

Pros, Cons, and Techniques of Pediatric Neutering

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KEYWORDS

• Pediatric • Castration • Ovariohysterectomy • Gonadectomy

KEY POINTS

- Pediatric anesthesia and surgery are safe, with decreased surgery time and quick patient recovery.
- The primary benefit of prepuberal gonadectomy in bitches and queens is decreased incidence of mammary neoplasia later in life.
- Detriments associated with gonadectomy at any age include various cancers, orthopedic problems including anterior cruciate ligament injury, and obesity.

INTRODUCTION

Pediatric gonadectomy is defined as ovariectomy or ovariohysterectomy, or castration, at 6 to 16 weeks of age. Significant research has been done regarding benefits and detriments of gonadectomy surgery. The reader is referred to extensively referenced review articles for detailed information.¹⁻⁴ Much of the published research looks at the large populations of gonadectomized versus intact animals without regard for age at the time of gonadectomy. The few studies that have specifically addressed age have shown no significant differences in long-term behavioral or medical outcomes of dogs and cats spayed or castrated at less than 24 weeks of age in comparison with those gonadectomized later, with the exception of increased incidence of infectious disease in one group of dogs gonadectomized when young that had come from one specific source.^{5,6}

This article focuses on anesthetic and surgical techniques and what is known regarding timing of gonadectomy, especially regarding performance of these surgeries in pediatric dogs and cats. It is important to remember that association between many of the disorders described and gonadectomy is not necessarily an indication of cause and effect, and that other factors, including breed, environment, and body condition, may play a role. These factors are not specifically addressed here.

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ANESTHESIA AND SURGERY

Gonadectomy is an elective procedure, and should not be performed on animals that are not healthy and are not well able to tolerate anesthesia. The vaccination series need not be complete if the animal has received colostrum. All puppies and kittens should receive a complete physical examination and should be treated for internal parasites and, if necessary, for external parasites, before surgery.

Puppies and kittens tolerate anesthesia and surgery well, with quick recovery time. In one study evaluating student completion of ovariohysterectomy and castration surgeries in dogs and cats aged 8 to 16 weeks compared with animals older than 6 months, surgery times for cat spays, dog spays, and dog castrations were decreased by 6%, 29%, and 85%, respectively.⁷ With completion of pediatric surgeries, students reported increased confidence in pediatric anesthesia and pediatric surgeries of all types, and improved general surgical skills.⁸

Concerns specific to anesthesia of pediatric animals include stress, hypoglycemia, hypothermia, and appropriate use of anesthetics and anesthetic equipment in physically small animals.⁹ To minimize stress, it is recommended that pediatric animals remain housed in groups until induction of anesthesia, and that the induction area be as calm and quiet as possible. Pediatric animals have relatively little muscle mass with consequently smaller glycogen stores than adult animals, and have reduced capacity to raise blood sugar by glycogenolysis or gluconeogenesis because of immature hepatic function. Presurgical fasting time must be minimized, and the animal should be fed immediately on recovery.¹⁰ Hypothermia occurs readily in pediatric animals because they have little body fat, a reduced ability to shiver to maintain their body temperature, and relatively greater surface area, permitting more rapid loss of body heat. Pediatric animals should be maintained on a warmed surface, preferably a warm-water circulating pad or similar diffuse heat source, from the time of induction through surgery and recovery. Surgical preparation liquids should be warmed before being applied to the animal.¹¹

Studies evaluating induction time and quality, analgesia, maintenance of anesthetic depth, and recovery time and quality have proposed optimal anesthetic protocols for pediatric animals (Table 1).^{12,13} There are published protocols using only inhalant anesthesia; these are not recommended because of the protracted excitation phase in animals induced by a mask, and because sufficient analgesia is not provided.

Species/Gender	Optimal Anesthesia Protocol
Canine, male	Propofol (6.5 mg/kg IV) 15 min after atropine (0.04 mg/kg IM) and oxymorphone (0.22 mg/kg IM). Use of midazolam (0.22 mg/kg IM) and butorphanol (0.44 mg/kg IM) instead of oxymorphone produced less sedation but good analgesia
Canine, female	Propofol (3.4 mg/kg IV) 15 min after atropine (0.04 mg/kg IM) and oxymorphone (0.11 mg/kg IM). Intubation-inhalant for maintenance
Feline, male	Tiletamine-zolazepam (11 mg/kg IM)
Feline, female	Midazolam (0.22 mg/kg IM) and ketamine (11 mg/kg IM). Intubation-inhalant for maintenance

Abbreviations: IM, intramuscular; IV, intravenous.

