

Early Spay-Neuter: Clinical Considerations

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Early spay-neuter is ovariectomy or castration of puppies or kittens 6 to 14 weeks of age. Pediatric animals may have an enhanced response to relatively low doses of anesthetic agents. Animals should be fasted no more than 3 to 4 hours before surgery to prevent hypoglycemia, and hypothermia should be avoided. Heart and respiratory rates must be monitored carefully throughout anesthesia. Pediatric gonadectomy surgeries are quick with minimal bleeding. Anesthetic recovery is rapid. No significant short-term or long-term effects have been reported. Prepuberal gonadectomy is most useful for humane organizations and conscientious breeders wishing to preclude reproduction of pet dogs and cats while placing animals at a young enough age to optimize socialization and training. Copyright 2002, Elsevier Science (USA). All rights reserved.

Early spay-neuter, also called prepuberal gonadectomy, is defined as castration or ovariectomy (OHE) of puppies or kittens 6 to 14 weeks of age. Prepuberal gonadectomy is endorsed by the American Veterinary Medical Association (AVMA), American Animal Hospital Association, American Humane Association (AHA), Humane Society of the United States, Society for the Prevention of Cruelty to Animals, Society for Theriogenology, American College of Theriogenologists, British Small Animal Veterinary Association, American Kennel Club, and Cat Fancier's Association/Winn Feline Foundation.

Prepuberal gonadectomy has been performed on puppies and kittens at humane shelters in the United States for at least 10 years. The goal is to place into adoptive homes only those animals that are incapable of reproducing. Compliance with spay-neuter contracts by new pet owners is poor, and animals left intact at time of adoption may be allowed to reproduce, repopulating humane shelters. Other groups that may benefit from early spay-neuter are dog and cat breeders, who can place pet-quality animals at 8 weeks of age after gonadectomy, precluding the introduction into a breeding program of purebred animals that are not of the breed standard or that have heritable defects, but allowing placement of the animal at a young enough age to facilitate socialization and training.

Finally, dogs and cats benefit from gonadectomy performed at any age. Disease of the ovaries and uterus of females and testes of males are obviously of no further concern. Incidence of prostate disorders, such as benign prostatic hypertrophy and prostatitis, are decreased in castrated male dogs.^{1,2} Mammary

neoplasia is much less likely to develop in those aged female dogs or cats in which OHE was performed before their first estrus.^{3,4} Some studies suggest that neutered animals may have a longer life span than intact animals for reasons that are not clear.⁵⁻⁷

Anesthesia

Anesthesia in pediatric animals is not difficult but differences in pediatric physiology must be kept in mind when handling the animals, choosing anesthetic agents, and maintaining and monitoring the animals during the anesthetic episode. Pediatric animals should undergo a complete physical examination before anesthesia and surgery. Because early spay-neuter is an elective procedure, only those animals that are in good health, vaccinated, and free of internal parasites should undergo the procedure. Male dogs and cats that have one or both testes retained in the abdomen or inguinal canal should not undergo gonadectomy until they are older and the testes have had an opportunity to descend into the scrotum.

Hypothermia occurs more readily in pediatric animals than in adults because of the pediatric animals' greater surface area: volume ratio, less subcutaneous fat, and reduced ability to shiver. Provide a warm environment pre- and postoperatively and maintain the animals on a circulating warm water blanket or under a warm air blanket (Bair Hugger Temperature Management, Augustine Medical, Eden Prairie, MN) during surgery. Hypothermia during surgery may cause a decreased heart rate, deepening of the plane of anesthesia, and prolonged anesthetic recovery.⁸

Anesthetic induction, maintenance, and recovery may be altered in excited animals. Minimize handling of puppies or kittens before anesthesia. Do not use excessive restraint when inducing anesthesia; intramuscular administration of anesthetic agents may be preferred to intravenous administration.⁸

Renal and hepatic function are immature in pediatric animals, not reaching adult levels until the animals are 12 to 14 weeks of age. Renal blood flow and glomerular filtration rate are decreased, and hepatic enzyme systems function more slowly than in adult animals, with a subsequent prolonged effect of anesthetic agents before they are metabolized and excreted. Plasma protein concentrations are decreased because of slower production of proteins in the liver, leaving a greater amount of anesthetic agent unbound and available at any given time.⁸ These conditions combine to cause effects of anesthetic agents at relatively lower doses than are used in adult animals.

