To:	Maria Kostrencich	**From:**	Cathie Turner
Fax:	12139781079	**Pages:**	13
Re:	Oppose File Item # 07-1212 Spay/Neuter Ordinance)	**Date:**	1/31/2008

X **Urgent** **For Review** **Please Comment** **Please Reply** **For Information**

• **Comments:**

Honorable City Council Member:

I respectfully urge you to vote no on File Item # 07-1212 (Spay/Neuter Ordinance). Spay/neuter has adverse health risks that must be weighed against its benefits, on a case by case basis. One size does not fit all. Please see the attached report. Thank you.

Cathie Turner
Concerned Dog Owners of California

Long-Term Health Risks and Benefits Associated with Spay / Neuter in Dogs

Laura J. Sanborn, M.S.
May 14, 2007

Precis

At some point, most of us with an interest in dogs will have to consider whether or not to spay / neuter our pet. Tradition holds that the benefits of doing so at an early age outweigh the risks. Often, tradition holds sway in the decision-making process even after countervailing evidence has accumulated.

Ms Sanborn has reviewed the veterinary medical literature in an exhaustive and scholarly treatise, attempting to unravel the complexities of the subject. More than 50 peer-reviewed papers were examined to assess the health impacts of spay / neuter in female and male dogs, respectively. One cannot ignore the findings of increased risk from osteosarcoma, hemangiosarcoma, hypothyroidism, and other less frequently occurring diseases associated with neutering male dogs. It would be irresponsible of the veterinary profession and the pet owning community to fail to weigh the relative costs and benefits of neutering on the animal's health and well-being. The decision for females may be more complex, further emphasizing the need for individualized veterinary medical decisions, not standard operating procedures for all patients.

No sweeping generalizations are implied in this review. Rather, the author asks us to consider all the health and disease information available as individual animals are evaluated. Then, the best decisions should be made accounting for gender, age, breed, and even the specific conditions under which the long-term care, housing and training of the animal will occur.

This important review will help veterinary medical care providers as well as pet owners make informed decisions. Who could ask for more?

Larry S. Katz, PhD
Associate Professor and Chair
Animal Sciences
Rutgers University
New Brunswick, NJ 08901

INTRODUCTION

Dog owners in America are frequently advised to spay/neuter their dogs for health reasons. A number of health benefits are cited, yet evidence is usually not cited to support the alleged health benefits.

When discussing the health impacts of spay/neuter, health risks are often not mentioned. At times, some risks are mentioned, but the most severe risks usually are not.

This article is an attempt to summarize the long-term health risks and benefits associated with spay/neuter in dogs that can be found in the veterinary medical literature. This article will not discuss the impact of spay/neuter on population control, or the impact of spay/neuter on behavior.

Nearly all of the health risks and benefits summarized in this article are findings from retrospective epidemiological research studies of dogs, which examine potential associations by looking backwards in time. A few are from prospective research studies, which examine potential associations by looking forward in time.

SUMMARY

An objective reading of the veterinary medical literature reveals a complex situation with respect to the long-term health risks and benefits associated with spay/neuter in dogs. The evidence shows that spay/neuter

correlates with both positive AND adverse health effects in dogs. It also suggests how much we really do not yet understand about this subject.

On balance, it appears that no compelling case can be made for neutering most male dogs, especially immature male dogs, in order to prevent future health problems. The number of health problems associated with neutering may exceed the associated health benefits in most cases.