Data from Goeree G. Pediatric neuters can be technically challenging. *Can Vet J* 1998;39:244; and Faggella AM, Aronsohn MG. Evaluation of anesthetic protocols for neutering 6- to 14-week-old pups. *J Amer Vet Med Assoc* 1994;205:308-14.

Surgical techniques for ovariectomy and ovariectomy are the same as for adult animals. It is not uncommon to find a significant volume of serous intra-abdominal fluid on laparotomy (**Fig. 1**).¹¹ Care should be taken in handling and stretching friable pediatric tissues.¹² The ovarian vessels and uterine vessels and body may be ligated with suture material or with hemostatic clips. The linea alba may be closed with either absorbable or nonabsorbable suture material. Closure of the skin with absorbable suture material in a subcuticular pattern may minimize self-trauma at the incision site.¹² Use of tissue glue to close the skin is discouraged, as there may be insufficient cohesion of tissues.¹¹

Both testes usually are descended into the scrotum by 12 to 14 weeks of age in dogs and by birth in cats. Because the inguinal canal does not close until about 6 months of age in dogs and 7 to 8 months of age in cats, and because there is greater anesthetic and surgical risk associated with removal of a retained testis than a descended testis, it may behoove veterinarians to defer surgery and wait for testicular descent rather than to perform surgery in a young animal that requires laparotomy for complete castration.

Castration in cats is performed as in adult animals. Tying of the spermatic cord onto itself is discouraged because the spermatic cord is short and the tissues are friable.¹¹ Castration in very young puppies may be performed as in cats, with bilateral scrotal incisions and healing of incisions by second intention, or may be performed with a prescrotal incision and subcuticular closure with absorbable suture material, as in adult dogs.¹²

BENEFITS OF GONADECTOMY

Societal

The primary societal benefit of gonadectomy, and the primary reason veterinarians perform pediatric gonadectomy in dogs and cats, is population control.¹⁴ It is currently estimated that 5 to 7 million dogs and cats enter humane societies yearly in the United States, and that approximately 3 to 4 million are euthanized.¹⁵ Pediatric gonadectomy is more commonly performed at humane organizations than at veterinary practices, largely for reasons of population control. Historically, only about 50% to 60% of those adopting animals from humane organizations have had their animal spayed or castrated despite subsidizing the cost. Gonadectomy performed before adoption ensures that those adopted animals will not repopulate their shelter with their offspring, may

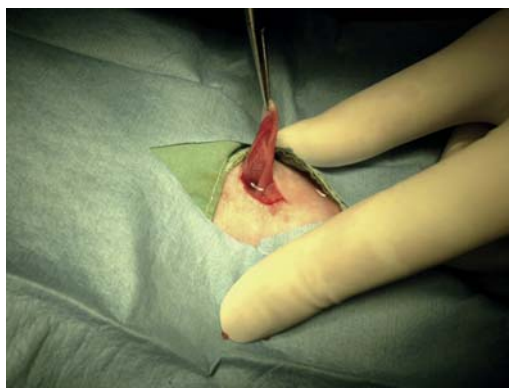


Fig. 1. Ovariectomy in a puppy. Note small size of the uterine horn and ovary, and presence of serous fluid. (Courtesy of MN Spay Neuter Assistance Program, Plymouth, MN; with permission.)

increase adoptability of those animals, and increase retention of the animals in their adoptive homes.¹⁴

Behavioral

It is not difficult to hypothesize the effects of gonadectomy on behavior. Gonadectomy is associated with changes in neurosteroid biosynthesis in the brain.¹⁶ Testosterone, estrogen, and progesterone are reported to have an anxiolytic effect, perhaps through stimulation of release of oxytocin and opioids; this effect may be lost with gonadectomy.^{17–19}

Reproductive behaviors are decreased by performance of gonadectomy, with females showing no behavioral changes associated with estrus, and males showing less roaming, mounting, and urine marking (dogs) and urine spraying and sexual aggression (cats). Changes in urine-spraying behavior in both male and female cats also are affected by environmental factors, including other cats in the household and similar stimuli.^{20,21} Gonadectomy will not effect change in inappropriate behaviors that are not driven by testosterone or estrogen (eg, fear-based aggression).

