

Resuscitation of canine and feline neonates

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Abstract

Fetal depression following dystocia and Cesarean section has two primary causes; the first (and often most important) cause is hypoxia, and the second is depression from anesthetic agents given to the dam. Resuscitation efforts should be provided in the following order: warmth, airway, breathing, circulation, and drugs. Adequate time should be allowed for correction of hypoxia using ventilatory and circulatory support before drugs are used, with the exception of drugs given to reverse anesthetic and analgesic agents that were given to the dam prior to delivery of the neonates.

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1. Introduction

When canine and feline neonates are born, they are typically lively and able to function without assistance. However, when puppies and kittens are stressed during dystocia or Cesarean section, they may require some assistance upon delivery.

Fetal depression following dystocia and Cesarean section has two primary causes, the first and often most important cause is hypoxia. The second cause is depression from anesthetic agents administered to the dam. Both can be minimized with proper anesthetic management; however, even under optimal conditions, depressed neonates will be born. Puppies and kittens have profoundly different responses to hypoxia than adult animals: Heart rate, respiratory rate and movement slow, presumably as a protective response to low

pO_2 . This compensatory response allows the neonate to survive a hypoxic state slightly longer than an adult.

The neonatal resuscitation strategy centers on keeping them warm and assisting them with oxygen delivery to hypoxic tissues, using methods that support ventilation and circulation. Often, medications are given too soon in the resuscitation process, not allowing enough time for adequate ventilation and tissue oxygenation to increase heart rate and vigor. The neonatal resuscitation strategy is described in detail below, and summarized in an accompanying flowchart (Fig. 1).

2. Supplies

The following should be readily available: a warming device (an incubator set to 90 °F (32.2 °C) and 50–60% humidity, Bair hugger™, hair dryer or warm water bottles in a container covered by towels); warm dry towels; soft hand-sized towels; bulb syringes; hemostats (to clamp umbilical cords); 25 gauge needles; 1 cm³ syringes; oxygen source; miniature mask; naloxone; epinephrine; doxapram; 12–16 gauge IV

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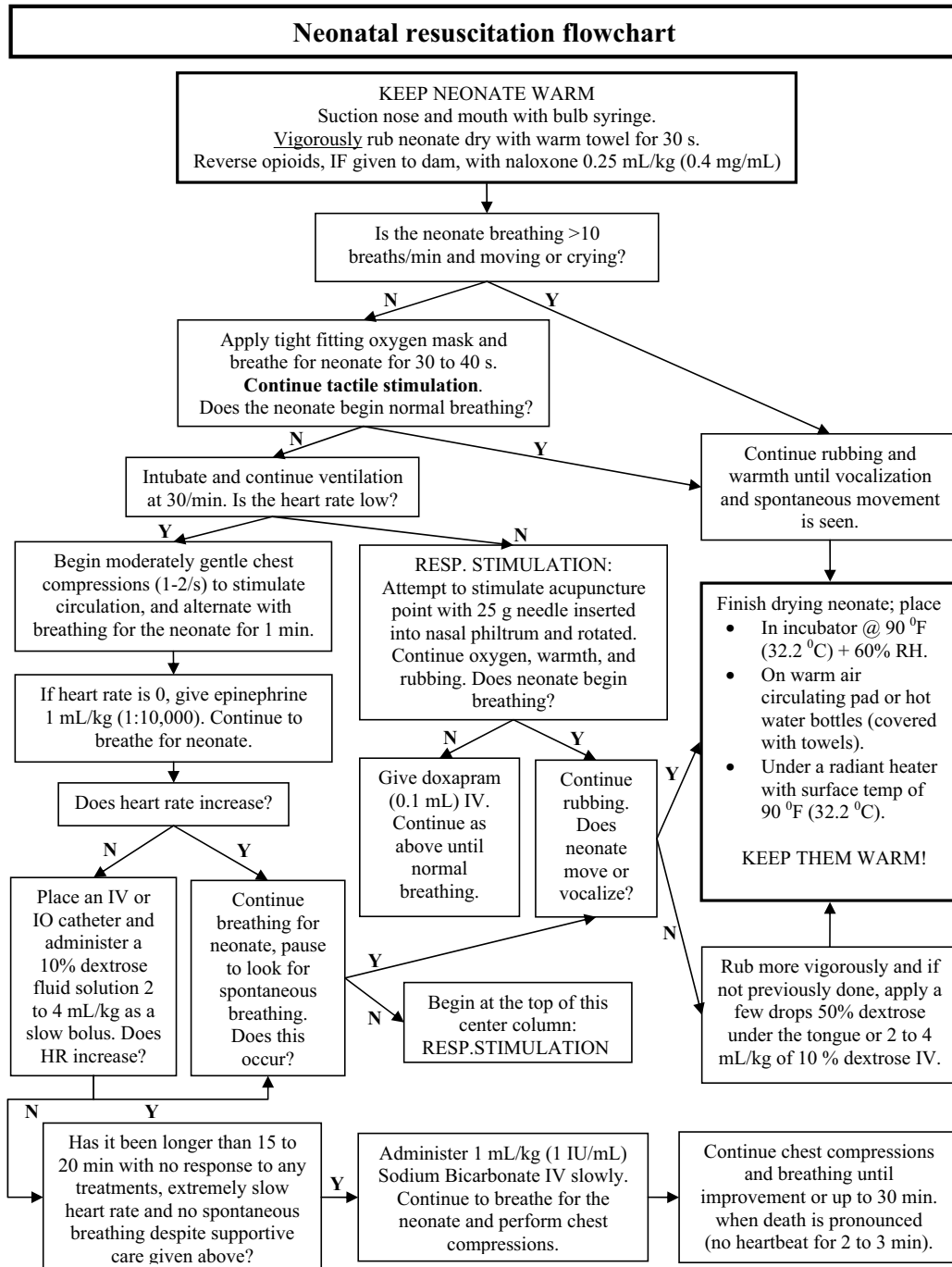