Pediatric animals are prone to hypoglycemia because of small reserves of glycogen in liver and skeletal muscle and slow glycogenolysis and gluconeogenesis. Pediatric animals should not be fasted for an extensive period before anesthetic induction. Healthy pediatric animals can safely be fasted for 3 to 4 hours before anesthesia is induced. Administer fluids containing dextrose during surgery and offer food shortly after anesthetic

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TABLE 1. Reported Anesthetic Protocols for Gonadectomy of Puppies Less Than 24 Weeks of Age

Anesthetic Protocol	Comments	Ref.
Premeds = atropine (0.04 mg/kg IM) and oxymorphone (0.22 mg/kg IM) Induction = propofol (6.5 mg/kg IV) Maintenance = isoflurane if needed	Rated best technique for castration	10
Premeds = atropine (0.04 mg/kg IM) and oxymorphone (0.11 mg/kg IM) Induction = propofol (4.3 mg/kg IV) Maintenance = isoflurane	Rated best technique for ovariohysterectomy	10
Premeds = butorphanol (0.22 mg/kg IM) and glycopyrrolate (0.011 mg/kg IM) Induction = thiopental sodium (22 mg/kg IV, titrated to effect) Maintenance = isoflurane or halothane		11
Induction = isoflurane or halothane via mask Maintenance = isoflurane or halothane via endotracheal tube	Analgesia may be poor	12,15
Premeds = atropine (0.07 mg/kg SQ) Induction = thiopental sodium (22-27 mg/kg IV) Maintenance = thiamylal (IV, to effect)		16

Note: IM, intramuscular; IV, intravenous; SQ, subcutaneous.

recovery to minimize hypoglycemia in these patients. The primary cardiopulmonary change that must be considered during anesthesia of pediatric animals is the reliance of puppies and kittens on heart rate for variability of cardiac output.⁸ Heart rate must be monitored and maintained to prevent hypotension and decreased oxygenation of tissues. Similarly, respiratory rate must be monitored and maintained because puppies and kittens have limited ability to respond to elevated carbon dioxide concentration in blood or tissue and have little oxygen reserves in the lungs.⁸ Use anesthetic equipment with little dead space and minimal resistance in the breathing circuit. Masks should be tight-fitting. The high respiratory rate and increased alveolar ventilation present in pediatric animals allows faster take-up of inhalational anesthetic agents.

In summary, lower doses of anesthetic agents should be used because of decreased rate of metabolism in the liver, decreased protein binding in circulation, decreased rate of excretion through the kidneys, and high respiratory rate and alveolar ventilation. Also, a greater proportion of pediatric animals' blood supply goes directly to the brain.⁸ Continuous monitoring of heart and respiratory rates and plane of anesthesia is required for puppies and kittens undergoing anesthesia.

Several anesthetic protocols have been reported for use in pediatric animals (Tables 1 and 2). Those noted as "best technique" defined the best depth of sedation, shortest time for

induction and recovery, and best quality of induction and recovery.^{9,10}

Reported complications during anesthesia of pediatric animals for gonadectomy include drug overdose, cardiac arrest, perioperative regurgitation and aspiration, and changes in cardiac rate or rhythm. Incidence of these complications was not greater in puppies and kittens gonadectomized at less than 12 weeks of age (n = 723) compared to those gonadectomized at 12 to 24 weeks of age (n = 532) or greater than 24 weeks of age (n = 733).¹¹

Postoperative anesthetic considerations include maintenance of body temperature until the animal is ambulatory, prevention of hypoglycemia by the offering of food shortly after the animal can stand, and pain management. Anesthetic recovery time is significantly shorter in pediatric animals than in older animals undergoing gonadectomy.¹² Butorphanol (0.11 to 0.22 mg/kg intravenously, intramuscularly, or subcutaneously) may be used for postoperative analgesia, if needed.¹³

Surgery

Preparation of the patient for sterile surgery is as for traditional age gonadectomy. Minimize the area shaved, keep the animal as dry as possible during surgical preparation, and use nonalcohol scrub solutions to prevent excessive loss of body heat.