On the positive side, neutering male dogs

- eliminates the small risk (probably <1%) of dying from testicular cancer
- reduces the risk of non-cancerous prostate disorders
- reduces the risk of perianal fistulas
- may possibly reduce the risk of diabetes (data inconclusive)

On the negative side, neutering male dogs

- if done before 1 year of age, significantly increases the risk of osteosarcoma (bone cancer); this is a common cancer in medium/large and larger breeds with a poor prognosis.
- increases the risk of cardiac hemangiosarcoma by a factor of 1.6
- triples the risk of hypothyroidism
- increases the risk of progressive geriatric cognitive impairment
- triples the risk of obesity, a common health problem in dogs with many associated health problems
- quadruples the small risk (<0.6%) of prostate cancer
- doubles the small risk (<1%) of urinary tract cancers
- increases the risk of orthopedic disorders
- increases the risk of adverse reactions to vaccinations

For female dogs, the situation is more complex. The number of health benefits associated with spaying may exceed the associated health problems in some (not all) cases. On balance, whether spaying improves the odds of overall good health or degrades them probably depends on the age of the female dog and the relative risk of various diseases in the different breeds.

On the positive side, spaying female dogs

- if done before 2.5 years of age, greatly reduces the risk of mammary tumors, the most common malignant tumors in female dogs
- nearly eliminates the risk of pyometra, which otherwise would affect about 23% of intact female dogs; pyometra kills about 1% of intact female dogs
- reduces the risk of perianal fistulas
- removes the very small risk (≤0.5%) from uterine, cervical, and ovarian tumors

On the negative side, spaying female dogs

- if done before 1 year of age, significantly increases the risk of osteosarcoma (bone cancer); this is a common cancer in larger breeds with a poor prognosis
- increases the risk of splenic hemangiosarcoma by a factor of 2.2 and cardiac hemangiosarcoma by a factor of >5; this is a common cancer and major cause of death in some breeds
- triples the risk of hypothyroidism
- increases the risk of obesity by a factor of 1.6-2, a common health problem in dogs with many associated health problems
- causes urinary "spay incontinence" in 4-20% of female dogs
- increases the risk of persistent or recurring urinary tract infections by a factor of 3-4
- increases the risk of recessed vulva, vaginal dermatitis, and vaginitis, especially for female dogs spayed before puberty
- doubles the small risk (<1%) of urinary tract tumors
- increases the risk of orthopedic disorders
- increases the risk of adverse reactions to vaccinations

One thing is clear – much of the spay/neuter information that is available to the public is unbalanced and contains claims that are exaggerated or unsupported by evidence. Rather than helping to educate pet

owners, much of it has contributed to common misunderstandings about the health risks and benefits associated of spay/neuter in dogs.

The traditional spay/neuter age of six months as well as the modern practice of pediatric spay/neuter appear to predispose dogs to health risks that could otherwise be avoided by waiting until the dog is physically mature, or perhaps in the case of many male dogs, foregoing it altogether unless medically necessary.

The balance of long-term health risks and benefits of spay/neuter will vary from one dog to the next. Breed, age, and gender are variables that must be taken into consideration in conjunction with non-medical factors for each individual dog. Across-the-board recommendations for all pet dogs do not appear to be supportable from findings in the veterinary medical literature.

FINDINGS FROM STUDIES

This section summarizes the diseases or conditions that have been studied with respect to spay/neuter in dogs.

Complications from Spay/Neuter Surgery

All surgery incurs some risk of complications, including adverse reactions to anesthesia, hemorrhage, inflammation, infection, etc. Complications include only immediate and near term impacts that are clearly linked to the surgery, not to longer term impacts that can only be assessed by research studies.

At one veterinary teaching hospital where complications were tracked, the rates of intraoperative, postoperative and total complications were 6.3%, 14.1% and 20.6%, respectively as a result of spaying female dogs[1]. Other studies found a rate of total complications from spaying of 17.7%[2] and 23%[3]. A study of Canadian veterinary private practitioners found complication rates of 22% and 19% for spaying female dogs and neutering male dogs, respectively[4].

Serious complications such as infections, abscesses, rupture of the surgical wound, and chewed out sutures were reported at a 1- 4% frequency, with spay and castration surgeries accounting for 90% and 10% of these complications, respectively.[4]

The death rate due to complications from spay/neuter is low, at around 0.1%[2].