Fig. 1. Flowchart summarizing resuscitation strategy of canine and feline neonates.

catheters (to serve as endotracheal tubes in very small puppies and kittens); size 1 and 2 endotracheal tubes; 25 gauge IV catheters, and 22 gauge needles; infant stethoscope or Doppler ultrasound blood pressure monitor (to assess heart rate); isotonic fluids; 50% dextrose; and chlorhexidine solution.

One of the most important supplies in the attempt to resuscitate any litter of puppies or kitten is adequate personnel. For Cesarean sections, especially when the neonates are known to be bradycardic and stressed, it is ideal to have one skilled person available to resuscitate *each* expected puppy or kitten.

3. Prevention of hypothermia

Prevention of hypothermia must be the first consideration in neonatal resuscitation. Warmth is extremely important in these tiny patients, as they are quickly cooled and they are unable to regulate their own body temperature. Shivering and vasoconstrictive reflexes are not yet developed. The first step in prevention is keeping the dam warm during surgery, especially cats and small dogs that rapidly lose body heat under anesthesia. As soon as the neonate is delivered, it should be promptly towel dried. In addition to getting the puppy dried, the rubbing has the added effect of stimulating the neonate to begin breathing.

Hypothermia can decrease response to attempts at resuscitation, as it leads to bradycardia, tissue hypoxia, and metabolic acidosis. Normal body temperature of newborn puppies and kittens ranges from 95 to 99 °F (35.0–37.2 °C). They should be dried quickly and kept in an environment of approximately 90 °F (32.2 °C). Many systems exist for keeping neonates warm including a human infant incubator set to 90 °F (32.2 °C) and 50–60% humidity; used units can often be purchased from human hospitals. Other methods include circulating hot air heaters typically used for anesthesia, hair dryers (warm setting), or warm water bottles changed frequently, covered by towels, and then placed in a container to keep puppies in contact with the bottle.

4. Airway

Immediately following delivery and removal of the fetal membranes, the healthy puppy or kitten normally spontaneously clears its own airway by crying. If the neonate requires assistance, the nose and mouth should be quickly cleared of membranes and fluids with a towel. The puppy or kitten should then be vigorously rubbed to dry it and to stimulate breathing, paying special attention to the genital and umbilical regions as a tactile respiratory reflex occurs in these regions for the first 3 d of life [1]. In addition, in the mildly depressed neonate, vigorous tactile stimulation of the lumbar area by rubbing the fur backwards will help to elicit crying and further clear the airways.

If the neonate does not immediately breathe on its own, the airway can be cleared with gentle suction using a bulb syringe to the nostrils and mouth. Stronger methods of suction are not recommended, due to injury to the airways and vagally mediated bradycardia and laryngospasm [2]. Vagal cholinergic innervation to the respiratory system is present and fully functional at

birth, in contrast to sympathetic innervation which has been demonstrated to be incomplete.

“Swinging”, a common historical practice, is no longer recommended for many reasons including the risk of dropping the puppies which may result in injury to the puppy, risk of cerebral hemorrhage from centrifugal forces, and risk of aspiration of stomach contents.

Depressed neonates with obvious meconium staining around the mouth and nares may benefit from suctioning deeper into the airways with a tomcat catheter attached to a 10–20 cm³ syringe (to remove any meconium that may have been aspirated). This is controversial and may carry some risk of damage to the airway.

