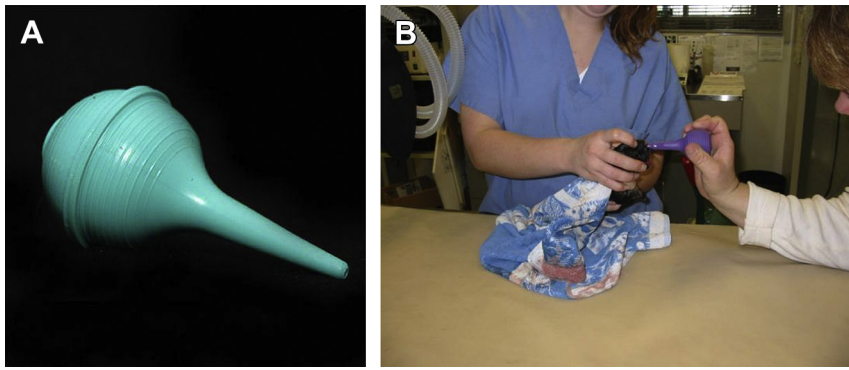

Fig. 2. (*A*) Preemie pediatric bulb syringe. (*B*) Removal of airway fluids using a bulb syringe.

Fig. 3. (*A*) DeLee aspirator for removal of airway fluid. (*B*) DeLee aspirator placed in neonate's upper airway. (*C*) DeLee aspirator trap filled with airway fluid.

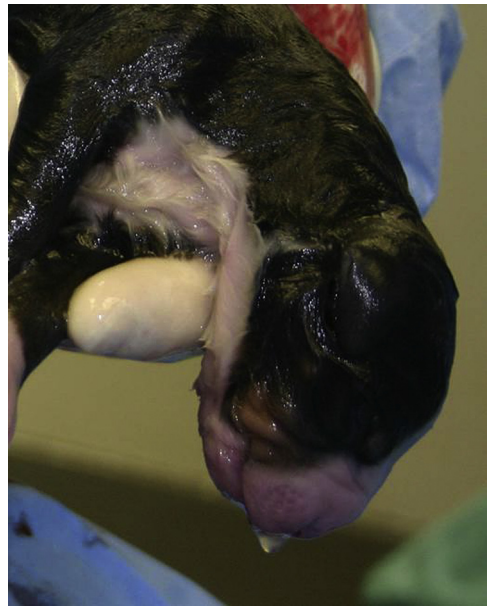

Fig. 4. Lowering the neonatal head facilitates fluid evacuation from the airways.

Cardiopulmonary resuscitation for neonates who fail to breathe spontaneously is challenging yet potentially rewarding. If clearing fetal membranes away from the muzzle and towel drying have not produced effective respiration, ventilatory support should include constant flow oxygen delivery by face mask. If this is ineffective after 1 minute, positive pressure with a snugly fitting mask should be started to effectively inflate the lungs (Fig. 6). Alternatively, positive pressure ventilation can be

Fig. 5. Brisk gently rubbing the thorax and muzzle stimulates respiration.

Fig. 6. Small, snugly fitting face mask permits oxygen flow by or positive pressure ventilation.

accomplished with a commercially available piglet resuscitator, which acts as an bag valve mask (**Fig. 7**). Endotracheal intubation and use of a rebreathing bag (using a 2-mm endotracheal tube or a 12- to 16-gauge intravenous catheter) is feasible but more technically difficult due to patient size and fragility and has more potential for trauma of the upper airway; 30 to 40 breaths per minute, with F_{IO_2} less than 40% to 60% and approximately 10 cm H_2O pressure, are advised. Effective ventilatory support causes the thorax to expand, indicating lung inflation. Excessive insufflation can cause aerophagia. Success at stimulating respiration with Jen Chung acupuncture point (GV 26) stimulation has been claimed when a small-gauge or acupuncture needle is inserted into the nasal philtrum at the base of the nares and rotated when cartilage/bone is contacted (**Fig. 8**). Drying the muzzle and Jen Chung likely stimulate respiratory neuroreceptors present in the muzzle and functional at birth.