Prostate Cancer

Much of the spay/neuter information available to the public asserts that neutering will reduce or eliminate the risk that male dogs develop prostate cancer. This would not be an unreasonable assumption, given that prostate cancer in humans is linked to testosterone. But the evidence in dogs does not support this claim. In fact, the strongest evidence suggests just the opposite.

There have been several conflicting epidemiological studies over the years that found either an increased risk or a decreased risk of prostate cancer in neutered dogs. These studies did not utilize control populations, rendering these results at best difficult to interpret. This may partially explain the conflicting results.

More recently, two retrospective studies were conducted that did utilize control populations. One of these studies involved a dog population in Europe[5] and the other involved a dog population in America[6]. Both studies found that neutered male dogs have a four times *higher* risk of prostate cancer than intact dogs.

Based on their results, the researchers suggest a cause-and-effect relationship: "this suggests that castration does not initiate the development of prostatic carcinoma in the dog, but does favor tumor progression"[5] and also "Our study found that most canine prostate cancers are of ductal/urothelial origin....The relatively low incidence of prostate cancer in intact dogs may suggest that testicular hormones

are in fact protective against ductal/urothelial prostatic carcinoma, or may have indirect effects on cancer development by changing the environment in the prostate."[6]

This needs to be put in perspective. Unlike the situation in humans, prostate cancer is uncommon in dogs. Given an incidence of prostate cancer in dogs of less than 0.6% from necropsy studies[7], it is difficult to see that the risk of prostate cancer should factor heavily into most neutering decisions. There is evidence for an increased risk of prostate cancer in at least one breed (Bouviers)[5], though very little data so far to guide us in regards to other breeds.

Testicular Cancer

Since the testicles are removed with neutering, castration removes any risk of testicular cancer (assuming the castration is done before cancer develops). This needs to be compared to the risk of testicular cancer in intact dogs.

Testicular tumors are not uncommon in older intact dogs, with a reported incidence of 7%[8]. However, the prognosis for treating testicular tumors is very good owing to a low rate of metastasis[9], so testicular cancer is an uncommon cause of death in intact dogs. For example, in a Purdue University breed health survey of Golden Retrievers[10], deaths due to testicular cancer were sufficiently infrequent that they did not appear on list of significant causes of "Years of Potential Life Lost for Veterinary Confirmed Cause of Death" even though 40% of GR males were intact. Furthermore, the GRs who were treated for testicular tumors had a 90.9% cure rate. This agrees well with other work that found 6-14% rates of metastasis for testicular tumors in dogs[11].

The high cure rate of testicular tumors combined with their frequency suggests that fewer than 1% of intact male dogs will die of testicular cancer.

In summary, though it may be the most common reason why many advocate neutering young male dogs, the risk from life threatening testicular cancer is sufficiently low that neutering most male dogs to prevent it is difficult to justify.

An exception might be bilateral or unilateral cryptorchids, as testicles that are retained in the abdomen are 13.6 times more likely to develop tumors than descended testicles[12] and it is also more difficult to detect tumors in undescended testicles by routine physical examination.

Osteosarcoma (Bone Cancer)

A multi-breed case-control study of the risk factors for osteosarcoma found that spay/neutered dogs (males or females) had twice the risk of developing osteosarcoma as did intact dogs[13].

This risk was further studied in Rottweilers, a breed with a relatively high risk of osteosarcoma. This retrospective cohort study broke the risk down by age at spay/neuter, and found that the elevated risk of osteosarcoma is associated with spay/neuter of young dogs[14]. Rottweilers spayed/neutered before one year of age were 3.8 (males) or 3.1 (females) times more likely to develop osteosarcoma than intact dogs. Indeed, the combination of breed risk and early spay/neuter meant that Rottweilers spayed/neutered before one year of age had a 28.4% (males) and 25.1% (females) risk of developing osteosarcoma. These results are consistent with the earlier multi-breed study[13] but have an advantage of assessing risk as a function of age at neuter. A logical conclusion derived from combining the findings of these two studies is that spay/neuter of dogs before 1 year of age is associated with a significantly increased risk of osteosarcoma.

