Average reported neonatal mortality rates (greatest during the first week of life) vary, ranging from 9%–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 impacts 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 neonatal period can be divided into the prepartum (prenatal) period, parturition, and the postpartum neonatal period; we will focus on the latter here.

Immediate Postpartum Resuscitation
Optimal neonatal resuscitation following birth (if the dam fails to do so) or caesarean section involves the same “A-B-Cs” as any cardiopulmonary resuscitation. First, prompt clearing of airways (“A”) by gentle suction with a bulb syringe, drying and stimulation of the neonate to promote respiration (“B”), and avoidance of chilling are performed. Neonates should not be swung to clear airways as described in the veterinary 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. Spontaneous breathing and vocalization at birth are positively associated with survival through seven days of age. Intervention for resuscitation of neonates following vaginal delivery should take place if the dam’s actions fail to stimulate respiration, vocalization, and movement within one minute of birth.

Cardiopulmonary resuscitation for neonates who fail to breathe spontaneously is challenging, yet potentially rewarding. Ventilatory support should include constant flow O2 delivery by facemask. If this is ineffective after one minute, positive pressure with a snugly fitting mask or endotracheal intubation and rebreathing bag (using a 2-mm endotracheal tube or a 12 to 16-gauge intravenous catheter) is advised. Anecdotal success with Jen Chung acupuncture point stimulation has been claimed when a 25-gauge needle is inserted into the nasal philtrum at the base of the nares and rotated when bone is contacted. Cardiac stimulation (“C”) should follow ventilation support, as myocardial hypoxemia is the most common cause of bradycardia or asystole. Direct transthoracic cardiac compressions are advised as the first step; epinephrine is the drug of choice for cardiac arrest/standstill (0.2 mg/kg administered best by the intravenous or intraosseous route). Venous access in the neonate is challenging, the single umbilical vein is one possibility. The proximal humerus, proximal femur, and proximomedial tibia offer intraosseous sites for drug administration. 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.

Beyond the ABCs
Chilled neonates can fail to respond to resuscitation. Loss of body temperature occurs rapidly when a neonate is damp. Keeping the neonate warm is important during resuscitation and in the immediate postpartum period. During resuscitation, placing the chilled neonate’s trunk into a warm water bath (95°F–99°F) can improve response. Working under a heat lamp or within a Bair hugger warming device is helpful. Post resuscitation, neonates should be placed in a warm box (a styrofoam picnic box with ventilation holes is ideal) with warm bedding until they can be left with their dam.

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 intravenously/intraosseously, at a dose of 0.5 to 1.0 g/kg using a 5%–10% solution; or a dose of 2 to 4 ml/kg of a 10% dextrose solution. Single administration of parenteral glucose is adequate if the puppy can then be fed or nurses. Fifty percent 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. Neonates administered 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 crystalloid (lactated ringer’s solution or normosol solution and 5% dextrose may be administered...
subcutaneously at a dose of 1 ml per 30 g of body weight, until the pup can be fed or nurses. A balanced warmed nutrient-electrolyte solution can be administered orally by stomach tube every 15–30 minutes until the neonate is capable of suckling.

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

**Husbandry: the First Days**
Post-resuscitation or within the first 24 hours of a natural delivery, a complete physical examination should be performed by a veterinarian, technician, or knowledgeable breeder. The oral cavity, haircoat, 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, the urethra and anus patent. A normal umbilicus is dry without surrounding erythema. 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 will squirm and vocalize when examined, nurse and sleep quietly when returned to the dam. Normal neonates will attempt to right themselves and orient by rooting toward their dam. 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.

**Warmth**
Puppies lack thermoregulatory mechanisms until four weeks of age, thus the ambient temperature must be high enough to facilitate maintenance of a body temperature of at least 97 degrees Fahrenheit (36°C). Hypothermia negatively impacts 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.