Cardiac stimulation (C = circulation) should follow ventilatory support. Myocardial hypoxemia is the most common cause of bradycardia or asystole in the neonate.

Fig. 7. Piglet resuscitator and preemie pediatric bulb syringes.

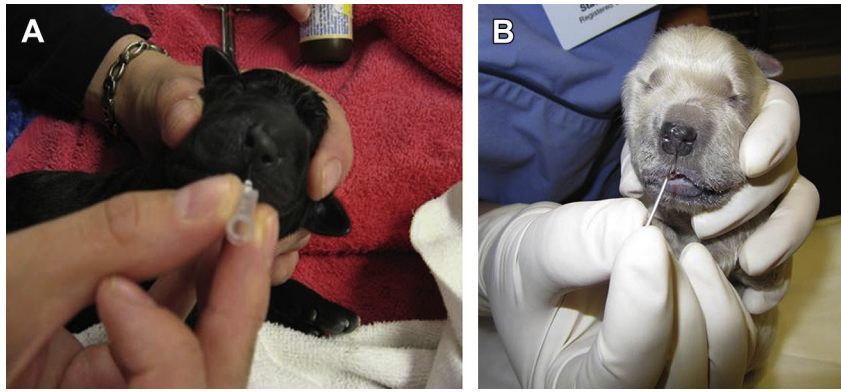

Fig. 8. Jen Chung acupressure point for stimulating respiration (*A*) Using a 25 G needle. (*B*) Using a 38 G acupuncture needle.

Improving oxygenation with positive pressure ventilation results in improved myocardial function; the neonatal heart rate improves. If bradycardia persists despite airway clearing and ventilation, direct transthoracic cardiac compressions are advised as the first step; epinephrine is the drug of choice for cardiac arrest/standstill (10–200 μg/kg or 0.01–0.20 μg/g) administered best by the intravenous or intraosseous route). Intratracheal dosage is not likely effective in the neonate and intracardiac puncture is traumatic. Epinephrine should be freshly diluted for neonatal resuscitation to permit accurate dosing. Venous access in the neonate is challenging; the single umbilical vein is one possibility if not already thrombosed; otherwise, a cephalic or the jugular vein can be accessed and eventually catheterized if intravenous fluids or therapy is desired (**Fig. 9**). The proximal humerus, proximal femur, and proximomedial tibia offer better, intraosseous sites for drug administration (**Fig. 10**). Circulation must be present for drug distribution; cardiac massage should continue after administration until a heartbeat is detectable. Atropine is currently not advised in neonatal resuscitation. The mechanism of bradycardia is hypoxemia-induced myocardial depression rather than vagal mediation, and anticholinergic-induced tachycardia can actually exacerbate myocardial oxygen deficits.

Fig. 9. Cephalic catheterization.

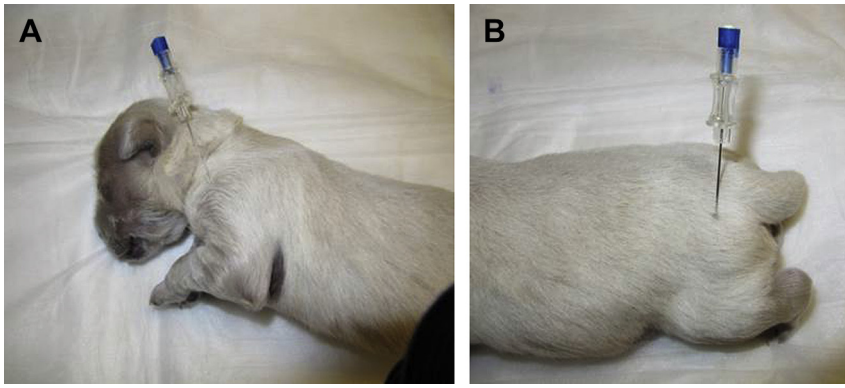

Fig. 10. Proximal (*A*) humeral and (*B*) femoral sites for intraosseous access.