5. Breathing

Initial respiratory rate of newborn puppies and kittens is 10–18 breaths/min [3]. Furthermore, they lack the typical pause between breaths that is normal in adult animals.

Ventilatory support is critical for the stressed neonate and high concentration oxygen is typically used. Because of the short-term nature of the oxygen therapy, the risk of oxygen toxicity is minimal. If it is necessary for the neonate be on longer-term therapy, inspired oxygen should not exceed 40–60%, as acute respiratory distress syndrome or retrolental fibroplasias [4] could occur. However, studies in human infants failed to demonstrate an improvement in survival when oxygen was used for resuscitation versus room air. In fact, room air was preferable to oxygen therapy in some studies [5].

If the neonate does not immediately take a breath upon delivery, an attempt to expand the lungs should be made. A tight fitting mask can be applied to the face of the neonate and 20–30 cm of water pressure, starting at low pressure and increasing if necessary, applied for approximately 3 s (until the chest wall expands). The head should be extended in order to limit the amount of air forced into the stomach. If the mask does not adequately seal, an endotracheal tube should be placed. Because of the very small size of some of these patients, size 1 and 2 standard uncuffed tubes may not be small enough. In these cases, 12–16 gauge IV catheters can be used in place of endotracheal tubes. However, uncuffed endotracheal tubes may be suboptimal for forced ventilation because of leakage of air around the tube. After a tube is placed, repeat the expansion attempts incrementally up to 30–60 cm of water [6]. Once the lungs have been expanded, continue to breathe for the

puppy at a rate of approximately 30 breaths/min, lasting approximately 1 s each, with no more than 10 cm of water pressure, pausing occasionally to assess the neonate's ability to breathe spontaneously. Once this happens, the tube should be removed and tactile stimulation of the neonate's lumbar, umbilical, and genital area continued until the puppy appears alert.

The use of the Renzhong (JenChung, GV26) acupressure point has been discussed to stimulate spontaneous breathing in these patients [7] and in the author's experience has some effect, although no clinical trials have been performed in puppies or kittens. A 25-gauge needle is inserted into the nasal philtrum at the base of the nostrils and rotated when bone is contacted.

If the above techniques are unsuccessful in stimulating respiration, doxapram may be administered, as discussed below. Continuing tactile stimulation and providing warmth during this process is critical.

6. Circulation

The decreased heart rate in stressed puppies and kittens is likely due to myocardial hypoxia and not vagally mediated [3]. Therefore, the most important treatment for neonatal bradycardia is to increase respiration and attempt to correct the myocardial hypoxia. In most cases, ventilatory efforts discussed above will be sufficient to restore normal oxygen saturation to the myocardium and increase heart rate.

Following respiratory resuscitation, in puppies with persistently low heart rates, lateral chest compressions with the thumb and forefinger should be begun at a rate of 1–2 beats/s, pausing for respiration. In very barrel-chested breeds (i.e. bulldogs), sternal compressions may be more effective.

For the neonate in cardiac arrest, once ventilation has been well established, epinephrine may be given to stimulate the heart, as described below.

7. Drugs

7.1. Route of administration

Intravenous (IV) access can be achieved using either a jugular vein or the umbilical vein. Most other veins are very difficult to access in these small patients and all vessels are fragile. The umbilical vein, a thin-walled single structure in the umbilical cord, can be easily injected using a 25-gauge needle. The umbilical arteries are paired, with thicker walls, and harder to access due to vasoconstriction, but they can also be used [6]. Due to

the absence of blood flow in the umbilical vein, drugs with very small volumes should be diluted to ensure that they enter the systemic circulation [6].

Placement of an indwelling catheter into the umbilical vein is not recommended; if the catheter is threaded too far, (e.g. more than 2 cm) a hepatic vessel may be cannulated. In many cases, intraosseous (IO) catheters are easier to place and maintain than IV catheters in these patients if prolonged access is needed. The IO administration of medications and fluids results in similar blood concentrations as IV administration. The author typically places IO catheters in the proximal femur, but other potential sites include the proximal humerus and proximal tibia. Alternatively, a sublingual route of administration may be used and may be appropriate for drugs such as dopram and naloxone, if an IV or IO route is difficult to obtain.

If an endotracheal tube is in place, the endotracheal route of administration may be employed with lipid-soluble drugs (naloxone, lidocaine, and epinephrine) but this method may be inappropriate in some situations due to very small tube diameter, delayed onset of action, poor absorption, or irritation of tracheal tissues. Endotracheal administration of naloxone is not recommended in human neonatal resuscitation [8] and the dose of epinephrine may need to be increased and the solution diluted to increase the contact area [6].