The researchers suggest a cause-and-effect relationship, as sex hormones are known to influence the maintenance of skeletal structure and mass, and also because their findings showed an inverse relationship between time of exposure to sex hormones and risk of osteosarcoma.[14]

The risk of osteosarcoma increases with increasing breed size and especially height[13]. It is a common cause of death in medium/large, large, and giant breeds. Osteosarcoma is the third most common cause of death in Golden Retrievers[10] and is even more common in larger breeds[13].

Given the poor prognosis of osteosarcoma and its frequency in many breeds, spay/neuter of immature dogs in the medium/large, large, and giant breeds is apparently associated with a significant and elevated risk of death due to osteosarcoma.

Mammary Cancer (Breast Cancer)

Mammary tumors are by far the most common tumors in intact female dogs, constituting some 53% of all malignant tumors in female dogs in a study of dogs in Norway[15] where spaying is much less common than in the USA.

50-60% of mammary tumors are malignant, for which there is a significant risk of metastasis[16]. Mammary tumors in dogs have been found to have estrogen receptors[17], and the published research[18] shows that the relative risk (odds ratio) that a female will develop mammary cancer compared to the risk in intact females is dependent on how many estrus cycles she experiences:

# of estrus cycles before spay	Odds Ratio
None	0.005
1	0.08
2 or more	0.26
Intact	1.00

The same data when categorized differently showed that the relative risk (odds ratio) that females will develop mammary cancer compared to the risk in intact females indicated that:

Age at Spaying	Odds Ratio
≤ 29 months	0.06
≥ 30 months	0.40 (not statistically significant at the $P<0.05$ level)
Intact	1.00

Please note that these are RELATIVE risks. This study has been referenced elsewhere many times but the results have often been misrepresented as absolute risks.

A similar reduction in breast cancer risk was found for women under the age of 40 who lost their estrogen production due to "artificial menopause"[19] and breast cancer in humans is known to be estrogen activated.

Mammary cancer was found to be the 10th most common cause of years of lost life in Golden Retrievers, even though 86% of female GRs were spayed, at a median age of 3.4 yrs[10]. Considering that the female subset accounts for almost all mammary cancer cases, it probably would rank at about the 5th most common cause of years of lost life in female GRs. It would rank higher still if more female GRs had been kept intact up to 30 months of age.

Boxers, cocker spaniels, English Springer spaniels, and dachshunds are breeds at high risk of mammary tumors[15]. A population of mostly intact female Boxers was found to have a 40% chance of developing mammary cancer between the ages of 6-12 years of age[15]. There are some indications that purebred dogs may be at higher risk than mixed breed dogs, and purebred dogs with high inbreeding coefficients may be at higher risk than those with low inbreeding coefficients[20]. More investigation is required to determine if these are significant.

In summary, spaying female dogs significantly reduces the risk of mammary cancer (a common cancer), and the fewer estrus cycles experienced at least up to 30 months of age, the lower the risk will be.

Female Reproductive Tract Cancer (Uterine, Cervical, and Ovarian Cancers)

Uterine/cervical tumors are rare in dogs, constituting just 0.3% of tumors in dogs[21].

Spaying will remove the risk of ovarian tumors, but the risk is only 0.5%[22].

While spaying will remove the risk of reproductive tract tumors, it is unlikely that surgery can be justified to prevent the risks of uterine, cervical, and ovarian cancers as the risks are so low.

Urinary Tract Cancer (Bladder and Urethra Cancers)

An age-matched retrospective study found that spay/neuter dogs were two times more likely to develop lower urinary tract tumors (bladder or urethra) compared to intact dogs[23]. These tumors are nearly always malignant, but are infrequent, accounting for less than 1% of canine tumors. So this risk is unlikely to weigh heavily on spay/neuter decisions.

Airedales, Beagles, and Scottish Terriers are at elevated risk for urinary tract cancer while German Shepherds have a lower than average risk[23].