Medical

Mammary neoplasia

For female dogs and cats, the greatest benefits are decreased risk of development of mammary neoplasia when aged and lack of development of pyometra. Incidence of mammary neoplasia in cats is 2.5% and is virtually always malignant adenocarcinoma.^{22–24} Mammary neoplasia is 7 times more likely to occur in aged queens than in spayed female cats, with the greatest decrease in incidence associated with spaying before the first estrus.²⁴ Incidence of mammary neoplasia in dogs is 3.4%, with about 50% being benign fibroadenomas and 50% malignant adenocarcinomas.^{22,25–32} Incidence is greatly decreased by spaying, especially by spaying before the first heat.^{1,33,34} A recent attempt to determine the significance of these data by systematic review of the veterinary literature was unable to identify strong evidence suggesting that spaying decreases the risk of mammary cancer; however, this systematic review is based on work in human medicine and requires a massive body of literature, which does not exist in veterinary medicine.³⁵

Pyometra

Pyometra, an acute manifestation of infection overlying chronic development of cystic endometrial hyperplasia and exacerbated by endometrial reactivity under the influence of progesterone, is common in aged bitches, with a reported incidence of 23% to 25% by 10 years of age, and also occurs in queens.^{36,37} Ovariohysterectomy at the time of diagnosis is curative, but mortality with surgical management is 0% to 17% in dogs and 8% in cats.^{38,39}

Benign prostatic hypertrophy

With increasing age, the prostate of male dogs gradually increases in both cell number (hyperplasia) and size (hypertrophy). This process, termed benign prostatic hypertrophy (BPH), is manifested clinically in 50% of dogs by 2 to 3 years of age and in 75% to 80% by 6 years of age.^{40–42} Castration is associated with loss of secretory epithelial cells and decrease in prostate size, with resolution of clinical signs.⁴³ The smaller prostate also is less likely to become infected.

Testicular neoplasia

Testicular neoplasia is a common neoplasm of aged dogs, with a reported incidence of 0.9%.⁴⁴ Three tumor types commonly are identified: Sertoli cell tumor, interstitial

cell tumor, and seminoma. Metastasis is uncommon, and castration at the time of diagnosis is curative.

General considerations

In a large study of 1660 cats, gonadectomy before 5.5 months of age was associated with a decreased incidence of feline asthma in males and females, and a decreased incidence of abscesses, aggression toward the veterinarian, and urine spraying in male cats.⁴⁵ In a large study of 1842 dogs, gonadectomy at less than 5.5 months was associated with decreased frequency of episodes of separation anxiety and submissive urination.⁴⁶

DETRIMENTS OF GONADECTOMY

Behavioral

Several behavioral changes have been associated with gonadectomy in dogs and cats. As mentioned earlier, behaviors not associated with testosterone or estrogen secretion are unlikely to be affected by gonadectomy. Some studies identified a greater number of aggressive dogs among gonadectomized populations, but these studies were done at humane organizations where it may well be that the dogs were gonadectomized in an attempt to control inappropriate behaviors and when this failed, were relinquished. Two differing types of behavior change have been specifically associated with gonadectomy. Increased reactivity and aggression have been identified in dogs after gonadectomy^{47–51}; this may be associated with prior training or may be breed specific.^{52,53} In one study, dogs castrated at less than 5.5 months of age were more likely to show aggression toward family members and strangers, and to bark excessively, in comparison with dogs castrated later in life.⁴⁶ Other studies refute these findings, with either no change in behavior or a decrease in aggressive behaviors noted with gonadectomy.^{50,51,54–56} Cognitive decline was demonstrated to occur more quickly in one population of dogs after gonadectomy.⁵⁷ However, studies evaluating histologic changes in the brain associated with cognitive decline did not support gonadectomy as a causative factor.⁵⁸ In one survey of male and female cats gonadectomized at 6 to 13 weeks versus 6 to 7 months of age, no negative changes in behavior were noted.⁵⁹

Questions regularly arise regarding changes in working ability of dogs after gonadectomy. In one study of male guide dogs, there were no differences in behavior or in placement rate as a working dog when comparing dogs castrated at 7 to 8 weeks, 6 to 8 months, or 10 to 14 months of age.⁶⁰ One publication describing management of dogs housed with flocks of sheep recommended castration, as it decreased premature death of those dogs caused by roaming with subsequent vehicular accidents, trapping, shooting, or poisoning.⁶¹ Finally, one study evaluating effects of breed, gender, and intact status on trainability in dogs showed no effect of spaying on trainability of female dogs of any breed, no negative effect of castration in males of any breed, and a positive effect of castration on trainability of male dogs of one breed.⁶²