Administration of medication by any route in the absence of circulation does not lead to adequate blood levels at the intended target. Chest compressions should be performed or continued if necessary to ensure that the drug (i.e. epinephrine) reaches the intended tissues.

7.2. Epinephrine

In cases where respiratory support and chest compression fail to elicit a heart beat, epinephrine may be administered (0.1–0.3 mg/kg may be given IV or IO). It is important that respiratory support and chest compression be attempted prior to drug administration, in order to limit myocardial hypoxia and damage during resuscitation.

7.3. Doxapram

The use of this drug in veterinary medicine is controversial. The drug is not mentioned at all in the most recent human infant resuscitation guidelines [8]. The method of action is unclear, but it is thought to be a central stimulant. Its effects in lambs were greatly decreased with brain hypoxia. At a dose of 0.1 mL IV, it is most likely to be beneficial to increase respiratory

efforts in a neonate with a low-frequency, gasping, erratic pattern following oxygen therapy. Doxapram has also been reported to be effective IM or sublingually, but this author believes that the IV route gives the best effect.

7.4. Naloxone

If opioids have been given to the dam prior to parturition, naloxone can be given to the neonates after birth (0.1 mg/kg IV; SQ and IM routes are also acceptable, but IV administration is preferred [6]). There is no clinical indication for naloxone administration in the absence of opioid administration to the dam prior to parturition or Cesarean section. In fact, administration may decrease function of endogenous opioids and is not recommended at all in human infants unless they show signs of respiratory depression [8].

7.5. Sodium bicarbonate

Sodium bicarbonate is discouraged during brief neonatal resuscitation. In cases in which adequate ventilation is established, but there is no response to other therapies and a prolonged resuscitation effort is unsuccessful, sodium bicarbonate may be useful. If more than 15 min of resuscitation has failed to return spontaneous respiration and adequate circulation, some cases have anecdotally responded to the administration of 0.5–1.0 mL/kg (8.4%) IV in the umbilical vein, diluted 1:2 with sterile water or normal saline. Continue ventilation during and after administration, since bicarbonate is metabolized to carbon dioxide and must be cleared via the lungs.

7.6. Atropine

Before 14 d of age in puppies, there is little effect, and before 11 d in kittens, there is no effect of atropine on heart rate [3]. In addition, because the low heart rate is most often due to myocardial hypoxia, myocardial damage could occur due to increased oxygen demand, especially if the neonate has not been properly ventilated. Therefore, for neonates with bradycardia, atropine is neither effective nor recommended.

7.7. Dextrose and fluids

Many practitioners routinely give dextrose during the resuscitation process. It may be helpful after a prolonged process, especially if the neonate is breathing well, but not alert. Typically, 10% dextrose is given IV or IO at a

dose of 2–4 mL/kg as a slow bolus. This dose is also helpful in volume resuscitation. It is noteworthy that the neonate can neither concentrate nor dilute its urine, and is therefore easily volume overloaded. In addition, glomerular filtration rate may be decreased in cold neonates, so it is important to be careful of the total IV and IO volumes given during the resuscitation process. Maintenance fluid rates for canine neonates range from 60 to 180 mL/(kg day) [3]. In addition, if volume resuscitation is not necessary, a solution of 50% dextrose may be given via orogastric tube or if the neonate is alert, orally.

7.8. Antibiotics

Sepsis in the stressed neonate has been demonstrated to occur in puppies due to hypoxia-induced bacterial translocation, even in the absence of mucosal lesions [9]. The neonate's body weight should be monitored twice daily; any loss or failure to gain may be the first sign of illness. Birth weight in kittens averages 100 g and in puppies ranges from 100 g in small toy breeds to over 900 g in giant-breed dogs, with medium-breed dogs averaging 500 ± 150 g at birth [3]. Most experienced breeders will know normal birth weights for their breed. Low birth weight is associated with higher neonatal mortality, likely associated with the effects of cooling and inability to nurse and maintain blood glucose concentrations. Administration of antibiotics to these neonates can be considered. Not all neonates should receive routine prophylaxis. Since, antibiotic resistance is a concern, treatment should be considered for only the most severely affected puppies. In cases where a placentitis at adjacent placental sites or pyometra during pregnancy have been documented, prophylactic antibiotic administration may be warranted following delivery and continuing for 5–7 d post-partum. Safe antibiotics in the neonate include: cephalosporins, penicillins, clavulanic acid, macrolides, trimethoprim-sulfonamide, and amikacin (if properly hydrated) [10].

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