BEYOND THE ABCS

When neonates fail to respond to routine resuscitation tactics, contributory factors should be considered. Chilled neonates can fail to respond to resuscitation. Loss of body temperature occurs rapidly when a neonate is damp. Keeping neonates warm is important during resuscitation and in the immediate postpartum period. During resuscitation, placing a chilled neonate's body into a warm water bath (95°F–99°F) can improve core temperature (Fig. 11). Thoracic compressions and oxygenation by face mask can continue while a neonate is in the water bath. Working under a heat lamp or a Bair hugger warming device is helpful in managing chilling during resuscitation. Postresuscitation, neonates should be placed in a warm box (a Styrofoam picnic box with ventilation holes is ideal) with warm bedding until they can be safely left with their dam (Fig. 12).

Hypoglycemia also results in a poor response to resuscitation. Neonates lack glucose reserves and have minimal capacity for gluconeogenesis. Providing energy during prolonged resuscitation efforts becomes critical. Clinical hypoglycemia involves blood glucose levels less than 30 to 40 mg/dL and can be treated with dextrose solution, given either intravenously/intraosseously, at a dose of 0.5 to

Fig. 11. Warm water bath during resuscitation.

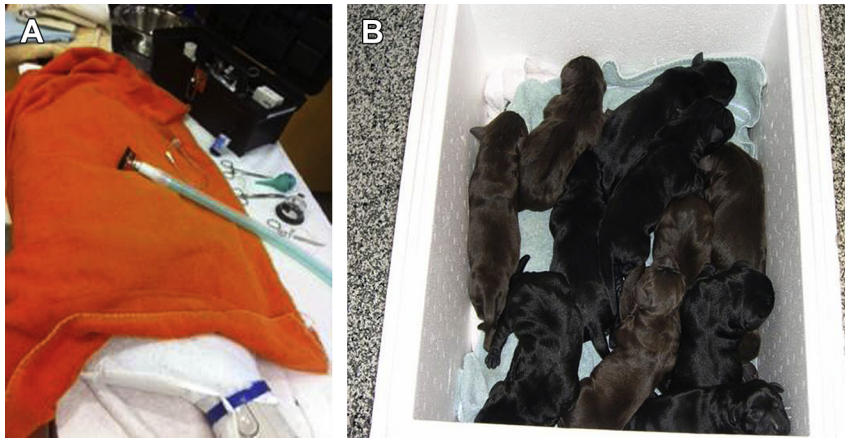

Fig. 12. (*A*) Bair hugger supplies a warm surface for resuscitation. Resuscitation equipment is tableside. (*B*) Simple but effective postresuscitation housing in a Styrofoam box with heat support.

1.0 g/kg body weight (0.0005–0.001 g/gram body weight) using a 5% to 10% dextrose solution, or at a dose of 2 to 4 mL/kg body weight (0.002–0.004 mL/gram body weight) of a 10% dextrose solution. Venous access is challenging in tiny neonates. Subcutaneous administration is undesirable due to the potential for abscessation at the site. A single administration of parenteral glucose is adequate if a puppy then nurses or can be fed; 50% dextrose solution should only be applied to the mucous membranes because of the potential for phlebitis if administered intravenously; however, circulation must be adequate for absorption from the mucosa or gastrointestinal tract, and there is a risk of aspiration. Neonates administered multiple doses of dextrose should be monitored for hyperglycemia because of immature metabolic regulatory mechanisms. If a neonate is too weak to nurse or suckle, a mixture of a warmed, balanced half-strength saline with 2.5% dextrose (so as not to be hypertonic) may be administered by stomach tube at a dose of 0.1 to 0.5 mL per 30 g of body weight, until the puppy can be fed or nurses. A balanced warmed dextrose-electrolyte solution can be administered orally by stomach tube every 15 to 30 minutes until the neonate is capable of suckling. Alternatively, acquiring colostrum from the dam is superior for this purpose.

