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FOCAL POINT

- ★ Pediatric patients as young as 6 weeks of age can be easily and safely anesthetized for gonadectomy if care is used and the physiologic differences between mature and immature animals are recognized and understood.

KEY FACTS

- Today the staffs of many veterinary hospitals as well as humane associations and societies perform prepubertal gonadectomies with great success.
- Pediatric patients are less able to compensate for hemorrhage and blood loss than are adult animals, and small volumes of blood loss in pediatric animals can result in clinically notable anemia.
- All pediatric animals undergoing elective surgery should have a complete physical examination before surgery, with particular attention devoted to the respiratory and cardiovascular systems.
- The depth of anesthesia should be constantly monitored to ensure adequate analgesia while minimizing respiratory and cardiovascular depression.

Prepubertal Gonadectomy in Dogs and Cats—Part I

Texas A&M University

Lisa M. Howe, DVM, PhD

ABSTRACT: Prepubertal gonadectomy, or early-age neutering, has become common in many humane organizations as a method of population control. The concept of prepubertal gonadectomy has remained controversial among veterinarians despite the lack of scientific data to support current recommendations regarding the ideal age at which dogs and cats should be neutered. Studies suggest that gonadectomy is safe in dogs and cats as young as 6 weeks of age; however, many veterinarians are reluctant to anesthetize and perform surgery on pediatric patients. Part I discusses the history of prepubertal gonadectomy, physiologic differences between pediatric and adult animals, and general anesthetic and surgical considerations. Part II will address surgical procedures as well as the safety of performing prepubertal gonadectomy.

Pet overpopulation continues to be a tremendous problem in the United States, resulting in the euthanasia of millions of cats and dogs annually.^{1,2} In addition, numerous unwanted animals die from exposure, trauma, or starvation every year. Many humane associations and societies require mandatory gonadectomy of all companion animals after adoption, but owner compliance with these programs is estimated to be less than 60%.^{3,4} Thus, these organizations along with many veterinarians have been promoting the concept of prepubertal gonadectomy, or early-age neutering, to increase the effectiveness of population control measures.⁵⁻¹² Prepubertal gonadectomy permits animals to be neutered before the onset of puberty and before adoption. The use of prepubertal gonadectomy by humane shelters can result in compliance rates of nearly 100% for neutering, the rejection or return of fewer animals, and improved staff morale.³

Scientific data regarding the ideal age at which dogs and cats should be neutered or supporting current age recommendations are lacking. Thus, the concept of prepubertal gonadectomy remains controversial among veterinarians. Studies suggest that prepubertal gonadectomy is safe in dogs and cats as young as 6 weeks of age^{5-7,9-13}; however, many veterinarians are reluctant to anesthetize pediatric patients and perform gonadectomy, citing concern about the potential for long-term effects. Part I of this article reviews the evolution of prepubertal gonadectomy and discusses important anesthetic and presurgical considerations.

Part II will describe surgical procedures and summarize findings from the literature on the safety of performing prepubertal gonadectomy.

HISTORY

Dr. Leo L. Lieberman has been actively involved in promoting the concept of prepubertal gonadectomy for nearly 30 years.^{10,14} In 1970, while president of the Connecticut Veterinary Medical Association, Lieberman assembled a group of veterinarians, animal control officers, and representatives from numerous animal welfare organizations to discuss the problem of pet overpopulation. One suggestion was to neuter animals before they were released from shelters. After the meeting, Lieberman began performing early-age gonadectomies and learned that other practitioners had been performing the procedure for many years.

While reviewing the literature, Lieberman also discovered that in the 1920s, veterinarians had performed the "stitchless spay" on animals 2 months of age. In addition, he noted a paucity of scientific evidence supporting the conventional age of 6 months as the ideal time to perform gonadectomy in dogs and cats. Scientific clinical and experimental studies now appear in the literature, and prepubertal gonadectomy has been accepted by the American Veterinary Medication Association (AVMA)^a and other organizations. Today many other humane organizations and veterinary hospitals, including Texas A&M College of Veterinary Medicine, have begun performing prepubertal gonadectomies with great success.