TABLE 2. Reported Anesthetic Protocols for Gonadectomy of Kittens Less Than 24 Weeks of Age

Anesthetic Protocol	Comments	Ref.
Induction = tiletamine/zolazepam (11 mg/kg IM) Maintenance = isoflurane if needed	Rated best technique for castration	9
Induction = ketamine hydrochloride (11 mg/kg IM) and midazolam (0.22 mg/kg IM) Maintenance = isoflurane	Rated best technique for ovariohysterectomy	9
Premeds = acepromazine maleate (0.055 mg/kg IM), butorphanol (0.22 mg/kg IM), and glycopyrrolate (0.011 mg/kg IM) Induction = ketamine hydrochloride (11 mg/kg IM) Maintenance = isoflurane		11
Induction = isoflurane via mask (4%) Maintenance = isoflurane via endotracheal tube (2-3%)	Analgesia may be poor	12,14
Premeds = atropine (0.045 mg/kg IM) Induction = isoflurane via mask Maintenance = isoflurane	Analgesia may be poor	13

Note: IM, intramuscular; IV, intravenous; SQ, subcutaneous.

Ovariohysterectomy, Canine or Feline

Surgical technique is as for OHE performed at the traditional age of 6 to 7 months. Free serous fluid may be present in the peritoneal cavity of normal pediatric animals.^{10,14-16} Reported techniques for ligation of the ovarian and uterine vessels and uterine body include hemostatic clips (Hemoclips, Solvay Animal Health, Mendota Heights, MN)^{15,17} and fine suture material. Types of suture material reported include 2/0 to 4/0 chromic gut, polydioxanone (PDS II, Ethicon Inc., Somerville, NJ) and polyglactin (Vicryl, Ethicon Inc., Somerville, NJ).^{11,14-18} Use of polydioxanone suture material may be associated with calcinosis circumscripta.¹⁹ In general, meticulous control of intraoperative hemorrhage and delicate manipulation of pediatric tissue is required.¹⁵ Clamping of the uterine body before ligation may best be performed with a small Carmalt clamp in preference to a mosquito or other small hemostatic clamp. The ridges on Carmalt clamps run perpendicular to the small uterine blood vessels when clamped across the uterine body at the level of the cervix, ensuring adequate crushing of the uterine vessels before ligation.¹⁶

Suture materials reported for closure of the linea alba and subcutaneous tissue are the same as those used for internal ligation. Suture materials reported for closure of the skin include polypropylene (Fluorofil, Pitman-Moore, Mundelein, IL), nylon (Dermalon, American Cyanamid Co., Danbury, CO) and polyglactin.^{11,15,18} Subcuticular closure, and closure with continuous or interrupted external skin sutures have been reported.^{11,15,18} External skin sutures are reported to be bothersome to pediatric animals postoperatively only if they are too tight.¹³ Tissue glue has been reported for skin closure after pediatric OHE but is reported to work poorly in puppies.¹⁴

Castration, Canine

A single prescrotal incision or bilateral scrotal incisions may be made.^{10,11} Both open castration techniques, in which the tunics overlying the spermatic vessels and ductuli deferentes are incised, and closed castration techniques, in which the tunics are left intact, have been described; neither technique is associated with increased morbidity postoperatively.¹⁰⁻¹² The spermatic vessels may be ligated with suture as described for OHE, or the spermatic cord tied on itself (closed technique) or the spermatic vessels tied to the ductuli deferentes on each side (open technique). A single prescrotal incision generally was closed with external skin sutures, whereas bilateral scrotal incisions were left open to heal by second intention.^{10,11}

Castration, Feline

Bilateral scrotal incisions are made. The spermatic vessels may be ligated with suture as described for OHE, or the spermatic cord tied on itself (closed castration technique) or the spermatic vessels tied to the ductuli deferentes on each side (open castration technique).^{11,14,18} The incisions are left open to heal by second intention.¹⁵

Surgery time for OHE and castration of pediatric animals is shorter than that for OHE and castration performed at the traditional age.¹¹ In one survey of 48 pediatric feline OHEs and 48 pediatric feline castrations in which all animals were at most 14 weeks of age at time of surgery, no surgical complications were reported.¹⁵ In a survey of OHEs or castrations performed