WHEN TO STOP RESUSCITATION

1. No response after 15 to 20 minutes of effort (continued agonal respiration or bradycardia)
2. Serious congenital defect detected (cleft palate, loud murmur, gastroschisis, large omphalocele, large fontanel, anasarca, or anogenital defect) (**Figs. 13–15**)

UMBILICAL CORD MANAGEMENT

Umbilical cord care should take place after the neonate is resuscitated (is vocal, moving, and pink). The umbilicus of neonates should be treated with 2% tincture of iodine immediately after birth to reduce contamination and prevent ascent of bacteria into the peritoneal cavity (omphalitis-peritonitis). Alcohol-based tincture of iodine is superior to betadyne, which is water based and does not promote umbilical desiccation as

Fig. 13. Complete soft and hard palate cleft.

quickly. After cutting the cord with clean scissors approximately 0.5 to 1.0 cm from the abdominal wall, or trimming it if the dam removed the placenta and nipped the cord, the cord should be ligated with suture and dunked thoroughly in 2% iodine (Fig. 16).

HUSBANDRY: THE FIRST DAYS

Postresuscitation or within the first 24 hours of a natural delivery, a complete physical examination should be performed by a veterinarian, technician, or knowledgeable breeder. Neonates should be individually identified if similar in appearance to facilitate record keeping using clipping (small patch on right or left shoulder, right or left hip, tail base, or top of head) or dot of nail polish. The use of small collars is less desirable due

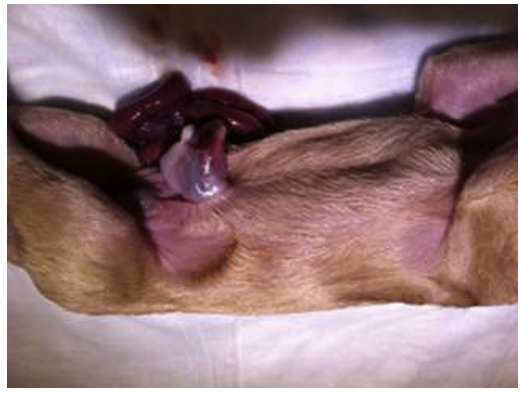

Fig. 14. Omphalocele.

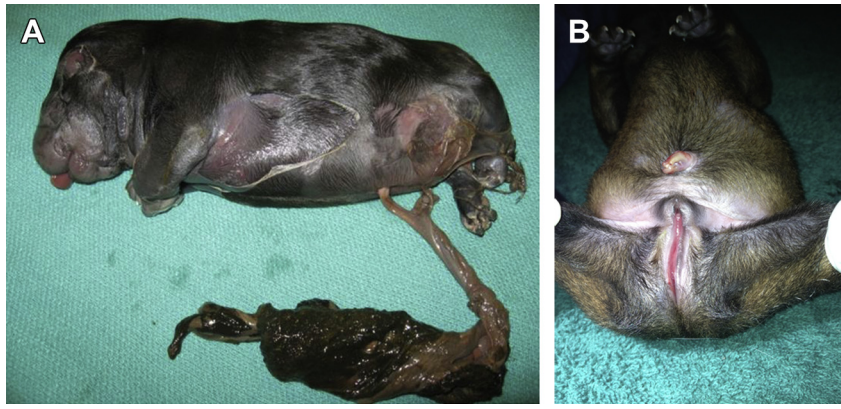

Fig. 15. (*A*) Anasarca. (*B*) Anogenital defect.