Hemangiosarcoma

Hemangiosarcoma is a common cancer in dogs. It is a major cause of death in some breeds, such as Salukis, French Bulldogs, Irish Water Spaniels, Flat Coated Retrievers, Golden Retrievers, Boxers, Afghan Hounds, English Setters, Scottish Terriesr, Boston Terriers, Bulldogs, and German Shepherd Dogs[24].

In an aged-matched case controlled study, spayed females were found to have a 2.2 times higher risk of splenic hemangiosarcoma compared to intact females[24].

A retrospective study of cardiac hemangiosarcoma risk factors found a >5 times greater risk in spayed female dogs compared to intact female dogs and a 1.6 times higher risk in neutered male dogs compared to intact male dogs.[25] The authors suggest a protective effect of sex hormones against hemangiosarcoma, especially in females.

In breeds where hermangiosarcoma is an important cause of death, the increased risk associated with spay/neuter is likely one that should factor into decisions on whether or when to sterilize a dog.

Hypothyroidism

Spay/neuter in dogs was found to be correlated with a three fold increased risk of hypothyroidism compared to intact dogs. [26].

The researchers suggest a cause-and-effect relationship: They wrote: "More important [than the mild direct impact on thyroid function] in the association between [spaying and] neutering and hypothyroidism may be the effect of sex hormones on the immune system. Castration increases the severity of autoimmune thyroiditis in mice" which may explain the link between spay/neuter and hypothyroidism in dogs.

Hypothyroidism in dogs causes obesity, lethargy, hair loss, and reproductive abnormalities.[27]

The lifetime risk of hypothyroidism in breed health surveys was found to be 1 in 4 in Golden Retrievers[10], 1 in 3 in Akitas[28], and 1 in 13 in Great Danes[29].

Obesity

Owing to changes in metabolism, spay/neuter dogs are more likely to be overweight or obese than intact dogs. One study found a two fold increased risk of obesity in spayed females compared to intact females[30]. Another study found that spay/neuter dogs were 1.6 (females) or 3.0 (males) times more likely to be obese than intact dogs, and 1.2 (females) or 1.5 (males) times more likely to be overweight than intact dogs[31].

A survey study of veterinary practices in the UK found that 21% of dogs were obese.[30]

Being obese and/or overweight is associated with a host of health problems in dogs. Overweight dogs are more likely to be diagnosed with hyperadrenocorticism, ruptured cruciate ligament, hypothyroidism, lower urinary tract disease, and oral disease[32]. Obese dogs are more likely to be diagnosed with hypothyroidism, diabetes mellitus, pancreatitis, ruptured cruciate ligament, and neoplasia (tumors)[32].

Diabetes

Some data indicate that neutering doubles the risk of diabetes in male dogs, but other data showed no significant change in diabetes risk with neutering[33]. In the same studies, no association was found between spaying and the risk of diabetes.

Adverse Vaccine Reactions

A retrospective cohort study of adverse vaccine reactions in dogs was conducted, which included allergic reactions, hives, anaphylaxis, cardiac arrest, cardiovascular shock, and sudden death. Adverse reactions were 30% more likely in spayed females than intact females, and 27% more likely in neutered males than intact males[34].

The investigators discuss possible cause-and-effect mechanisms for this finding, including the roles that sex hormones play in body's ability to mount an immune response to vaccination.[34]

Toy breeds and smaller breeds are at elevated risk of adverse vaccine reactions, as are Boxers, English Bulldogs, Lhasa Apsos, Weimaraners, American Eskimo Dogs, Golden Retrievers, Basset Hounds, Welsh Corgis, Siberian Huskies, Great Danes, Labrador Retrievers, Doberman Pinschers, American Pit Bull Terriers, and Akitas.[34] Mixed breed dogs were found to be at lower risk, and the authors suggest genetic hetereogeneity (hybrid vigor) as the cause.