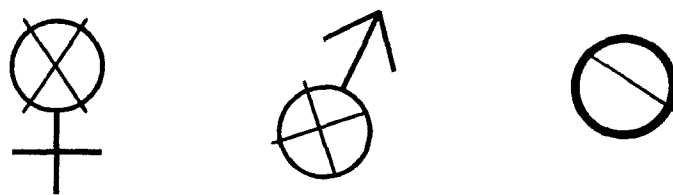


Fig 1. Symbols recommended for tattoo in the prepubic area of female puppies and kittens and inguinal area of male puppies and kittens after prepuberal gonadectomy.

in puppies and kittens ages less than 12 weeks ($n = 723$), 12 to 24 weeks ($n = 532$), or greater than 24 weeks ($n = 733$), there was no difference in incidence of postsurgical complications between groups.¹¹ Reported complications in all groups included breaks in asepsis intraoperatively, torn pedicles, and postoperative incisional dehiscence, incisional infection, and hemorrhage.¹¹

The AVMA and AHA recommend that all animals undergoing prepuberal gonadectomy be tattooed to prevent unnecessary anesthesia and surgery to ascertain intact status later in the animal's life. Suggested tattoos include an open circle containing a diagonal bar, or the traditional "male" or "female" symbol with an "x" superimposed over the circular portion (Fig 1). Tattoos should be 0.5 to 0.75 inches in diameter, placed in the prepubic area of females and inguinal area of males.²⁰

Long-Term Effects of Early Spay-Neuter

Long-term effects of prepuberal gonadectomy are the same as those seen after gonadectomy performed at the more traditional age of 6 to 7 months. These include obesity, possible decreased ability of the immune system to respond to challenge with infectious disease agents, delayed closure of physes of long bones, predisposition to obstructive lower urinary tract disease in cats and urinary incontinence in female dogs, and changes in behavior. In general, kittens gonadectomized at less than 24 weeks of age ($n = 188$) were no more likely to exhibit long-term effects of gonadectomy than were kittens gonadectomized at greater than 24 weeks of age ($n = 263$) when evaluated a median of 37 months after surgery.²¹ Similarly, puppies gonadectomized at less than 24 weeks of age ($n = 175$) were no more likely to exhibit long-term effects of gonadectomy than were those puppies gonadectomized at greater than 24 weeks of age ($n = 94$) when evaluated a median of 48 months after surgery.²² One exception to this in puppies was predisposition to infectious disease; this is described in detail in the following section.

Obesity

Obesity is considered to be the most common nutritional disorder in small animals. Cats gonadectomized at 7 weeks or 7 months of age were more likely to have a higher body weight, body condition score, and body mass index, and to have more falciform fat than intact cats; age at time of gonadectomy had no effect.^{21,23,24} Metabolic rate has been shown to be decreased in gonadectomized cats compared to intact cats and, again, age at time of gonadectomy had no effect.¹⁸ Dogs gonadectomized at 7 weeks or 7 months of age or left intact showed no difference in food intake, weight gain, or depth of back fat when evaluated at 15 to 18 months of age.^{12,25} Obesity is a multifactorial problem, of which gonadectomy is one component. Owner education

regarding appropriate diet and exercise after gonadectomy should be stressed.

Infectious Disease

Increased incidence in infectious disease correlated with age at time of gonadectomy has not been reported to occur in cats.²³ In dogs, a greater incidence of postsurgical parvoviral enteritis was reported in puppies gonadectomized at less than 24 weeks of age compared to those gonadectomized at greater than 24 weeks of age.²² In a survey comparing humane shelter puppies gonadectomized at 8 weeks ($n = 71$) or 7 months of age ($n = 71$), 23 puppies died of infectious disease, including parvoviral enteritis, coronaviral enteritis, and distemper.¹² Incidence of disease was evenly split between the two groups.¹² No comparison has been reported in disease incidence between animals gonadectomized and animals left intact. Neither anesthesia nor surgery has been reported to affect dogs' ability to mount a humoral response to vaccination against canine distemper, but cell-mediated immunity may be affected.²⁶ This may have an impact on the animal's ability to respond to a challenge with an infectious agent postoperatively, regardless of age at the time of surgery.