Medical

Surgical complications

The complication rate after ovariohysterectomy has been reported as 6.1% to 27% in bitches and 2.6% to 33% in queens.^{63,64} Intraoperative bleeding is of greatest concern in animals spayed while in estrus, and so is not a concern in prepuberal animals. Most complications are mild, not requiring veterinary intervention, and incidence is lower in young than in adult animals.^{10,63}

Obesity

Retrospective surveys have consistently demonstrated increased body condition in dogs and cats after gonadectomy.^{65,66} Research in rodents has shown an association between circulating steroid hormone concentrations and the concentration of adiponectin, a protein secreted by adipocytes that regulates lipid and glucose metabolism.⁶⁷ In cats, a decline in metabolic rate has been demonstrated after gonadectomy.^{68,69} Other changes in cats postgonadectomy include increase in body weight of up to 20% greater than their initial weight, increase in insulin-like growth factor 1 and leptin, and increase in fasting glucose and triglyceride concentrations, suggesting profound changes in glucose metabolism.^{70,71} In dogs, specific research documenting hormone changes and change in metabolic rate has not been published. Gonadectomy before 6 months of age was associated with a lower incidence of obesity in dogs in one study.⁴⁶ Obesity can be controlled by the animal's owner with appropriate diet and exercise.

Neoplasia

Incidence of several different types of cancers has been associated with gonadectomy in dogs, including prostatic carcinoma in male dogs, lymphosarcoma in male dogs, transitional cell carcinoma in female dogs, mast cell tumors in female dogs, and hemangiosarcoma and osteosarcoma in both male and female dogs. Cause and effect have not been defined. Because it also has been reported that life span is increased in animals that have been spayed or castrated, one might question whether this increased incidence is simply due to greater longevity in the gonadectomized population of dogs.¹

Incidence of prostatic carcinoma in dogs is low, at 0.2% to 0.6%.^{72,73} The reported increase in risk of developing prostatic carcinoma after castration is 2.4- to 4.3-fold.⁷²⁻⁷⁵ Cause and effect are not defined.

Lymphosarcoma in golden retrievers was reported to be significantly more common in males castrated before 1 year of age than in intact males; no cases were reported in males castrated when older than 1 year of age in that study.⁷⁶ There is a breed risk for lymphosarcoma in golden retrievers, and cause and effect with gonadectomy are not defined.

Transitional cell carcinoma is reportedly more common in female dogs after ovariohysterectomy, with a 2- to 4-fold increase in risk.^{77,78} Cause and effect are not defined.

Incidence of mast cell tumors was increased in female golden retrievers spayed after 1 year of age.⁷⁶ Cutaneous mast cell tumors were more common in spayed female dogs of various breeds than in intact female dogs.⁷⁹ Cause and effect are not defined.

Overall incidence of hemangiosarcoma, either of major vessels or the spleen, is 0.2% in dogs and 0.03% in cats.¹ Hemangiosarcoma was 4 times more common in female golden retrievers spayed after 1 year of age than in bitches spayed before 1 year of age or left intact in one study; in general, there is increased risk by a factor of 2.2 for splenic hemangiosarcoma and by a factor of 5 for cardiac hemangiosarcoma in spayed female dogs in comparison with intact bitches.^{76,80,81} In male dogs, the overall risk of hemangiosarcoma is increased by a factor of 2.4 after castration.^{80,81} Cause and effect are not defined.

Osteosarcoma is an uncommon tumor of dogs with high morbidity and mortality, with a reported incidence of 0.2%.⁴ Gonadectomy is a risk factor, with a 1.3- to 2-fold increased risk reported.^{82,83} Cause and effect are not defined.

Orthopedic problems

Injury or rupture of the cranial cruciate ligament has been reported to be more likely to occur in gonadectomized dogs than in intact dogs, even after accounting for the effect

of obesity.^{76,84–87} Cause and effect have not been identified, although hypothesized associations include changes in biomechanics resulting from hormonal change, and changes in structure of the stifle caused by alterations in growth-plate closure of the distal femur and proximal tibia, changing the tibial plateau angle and presumably putting more pressure on the cruciate ligaments. In rabbits, gonadectomy is associated with a decreased concentration of collagen in the cruciate ligaments.⁸⁸