to the potential for entrapment of limbs and choking. The oral cavity, hair coat, limbs, umbilicus, and urogenital structures should be visually inspected. The mucous membranes should be pink and moist, a suckle reflex present, the coat full and clean, and the urethra and anus patent. A normal umbilicus is dry without surrounding erythema (**Fig. 17**). An umbilical hernia is of concern if large enough to entrap bowel. Omental entrapment outside of a closed umbilical site should not be misinterpreted as a body wall defect. No urine should be evident at the umbilicus (patent urachus). The thorax should be ausculted; vesicular breath sounds and a lack of murmur are normal. The abdomen should be pliant and not painful. A normal neonate squirms and vocalizes when examined and nurses and sleeps quietly when returned to the dam and litter. Normal neonates attempt to right themselves and orient by rooting toward their dam using the olfactory and tactile senses. Neonates are highly susceptible to environmental stress, infection, and malnutrition. Proper husbandry is critical and should include daily examination of each neonate for vigor and recording of weight. Lack of weight gain or actual weight loss is the first signs in a neonate failing to thrive. Post-resuscitation, each neonate should be weighed and recorded for the owner to follow-up with daily (**Fig. 18**).

Fig. 16. Dunking the entire umbilical cord in 2% tincture of iodine.

Fig. 17. Normal appearance of ligated umbilicus.

WARMTH

Neonates lack thermoregulatory mechanisms until 4 weeks of age; thus, the ambient temperature must be high enough to facilitate maintenance of a body temperature of at least 97°F (36°C) (Table 1). Hypothermia has a negative impact on immunity, nursing, and digestion. Exogenous heat should be supplied, best in the form of an overhead heat lamp. Heating pads run the risk of burning neonates incapable of moving away from excessively hot surfaces.

Postresuscitation, chilled older neonates must be rewarmed slowly (30 minutes) to avoid peripheral vasodilation and dehydration. Tube feeding should be delayed until the neonate is euthermic; hypothermia induces ileus and regurgitation and aspiration can result.

IMMUNITY

Incompletely developed immune systems during the first 10 days of life make neonates vulnerable to systemic infection (most commonly bacterial and viral). Adequate ingestion of colostrum must occur promptly postpartum for puppies and kittens to acquire passive immunity. The intestinal absorption of IgG generally ceases by

Fig. 18. Gram scale for neonatal weighing.

Table 1
Normal body temperatures and environmental warmth required for neonates

Neonatal normal body temperature (rectal)	
Week 1	95°F–99°F
Week 2–3	97°F–100°F
At weaning	99°F–101°F
Environmental warmth required	
Week 1	84°F–89°F
Week 2/3	80°F
Week 4	69°F–75°F
Week 5	69°F

24 hours after parturition. Colostrum-deprived kittens given adult cat serum at a dose of 150 mL/kg (0.15 mL/g) subcutaneously or intraperitoneally developed serum IgG levels comparable with suckling littermates; however, colostrum-deprived puppies given 40 mL/kg adult dog serum orally and parentally failed to match suckling littermates' IgG levels. Puppies likely require as much as 0.10 mL/g). The dose should be divided over several administrations. Colostrum or serum replacement can be given orally during the first 24 hours of life; thereafter, it must be given parenterally and intestinal absorption of macromolecules is compromised. The subcutaneous route is preferred to intraperitoneal administration. Neonates should be encouraged to suckle promptly after resuscitation is completed; this usually necessitates close monitoring after a cesarean section because the dam is still groggy from anesthesia (**Fig. 19**). Maternal instincts (protecting, retrieving, grooming, and nursing) usually return within 24 hours postanesthesia. The use of appropriate analgesics (narcotics) hastens good maternal behavior.

Neonatal bacterial septicemia can cause rapid deterioration, resulting in death if not recognized and treated promptly. Factors that reportedly predispose a puppy to septicemia include endometritis in the bitch, a prolonged delivery/dystocia, feeding of replacement formulas, the use of ampicillin, stress, low birth weight (<350 g for a medium-sized breed), and chilling with body temperature less than 96°. The organisms most frequently associated with septicemia are *Escherichia coli*, *Streptococci*,

Fig. 19. Supervised nursing during postanesthesia recovery provides valuable glucose, calories, and immunoglobulins to neonates.