PRE- AND PERIOPERATIVE CONSIDERATIONS

Pediatric patients as young as 6 weeks of age can be easily and safely anesthetized if care is used and the physiologic differences between mature and immature animals are recognized and understood.

Physiologic

In general, pediatric patients have higher cardiac outputs, heart rates, plasma volumes, and central venous pressures compared with those of adult animals.¹⁵⁻¹⁸ Pediatric patients also have lower blood pressures, peripheral vascular resistance, and stroke volumes.^{15,16} In addition, the parasympathetic innervation to the heart is mature at birth and sympathetic innervation continues to develop after birth.^{17,18} Thus, the pediatric heart is less able to increase the force of contraction and the

cardiac output depends mainly on the heart rate. Further, because cardiac output depends on the heart rate of pediatric dogs and cats, hypotension is a greater problem during anesthesia.¹⁵⁻¹⁸

Pediatric patients are less able to compensate for hemorrhage and blood loss than are adult animals, and small volumes of blood loss in pediatric animals may result in clinically notable anemia.^{15,16} Veterinarians must use care with intravenous administration of fluids to help correct hypotension because young animals have limited ability to increase cardiac output in response to the volume loading attributed to less compliant ventricles.

The respiratory system of pediatric patients also differs from that of adults. The tidal volume of puppies and kittens older than 1 month of age is approximately the same as that for adults, but the rate of oxygen consumption in pediatric animals is approximately two to three times greater than that of adults.^{15,16,18} Thus, the respiratory rate of pediatric dogs and cats may be two to three times higher than that of adults to increase the minute ventilation necessary for greater oxygen demand. To avoid hypercapnia and hypoxia, a relatively higher respiratory rate must be maintained during anesthesia.¹⁵⁻¹⁸ In addition, high alveolar ventilation increases the exchange of gases in the lungs, causing the need for more rapid induction and recovery from inhalation anesthesia.^{15,16} Pediatric animals are also at greater risk for airway obstruction than are adults, and care must be taken during intubation because the larynx and trachea are small.^{17,18}

The hepatic enzyme systems involved with biotransformation of compounds need at least 4 weeks to develop after birth.^{16,18} Albumin levels are lower in very young animals compared with those of adults. Therefore, if highly protein-bound drugs are administered intravenously, more unbound fraction of the drug remains in circulation, which may result in apparent greater sensitivity to the drug.^{15,16,18} In addition, neonatal animals have minimal stores of hepatic glycogen and are prone to hypoglycemia.^{15,16,18} Therefore, food should not be withheld for more than a few hours before surgery.

In puppies, glomerular filtration matures at 2 to 3 weeks of age and tubular secretion matures at 4 to 8 weeks of age. Thus, renal excretion of drugs may be affected in very young animals.¹⁸

Pediatric animals undergoing gonadectomy are also more prone than are adults to develop hypothermia because they have a larger surface area:volume ratio, an immature thermoregulatory system, less subcutaneous fat, and less ability to shiver.¹⁵⁻¹⁸ Hypothermia can result in bradycardia, low cardiac output, and hypotension, which may prolong drug elimination and recovery from anesthesia.^{15,16,18}

^aIn 1993, the AVMA House of Delegates approved Resolution 6, which stated: "...resolved that AVMA supports the concept of early (8 to 16 weeks of age) ovariohysterectomies/gonadectomies in dogs and cats, in an effort to stem the overpopulation problem in these species."

An additional physiologic consideration is related to the size of young patients. Because they are small, considerable attention must be given to their weight and fluid volume. These animals should be carefully weighed to ensure accurate dosing of intravenous drugs, and intravenous drugs should be diluted to permit drug titration. Fluids should be administered carefully and accurately to prevent volume overload.