Physcal Closure

Development and eventual closure of the physes of long bones is dependent on the gonadal hormones estradiol and testosterone. Cats and dogs gonadectomized at either 7 weeks or 7 months of age have been demonstrated to have delayed closure of the distal radial physis compared to intact animals.^{23,25,27} Age at gonadectomy had no effect. Clinical significance of this effect is unknown; neither increased predisposition to growth plate fractures nor abnormalities of long bone growth has been reported in gonadectomized dogs and cats.

Feline Lower Urinary Tract Disease

The common perception that male cats are predisposed to obstructive lower urinary tract disease by neutering is not borne out by the scientific evidence. In a retrospective survey, cats castrated at less than 24 weeks of age had no greater incidence of obstructive urinary tract disease than did cats castrated at greater than 24 weeks of age.²¹ Urethral diameter was not demonstrated to vary between cats castrated at 7 weeks or 7 months of age and cats left intact.^{23,28}

Canine Urinary Incontinence

Urinary incontinence that develops after OHE in female dogs often is called estrogen-responsive urinary incontinence, based on clinical response to that hormone. Incidence of urinary incontinence in dogs undergoing OHE after their first estrus is reported to be 20.1%, with 75% of these cases developing within 3 years of surgery.²⁹ Incidence of urinary incontinence in bitches undergoing OHE before their first estrus is reported to be much lower, at 9.7%.³⁰ Pathogenesis of post-OHE urinary incontinence is undefined, because most ovariohysterectomized bitches do not exhibit urinary incontinence, and because serum estrogen concentrations do not differ between ovariohysterectomized bitches and intact bitches in anestrus.²⁹ Elevated serum concentrations of gonadotropins after OHE may be a factor (personal communication, Dr. Susi Arnold, April 2002).

Urinary incontinence associated with obesity and the presence of a juvenile "tucked-up" vulva may contribute to perivulvar dermatitis in spayed female dogs. Allowing bitches to undergo an estrous cycle to cause development of a larger vulva is not effective in preventing this condition in the long term and is discouraged by the author.

Behavior

Anecdotal reports suggest that dogs and cats gonadectomized prepuberally are more likely to maintain juvenile behaviors and be more difficult to train. Scientific evidence suggests the contrary. Groups of cats gonadectomized at either less than or greater than 24 weeks of age and adopted from a humane shelter showed no difference in urinary or aggressive behaviors according to their owners, who were unaware of the age at which the cat had undergone OHE or castration.^{21,31} Rate of retention of cats in adoptive households did not differ between the groups.²¹ Groups of dogs spayed or castrated at 7 weeks of age ($n = 65$) or 7 months of age ($n = 64$) and trained as service dogs for the handicapped were equally likely to succeed in training (personal communication, Ruth Daniels, Canine Companions for Independence, April 2002). Prepuberal neutered dogs had a higher success rate in becoming guide dogs as compared to littermates neutered at traditional times (personal communication, Dr. Patricia Olson, Guide Dogs for the Blind, Inc., April 2002).

Conclusion

Pediatric anesthesia and surgery are safe procedures, as long as veterinarians performing these techniques bear in mind unique aspects of pediatric physiology. No significant short- or long-term effects have been reported when comparing prepuberally gonadectomized dogs and cats to those animals spayed or castrated at a more traditional age. Prepuberal gonadectomy surgeries are quick with minimal bleeding, and the anesthetic recovery is rapid.

It has been reported that 57% of humane shelters interested in OHE and castration of animals before adoption cannot find a veterinarian that will perform the procedure.³² Although 90% of the veterinary colleges in North America had a cooperative arrangement with nearby humane organizations for students in 1998, only 48% provided instruction in early spay-neuter surgery.³² A survey was performed of fourth-year veterinary students from one veterinary college that does instruct students in early spay-neuter by supervising them as they perform OHEs and castrations on dogs and cats of various ages for local humane organizations. The percentage of students that claimed to be extremely or somewhat confident of their surgical capabilities regarding early spay-neuter (88.6%) was not significantly different from that regarding gonadectomy at traditional age (91.2%), and 84.4% claimed an increase in their confidence level in performing pediatric anesthesia and pediatric surgery in general after having performed prepuberal gonadectomies.³³ Training in early spay-neuter should be encouraged for veterinary students and graduate veterinarians.

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