Staphylococci, and *Klebsiella* spp. Premortem diagnosis can be challenging; clinical signs may not be noted due to sudden death. Commonly, a decrease in weight gain, failure to suckle, hematuria, persistent diarrhea, unusual vocalization, abdominal distension and pain, and sloughing of the extremities indicate septicemia may be present. Prompt therapy with broad-spectrum, bactericidal antibiotics, and improved nutrition via supported nursing, tube feeding or bottle-feeding, maintenance of body temperature, and appropriate fluid replacement are indicated. The third-generation cephalosporin antibiotic ceftiofur sodium (Naxcel, Pharmacia & Upjohn, Kalamazoo, Michigan) is an appropriate choice for neonatal septicemia because it alters normal intestinal flora minimally and is usually effective against the causative organisms. Ceftiofur sodium should be administered at a dose of 2.5 mg/kg (0.0025 mg/g) subcutaneously every 12 hours for no longer than 5 days. Because puppies less than 48 hours old have reduced thrombin levels, presumptive therapy with vitamin K_1 may be used (0.01–1.0 mg subcutaneously per puppy) (**Box 1**, **Fig. 20**).

GROCERIES

Neonates have minimal body fat reserves and limited metabolic capacity to generate glucose from precursors. Glycogen stores are depleted shortly after birth, making

Box 1
Contents of neonatal resuscitation kit

Neonatal Resuscitation Kit

- Tuberculin syringe (TB), acupuncture needles, very small gauge needles $\leq$25 G
- Epinephrine freshly diluted 1:9, 50% dextrose freshly diluted to 5%
- Oxygen sources
- Suction (pediatric bulb syringes)
- DeLee aspirators
- Small face masks
- Towels (small)
- Heat source (Bair hugger, warm water blanket, infrared lamp)
- Puppy box (Styrofoam) with heat support
- Multiple clean mosquito forceps and small scissors
- 3-0 Gut suture for umbilical cords needle removed, cut in 5″ lengths
- Tincture of iodine 2%
- Bowls for warm water baths
- Pediatric/neonatal stethoscope
- Doppler
- Neonatal scale

Neonatal Resuscitation Drugs

- Dilute epinephrine
- Dilute dextrose
- Ceftiofur reconstitute, dilute and freeze for improved shelf life
- Vitamin K_1

Fig. 20. Dedicated neonatal resuscitation kit.

adequate nourishment from nursing vital. Even minimal fasting can result in hypoglycemia. Hypoglycemia can also result from endotoxemia, septicemia, portosystemic shunts, and glycogen storage abnormalities. Oral fluid and glucose replacement may be preferable if a puppy has an adequate swallowing reflex and is not clinically compromised. The neonatal caloric requirement is 133 cal/kg/d during the first week of life, 155 cal/kg/d for the second, 175 to 198 cal/kg/d for the third, and 220 cal/kg/d for the fourth. Commercially manufactured milk replacement formulas (Esbilac and KMR, PetAg, Hampshire, Illinois; Eukanuba Puppy Milk Replacer Formula, Iams, Dayton, Ohio; and Veta-Lac, Lloyd, Shenandoah, Iowa) are usually superior to homemade versions. The use of milk obtained from the dam can be considered if available. An osmotic diarrhea (usually yellow, curdled stool appearance) can result from overfeeding formula, necessitating diluting the product 50% with water or a balanced crystalloid, such as lactated Ringer solution. Neonates should gain weight steadily from the first day after birth (a transient mild loss from birth weight is acceptable on day 1); puppies should gain 1 to 3 g per day per pound (2.2 kg) of anticipated adult weight and kittens 50 to 100 g weekly. Minimal weight gain of 10%/d should occur. Neonatal weights should be recorded daily for the first 2 weeks, then every 3 days until a month of age. Healthy, well-nourished neonates are quiet and sleep when not nursing.

FURTHER READINGS

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