General

All pediatric animals undergoing elective surgery should receive a complete physical examination before surgery, with particular attention devoted to the respiratory and cardiovascular systems. Many young animals, especially those in shelters, have never been examined by a veterinarian and may have congenital anomalies, infectious diseases, or other problems.

The normal respiratory rate in pediatric animals is approximately 15 to 35 breaths/min, and the normal heart rate may be approximately 200 beats/min or faster in puppies and kittens.^{15,16} On auscultation, determination of the heart rate and rhythm and the presence or absence of murmurs is important. The respiratory system is best evaluated by auscultation; observing the rate, rhythm, and character of breathing; and closely evaluating the nares and eyes for signs of discharge.

Hydration status should also be determined, and dehydration corrected before surgery. When possible, lab-

oratory evaluation of pediatric patients undergoing elective gonadectomy should include a hematocrit and total solids determination. High packed cell volumes often occur during the first few days of life; however, these levels decrease to approximately 27% to 30% by 7 weeks of age and gradually increase to normal adult levels thereafter.^{15,16,18}

Food should be withheld no longer than 8 to 9 hours, with 3 to 4 hours recommended for the youngest patients.^{4,9,11} Administration of dextrose-containing intravenous fluids is recommended except for very short procedures (for castration of kittens, a balanced subcutaneous electrolyte solution should be administered). Pediatric animals can be fed a small meal 1 to 2 hours after recovery from anesthesia.^{9,11}

Hypothermia can be lessened by using warm circulating water blankets, warmed water bottles (or water-filled examination gloves), or warm intravenous fluids (if administered). The use of electric heating pads should be avoided because cutaneous burns may result. Minimizing the length of surgery can also lessen the severity of hypothermia. Excessive wetting of pediatric patients during preparation of the surgical site should be avoided, and the use of warmed scrub (chlorhexidine) and avoidance of alcohol can help preserve body heat.

The tissue of pediatric patients is very friable and should be handled carefully. The small blood volume of pediatric patients makes meticulous hemostasis very

TABLE I
Drug Protocol for Ovariohysterectomy in Puppies

<i>Protocol</i>	<i>Age (wk)</i>	<i>Premedication Agents (mg/kg)</i>	<i>Induction Agents (mg/kg)</i>	<i>Maintenance Agents</i>
Faggella and Aronsohn ⁹	6–14	0.04 IM atropine, 0.11 IM oxymorphone	3.4 IV propofol administered slowly 15 min after premedications	Isoflurane
Faggella and Aronsohn ⁹	6–14	0.04 IM atropine, 0.11 IM oxymorphone, 13.2 IM tiletamine–zolazepam	Isoflurane (mask induction)	Isoflurane
Faggella and Aronsohn ⁹	6–14	0.22 IM midazolam, 0.44 IM butorphanol	Isoflurane (mask induction)	Isoflurane
Texas A&M University	<20	0.011 IM glycopyrrolate, 0.22 IM butorphanol	22 titrated IV pentothal to effect; if total volume <3 ml, dilute with equal volume of sterile water to permit accurate titration	Halothane or isoflurane
Texas A&M University	20–24	0.011 IM glycopyrrolate, 0.22 IM butorphanol, 0.026 IM acepromazine	22 titrated IV pentothal to effect; if total volume <3 ml, dilute with equal volume of sterile water to permit accurate titration	Halothane or isoflurane

IM = intramuscular; *IV* = intravenous.

TABLE II
Drug Protocol for Castration in Puppies

<i>Protocol</i>	<i>Age (wk)</i>	<i>Premedication Agents (mg/kg)</i>	<i>Induction Agents (mg/kg)</i>	<i>Maintenance Agents</i>
Faggella and Aronsohn ⁹	6–14	0.04 IM atropine, 0.22 IM oxymorphone	6.5 IV propofol administered slowly 15 min after premedications	Isoflurane (if additional analgesia is needed)
Faggella and Aronsohn ⁹	6–14	0.22 IM midazolam, 0.44 IM butorphanol	6.5 IV propofol administered slowly 15 min after premedications	Isoflurane (if additional analgesia is needed)
Texas A&M University	<20	0.011 IM glycopyrrolate, 0.22 IM butorphanol	22 titrated IV pentothal to effect; if total volume <3 ml, dilute with equal volume of sterile water to permit accurate titration	Halothane or isoflurane
Texas A&M University	20–24	0.011 IM glycopyrrolate, 0.22 IM butorphanol, 0.026 IM acepromazine	22 titrated IV pentothal to effect; if total volume <3 ml, dilute with equal volume of sterile water to permit accurate titration	Halothane or isoflurane