<table>
<thead>
<tr>
<th>Neonatal Normal Body Temperature (rectal)</th>
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<tbody>
<tr>
<td>Week 1: 95̊–99̊F</td>
</tr>
<tr>
<td>Week 2–3: 97̊–100̊F</td>
</tr>
<tr>
<td>At weaning: 99̊–101̊F</td>
</tr>
</tbody>
</table>

**Environmental Warmth Required**

|  
|-----------------------------------------|
| Week 1: 84̊–89̊F |  
| Weeks 2/3: 80̊F |  
| Week 4: 69̊–75̊F |  
| Week 5: 69̊F |  

Chilled neonates must be re-warmed 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 to acquire passive immunity. The intestinal absorption of IgG generally ceases by 24 hours after parturition. Colostrum deprived kittens given adult cat serum at a dose of 150 ml/kg sc or ip 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 littermate’s IgG levels. Neonates should be encouraged to suckle promptly after resuscitation is completed; this usually necessitates close monitoring after a caesarean section as the dam is still
s – an adults. This results in a
anesthetic to produce anesthesia/local block than adult nerves.
nervous systems and immature neuromuscular
mean that inhaled agents will have a more rapid onset and recovery.
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Anesthesia of the neonate may be necessitated by an emergency or for an elective procedure.
Neonatal Anesthesia
Increase of 5
Normal Neon
–
– 10 % body weight per day

Neonatal Anesthesia
Anesthesia of the neonate may be necessitated by an emergency or for an elective procedure. The distribution and
metabolism of drugs are different in the neonate than in the adult. Neonates have decreased protein binding and
increased permeability of the blood brain barrier. Decreased protein binding is due to lower albumin levels with a
lower affinity for drugs. Neonates have higher body water content and lower fat content than adults. This results in a
greater initial volume of distribution for some drugs. In most neonatal animals there is a decreased ability to
metabolize drugs, via conjugation, hydrolysis, oxidation, and reduction. Renal clearance mechanisms are reduced in
the neonate. Nephrogenesis in puppies is not complete until the third week of life and the outer cortical nephrons are
the last ones to become fully functional. The ability of the neonatal kidney to produce a concentrated urine is less
than that of the adult and so fluid balance is more labile in neonates. The differences in neonatal respiratory function
mean that inhaled agents will have a more rapid onset and recovery. Neonates have immature central and peripheral
nervous systems and immature neuromuscular junctions, such that neonatal nerves require less general/local
anesthetic to produce anesthesia/local block than adult nerves.
Fluid support is indicated with neonates, but it is possible to overload a neonate with fluids just because of the capacity of the fluid lines used for larger patients. For this reason, it is wise to use tubing with a much smaller internal diameter to avoid this problem. Care must also be taken to ensure that the lines do not contain any air because these patients are very small and may still have communication between the left and right atrium making it possible for IV air to produce coronary or cerebral emboli.

Core body temperature should be monitored and hypothermia treated as soon as possible. A supplemental source of heat should be available (circulating water blanket or warm air blanket) in order to prevent hypothermia since many of the anesthetic drugs eliminate the ability of the patient to thermoregulate and neonatal animals are more prone to hypothermia than adults. Premedication with an anticholinergic is acceptable and usually sufficient by itself. Most neonates tolerate a simple mask induction with an inhalant such as isoflurane or sevoflurane. Propofol can be used as an induction drug in young animals. Maintenance by mask avoids the potential for trauma during entubation in tiny neonates, but less control of the airway is achieved.

During neonatal anesthesia, it is especially important to support and monitor cardiopulmonary function. Cardiac output in these patients is dependent on heart rate; preventing bradycardia is more important than in an adult. It is important to monitor blood pressure and support cardiovascular function. If hypotension is detected or it is judged that tissue perfusion is inadequate, treatment should be instituted. Initial therapy should include a reduction in the amount of anesthetic, if possible, and an increase in the rate of fluid administration. If these treatments are ineffective it is probably better to use a positive inotrope/chronotrope than a peripheral vasoconstrictor to try to increase blood pressure (unless it is very low and a vasoconstrictor is needed to raise the pressure long enough to allow other therapies to work). Dopamine has been shown to increase blood pressure in puppies <10 days old at 5-10 µg/kg/min but has very little effect on heart rate or cardiac output. Dobutamine appears to have little effect at clinical

**Neonatal Resuscitation Kit**
- Syringes (tb), acupuncture needles
- Epinephrine freshly diluted 1:9, 50% Dextrose freshly diluted to 5%
- Oxygen sources
- Suction (pediatric bulb syringes)
- Small face masks
- Towels (smallish and lots of them)
- Heat source (Baer, warm water blanket, infrared lamp)
- Puppy box (Styrofoam) with heat support or incubator
- Multiple clean mosquito forceps & small scissors
- 3–0 Gut Suture for umbilical cords needle removed, cut in 5” lengths
- Tincture of iodine
- Bowls for warm water baths
- Pediatric/neonatal stethoscope
- Doppler
- Neonatal scale

**Neonatal Resuscitation Drugs**
- Dilute epinephrine
- Dilute dextrose
- Cefitiofur
- Vitamin K1