Urogenital Disorders

Urinary incontinence is common in spayed female dogs, which can occur soon after spay surgery or after a delay of up to several years. The incidence rate in various studies is 4-20% [35,36,37] for spayed females compared to only 0.3% in intact females[38]. Urinary incontinence is so strongly linked to spaying that it is commonly called "spay incontinence" and is caused by urethral sphincter incompetence[39], though the biological mechanism is unknown. Most (but not all) cases of urinary incontinence respond to medical treatment, and in many cases this treatment needs to be continued for the duration of the dog's life.[40]

A retrospective study found that persistent or recurring urinary tract (bladder) infections (UTIs) were 3-4 times more likely in spayed females dogs than in intact females[41]. Another retrospective study found that female dogs spayed before 5 ½ months of age were 2.76 times more likely to develop UTIs compared to those spayed after 5 ½ months of age.[42]

Depending on the age of surgery, spaying causes abnormal development of the external genitalia. Spayed females were found to have an increased risk of recessed vulva, vaginal dermatitis, vaginitis, and UTIs.[43] The risk is higher still for female dogs spayed before puberty.[43]

Pyometra (Infection of the Uterus)

Pet insurance data in Sweden (where spaying is very uncommon) found that 23% of all female dogs developed pyometra before 10 years of age[44]. Bernese Mountain dogs, Rottweilers, rough-haired Collies, Cavalier King Charles Spaniels and Golden Retrievers were found to be high risk breeds[44]. Female dogs that have not whelped puppies are at elevated risk for pyometra[45]. Rarely, spayed female dogs can develop "stump pyometra" related to incomplete removal of the uterus.

Pyometra can usually be treated surgically or medically, but 4% of pyometra cases led to death[44]. Combined with the incidence of pyometra, this suggests that about 1% of intact female dogs will die from pyometra.

Perianal Fistulas

Male dogs are twice as likely to develop perianal fistulas as females, and spay/neutered dogs have a decreased risk compared to intact dogs[46].

German Shepherd Dogs and Irish Setters are more likely to develop perianal fistulas than are other breeds.[46]

Non-cancerous Disorders of the Prostate Gland

The incidence of benign prostatic hypertrophy (BPH, enlarged prostate) increases with age in intact male dogs, and occurs in more than 80% of intact male dogs older than the age of 5 years[47]. Most cases of BPH cause no problems, but in some cases the dog will have difficulty defecating or urinating.

Neutering will prevent BPH. If neutering is done after the prostate has become enlarged, the enlarged prostate will shrink relatively quickly.

BPH is linked to other problems of the prostate gland, including infections, abscesses, and cysts, which can sometimes have serious consequences.

Orthopedic Disorders

In a study of beagles, surgical removal of the ovaries (as happens in spaying) caused an increase in the rate of remodeling of the ilium (pelvic bone)[48], suggesting an increased risk of hip dysplasia with spaying. Spaying was also found to cause a net loss of bone mass in the spine [49].

Spay/neuter of immature dogs delays the closure of the growth plates in bones that are still growing, causing those bones to end up significantly longer than in intact dogs or those spay/neutered after maturity[50]. Since the growth plates in various bones close at different times, spay/neuter that is done after some growth plates have closed but before other growth plates have closed might result in a dog with unnatural proportions, possibly impacting performance and long term durability of the joints.

Spay/neuter is associated with a two fold increased risk of cranial cruciate ligament rupture[51]. Perhaps this is associated with the increased risk of obesity[30].

Spay/neuter before 5 ½ months of age is associated with a 70% increased aged-adjusted risk of hip dysplasia compared to dogs spayed/neutered after 5 ½ months of age, though there were some indications that the former may have had a lower severity manifestation of the disease[42]. The researchers suggest "it is possible that the increase in bone length that results from early-age gonadectomy results in changes in joint conformation, which could lead to a diagnosis of hip dysplasia."