IM = intramuscular; *IV* = intravenous.

TABLE III
Drug Protocol for Ovariohysterectomy or Castration in Kittens

<i>Protocol</i>	<i>Age (wk)</i>	<i>Procedure</i>	<i>Premedication/Induction Agents (mg/kg)</i>	<i>Maintenance Agents</i>
Faggella and Aronsohn ⁹	6–14	Kitten OHE	0.22 IM midazolam, 11 IM ketamine	Isoflurane
Texas A&M University	<24	Kitten OHE	0.011 IM glycopyrrolate, 0.44 IM butorphanol, 0.055 IM acepromazine, 11 IM ketamine; halothane or isoflurane administered via facemask (kittens are immobilized; however, gas anesthetic is generally needed for a few minutes to permit intubation)	Halothane or isoflurane
Faggella and Aronsohn ⁹	6–14	Kitten castration	11 IM tiletamine–zolazepam	Isoflurane (if additional analgesia is needed)
Texas A&M University	<24	Kitten castration	Same as kitten OHE, except male kittens are not intubated unless risk factor identified	Same as kitten OHE

IM = intramuscular; *IV* = intravenous; *OHE* = ovariohysterectomy.

important. Fortunately, the small size of blood vessels and the presence of minimal abdominal and ovarian bursal fat allow excellent visualization of the vasculature and make precise hemostasis simple to achieve.

Care also should be taken to minimize anxiety and stress during the perioperative period so that induction and recovery proceed smoothly. Animals should be housed in a calm environment (they may be housed with littermates), with minimal handling just before receiving anesthetic premedications to decrease excitation.

ANESTHESIA Protocols

Several anesthetic protocols have been reported by Faggella and Aronsohn^{6,9} for use in dogs or cats undergoing early-age gonadectomy, and specific protocols have been developed for patients at Texas A&M University¹² (Tables I, II, and III).

The anesthetic protocols used in pediatric patients at Texas A&M were developed to fulfill several criteria, including adequate sedation for nonstressful catheter place-

ment and anesthetic induction and adequate postoperative analgesia without excessive sedation. In addition, a protocol similar to that used in traditional-age animals was developed to minimize confusion by veterinary students. Finally, when selecting protocols, consideration should include the use of drugs that are readily available in most small animal practices and that minimize the need for large, costly drug inventories.

At Texas A&M University, all pediatric patients (except kittens being castrated) undergo endotracheal intubation (Figure 1). In male kittens, a close-fitting mask can be used because the duration of surgery is short; if a risk factor is noted, however, an endotracheal tube should be placed. A Bain coaxial nonbreathing system is used for patients weighing less than 6.8 kg; other nonbreathing anesthetic circuits can also be used. In addition, an intravenous catheter is placed in all patients, and all except male kittens receive intravenous fluids for the duration of surgery. Because the duration of surgery in male kittens is short, an intravenous catheter is placed only for vascular access in case of emergency; however, subcutaneous fluids are administered on completion of surgery. Intravenous fluids containing dextrose are administered at a rate of 22 ml/kg for the first hour of anesthesia and 11 ml/kg thereafter. Male kittens receive a total dose of 11 ml/kg of subcutaneous lactated Ringer's solution.