Canine hip dysplasia also is reported to be more common in gonadectomized than in intact dogs.^{46,89} In a recent study of golden retrievers, the incidence of hip dysplasia was 10.3% in males castrated before 1 year of age compared with 5.1% in those left intact; no such effect of gonadectomy was demonstrated in female dogs in this study.⁷⁶ One hypothesized mechanism is alteration in hip-joint conformation caused by delays in physeal closure. In one study, although the incidence of hip dysplasia was higher in dogs gonadectomized when younger than 5.5 months, severity of disease was less than in dogs gonadectomized later in life.⁴⁶

Closure of the growth plates of long bones depends on sex steroids. Growth-plate closure is delayed in dogs and cats that are gonadectomized prepuberally.^{90–94} The clinical significance of this change is not known. Capital physeal fractures are reportedly more common in cats gonadectomized prepuberally, but obesity may have been a complicating factor in this study.⁹⁵

General considerations

External genitalia of dogs and cats gonadectomized prepuberally is infantile compared with animals gonadectomized postpuberally or left intact.^{91,96} Male cats castrated at 7 weeks of age were less likely to be able to extrude their penis from the prepuce in comparison with male cats castrated at 7 months of age or left intact.⁹⁶ The significance of these changes was not reported in these studies. It is hypothesized that maintenance of a juvenile vulva in female dogs, especially those who become overweight and have urinary incontinence, is associated with an increased incidence of perivulvar dermatitis and, perhaps, chronic vaginitis. In a large study evaluating long-term outcomes of dogs relative to age at gonadectomy, female dogs spayed before 5.5 months of age were more likely to develop cystitis, but none of the dogs described had more than 2 episodes of cystitis.⁴⁶

Urinary incontinence, more specifically urethral sphincter mechanism incompetence, is more common in spayed than in intact female dogs, with an incidence of 5% to 20%.^{97–100} In one large study, female dogs spayed at less than 3 months of age were at greatest risk; recent work refutes this, showing no correlation between age at gonadectomy and incidence of urinary incontinence.^{46,97} A recent attempt to determine the significance of these data by systematic review of the veterinary literature was unable to identify strong evidence demonstrating an association between age at ovariectomy and onset of urinary incontinence; however, this systematic review is based on work in human medicine and requires a massive body of literature, which does not exist in veterinary medicine.¹⁰¹ Specific cause and effect have not been defined, although it has been demonstrated that by 12 months after removal of ovaries, urethral closure pressure is significantly reduced.^{102,103} This condition is more common in larger dogs than in small dogs.⁹⁷

SUMMARY

There is much conflicting evidence in the veterinary literature regarding benefits and detriments of gonadectomy, with few of such studies directly addressing the effect of age at the time of surgery. One study asked veterinarians to rate morbidity and mortality of various disorders and multiplied this value by incidence to create an impact

Disorder	Female Dog	Male Dog	Female Cat	Male Cat
Mammary neoplasia	+24	—	+19	—
Pyometra	+100	—	—	—
Surgical complications	-20	-16	-7	-3
Osteosarcoma	-2	-2	—	—
Hemangiosarcoma	-2	-2	—	—
Transitional cell carcinoma	-7	-7	—	—
Prostate neoplasia	—	-3	—	—
Testicular neoplasia	—	+5	—	—
Urethral sphincter mechanism incompetence	-66	—	—	—
Benign prostatic hypertrophy	—	+368	—	—
Rupture of the cranial cruciate ligament	-11	-11	—	—
Obesity	-14	-13	-28	-26

^a Positive impact score = benefit from gonadectomy; negative impact score = detriment from gonadectomy.

score, to help guide veterinarians as they educate clients or make decisions for stray animals in shelters (Table 2).¹⁰⁴

For both species and genders, obesity is a significant detriment of gonadectomy. Veterinarians can use this opportunity to talk to clients about proper nutrition and exercise for maintenance of normal body weight. Setting aside obesity, the clear benefit of ovariohysterectomy for bitches and queens is evident. For male dogs, the high incidence of BPH artificially increases this impact factor. Because castration at the time of clinical manifestation of BPH is curative and because dogs are unlikely to develop clinical manifestations of this disorder until 2 to 3 years of age, castration can safely be deferred until that time in most dogs.⁴⁰⁻⁴² Benefits for male cats are primarily behavioral and are not readily assessed using impact factors. Because normal male cat reproductive behavior precludes their being good house pets and is readily controlled by castration, it is recommended that male cats be castrated prepuberally if they are not to be used for breeding.¹⁰⁵

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