In a breed health survey study of Airedales, spay/neuter dogs were significantly more likely to suffer hip dysplasia as well as "any musculoskeletal disorder", compared to intact dogs[52], however possible confounding factors were not controlled for, such as the possibility that some dogs might have been spayed/neutered because they had hip dysplasia or other musculoskeletal disorders.

Compared to intact dogs, another study found that dogs neutered six months prior to a diagnosis of hip dysplasia were 1.5 times as likely to develop clinical hip dysplasia.[53]

Compared to intact dogs, spayed/neutered dogs were found to have a 3.1 fold higher risk of patellar luxation.[54]

Geriatric Cognitive Impairment

Neutered male dogs and spayed female dogs are at increased risk of progressing from mild to severe geriatric cognitive impairment compared to intact male dogs[55]. There weren't enough intact geriatric females available for the study to determine their risk.

Geriatric cognitive impairment includes disorientation in the house or outdoors, changes in social interactions with human family members, loss of house training, and changes in the sleep-wake cycle[55].

The investigators state "This finding is in line with current research on the neuro-protective roles of testosterone and estrogen at the cellular level and the role of estrogen in preventing Alzheimer's disease in human females. One would predict that estrogens would have a similar protective role in the sexually intact female dogs; unfortunately too few sexually intact female dogs were available for inclusion in the present study to test the hypothesis"[55]

CONCLUSIONS

An objective reading of the veterinary medical literature reveals a complex situation with respect to the long-term health risks and benefits associated with spay/neuter in dogs. The evidence shows that spay/neuter correlates with both positive AND adverse health effects in dogs. It also suggests how much we really do not yet understand about this subject.

On balance, it appears that no compelling case can be made for neutering most male dogs to prevent future health problems, especially immature male dogs. The number of health problems associated with neutering may exceed the associated health benefits in most cases.

For female dogs, the situation is more complex. The number of health benefits associated with spaying may exceed the associated health problems in many (not all) cases. On balance, whether spaying improves the odds of overall good health or degrades them probably depends on the age of the dog and the relative risk of various diseases in the different breeds.

The traditional spay/neuter age of six months as well as the modern practice of pediatric spay/neuter appear to predispose dogs to health risks that could otherwise be avoided by waiting until the dog is physically mature, or perhaps in the case of many male dogs, foregoing it altogether unless medically necessary.

The balance of long-term health risks and benefits of spay/neuter will vary from one dog to the next. Breed, age, and gender are variables that must be taken into consideration in conjunction with non-medical factors for each individual dog. Across-the-board recommendations for all dogs do not appear to be supportable from findings in the veterinary medical literature.

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To:	Brian Walters	**From:**	Cathie Turner
Fax:	12139781079	**Pages:**	13
Re:	Oppose File Item # 07-1212 Spay/Neuter Ordinance)	**Date:**	1/31/2008

X **Urgent** **For Review** **Please Comment** **Please Reply** **For Information**

• **Comments:**

Honorable City Council Member:

I respectfully urge you to vote no on File Item # 07-1212 (Spay/Neuter Ordinance). Spay/neuter has adverse health risks that must be weighed against its benefits, on a case by case basis. One size does not fit all. Please see the attached report. Thank you.

Cathie Turner
Concerned Dog Owners of California

Long-Term Health Risks and Benefits Associated with Spay / Neuter in Dogs

Laura J. Sanborn, M.S.
May 14, 2007

Precis

At some point, most of us with an interest in dogs will have to consider whether or not to spay / neuter our pet. Tradition holds that the benefits of doing so at an early age outweigh the risks. Often, tradition holds sway in the decision-making process even after countervailing evidence has accumulated.

Ms Sanborn has reviewed the veterinary medical literature in an exhaustive and scholarly treatise, attempting to unravel the complexities of the subject. More than 50 peer-reviewed papers were examined to assess the health impacts of spay / neuter in female and male dogs, respectively. One cannot ignore the findings of increased risk from osteosarcoma, hemangiosarcoma, hypothyroidism, and other less frequently occurring diseases associated with neutering male dogs. It would be irresponsible of the veterinary profession and the pet owning community to fail to weigh the relative costs and benefits of neutering on the animal's health and well-being. The decision for females may be more complex, further emphasizing the need for individualized veterinary medical decisions, not standard operating procedures for all patients.