Several methods can be used to ensure safe administration of intravenous fluids. In all except the smallest patients (i.e., weighing approximately 1.5 lb or less), a standard microdrip (60 drops/ml) administration set can be used to deliver fluids if care is used to continuously ensure the accuracy of the drip rate. The use of a



Figure 1—Endotracheal intubation is no more difficult in an 8-week-old puppy than in an adult dog.



Figure 2—Inexpensive mechanical syringe pump (Flowline™ Springfusor™—Mila International, Erlanger, KY). The syringe is filled with fluids and attached to specially made tubing that controls the flow rate, which ranges in intervals of 1.25 to 120 ml/hr. The syringe and attached tubing are then inserted into the spring-loaded syringe pump. The spring inside the syringe pump applies a constant pressure to the syringe plunger, and the flow rate to the animal is controlled by the size of tubing selected.

burette with the microdrip administration set decreases the possibility of overhydration. Electronic syringe and fluid pumps accurately deliver precise volumes of fluids and are the safest method but expensive. Inexpensive mechanical syringe pumps (Figure 2) can be used in very small patients and have the advantage of being reusable. A standard syringe can also be filled with the calculated dose of fluids and administered in several small boluses over time.

Monitoring

Monitoring of pediatric dogs or cats during anesthesia is similar to that in adults. The depth of anesthesia should be constantly monitored to ensure adequate analgesia while minimizing respiratory and cardiovascular depression.

An esophageal stethoscope is invaluable for monitoring heart and respiratory rates in pediatric patients and can be connected to standard stethoscope earpieces or an amplified speaker system for continuous auditory monitoring^{15,18} (Figure 3). An 18-Fr esophageal stethoscope is suitable for most puppies and kittens, although a 12-Fr stethoscope may be needed for the smallest patients.^{15,18} If esophageal stethoscopes are not available, a stethoscope diaphragm can be taped to the chest to monitor for heart sounds but care should be taken not to impede ventilation.¹⁸

If available, an electrocardiogram is extremely valuable for monitoring changes in cardiac rate and rhythm and can be used on patients of all sizes. Lingual, dorsal pedal, or femoral arteries can be palpated for pulse quality and estimated blood pressure. Arterial blood pressure can be measured indirectly using a Dinamap® veterinary blood pressure monitor^b but requires the



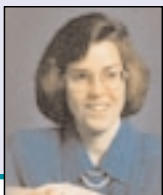
Figure 3—An anesthetized pediatric gonadectomy patient is being monitored with an esophageal stethoscope, which is attached to an amplified speaker system for continuous auditory monitoring.



A Look Back

One of the most significant events affecting humane solutions to controversial issues on pet population was the 1993 approval of Resolution 6 by the American Veterinary Medical Association Board of Delegates.

This resolution provided support and legitimacy for adoption of early-age neutering procedures. Since the passage of Resolution 6, many veterinary organizations and hospitals have endorsed prepubertal gonadectomy as a useful tool in the fight against pet overpopulation. Twenty years ago, this option was not a viable alternative.



smallest pediatric cuffs (which may still be too large for the smallest feline patients).^{15,18} Pulse oximetry can noninvasively measure arterial oxygen saturation of hemoglobin and provide an accurate assessment of the heart rate. Body temperature should be frequently monitored either rectally or orally and fluid administration monitored continuously to prevent fluid overload.

SUMMARY

Although the physiology of pediatric patients differs from that of adults, numerous anesthetic protocols have been found to be safe and effective for use in elective prepubertal gonadectomy. Anesthetic induction and maintenance of pediatric patients is not difficult, and veterinarians who are familiar with techniques for general gas anesthesia on traditional-age patients can safely and efficiently anesthetize pediatric patients undergoing gonadectomy. When per-

forming gonadectomy on pediatric patients, however, extra care should be taken to minimize complications associated with hypothermia, hypoglycemia, blood loss, and tissue handling.

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About the Author

Dr. Howe is affiliated with the Department of Small Animal Medicine and Surgery, College of Veterinary Medicine, Texas A&M University, College Station, Texas. She is a Diplomate of the American College of Veterinary Surgeons.