No sweeping generalizations are implied in this review. Rather, the author asks us to consider all the health and disease information available as individual animals are evaluated. Then, the best decisions should be made accounting for gender, age, breed, and even the specific conditions under which the long-term care, housing and training of the animal will occur.

This important review will help veterinary medical care providers as well as pet owners make informed decisions. Who could ask for more?

Larry S. Katz, PhD
Associate Professor and Chair
Animal Sciences
Rutgers University
New Brunswick, NJ 08901

INTRODUCTION

Dog owners in America are frequently advised to spay/neuter their dogs for health reasons. A number of health benefits are cited, yet evidence is usually not cited to support the alleged health benefits.

When discussing the health impacts of spay/neuter, health risks are often not mentioned. At times, some risks are mentioned, but the most severe risks usually are not.

This article is an attempt to summarize the long-term health risks and benefits associated with spay/neuter in dogs that can be found in the veterinary medical literature. This article will not discuss the impact of spay/neuter on population control, or the impact of spay/neuter on behavior.

Nearly all of the health risks and benefits summarized in this article are findings from retrospective epidemiological research studies of dogs, which examine potential associations by looking backwards in time. A few are from prospective research studies, which examine potential associations by looking forward in time.

SUMMARY

An objective reading of the veterinary medical literature reveals a complex situation with respect to the long-term health risks and benefits associated with spay/neuter in dogs. The evidence shows that spay/neuter

correlates with both positive AND adverse health effects in dogs. It also suggests how much we really do not yet understand about this subject.

On balance, it appears that no compelling case can be made for neutering most male dogs, especially immature male dogs, in order to prevent future health problems. The number of health problems associated with neutering may exceed the associated health benefits in most cases.

On the positive side, neutering male dogs

- eliminates the small risk (probably <1%) of dying from testicular cancer
- reduces the risk of non-cancerous prostate disorders
- reduces the risk of perianal fistulas
- may possibly reduce the risk of diabetes (data inconclusive)

On the negative side, neutering male dogs

- if done before 1 year of age, significantly increases the risk of osteosarcoma (bone cancer); this is a common cancer in medium/large and larger breeds with a poor prognosis.
- increases the risk of cardiac hemangiosarcoma by a factor of 1.6
- triples the risk of hypothyroidism
- increases the risk of progressive geriatric cognitive impairment
- triples the risk of obesity, a common health problem in dogs with many associated health problems
- quadruples the small risk (<0.6%) of prostate cancer
- doubles the small risk (<1%) of urinary tract cancers
- increases the risk of orthopedic disorders
- increases the risk of adverse reactions to vaccinations

For female dogs, the situation is more complex. The number of health benefits associated with spaying may exceed the associated health problems in some (not all) cases. On balance, whether spaying improves the odds of overall good health or degrades them probably depends on the age of the female dog and the relative risk of various diseases in the different breeds.

On the positive side, spaying female dogs

- if done before 2.5 years of age, greatly reduces the risk of mammary tumors, the most common malignant tumors in female dogs
- nearly eliminates the risk of pyometra, which otherwise would affect about 23% of intact female dogs; pyometra kills about 1% of intact female dogs
- reduces the risk of perianal fistulas
- removes the very small risk (≤0.5%) from uterine, cervical, and ovarian tumors

On the negative side, spaying female dogs

- if done before 1 year of age, significantly increases the risk of osteosarcoma (bone cancer); this is a common cancer in larger breeds with a poor prognosis
- increases the risk of splenic hemangiosarcoma by a factor of 2.2 and cardiac hemangiosarcoma by a factor of >5; this is a common cancer and major cause of death in some breeds
- triples the risk of hypothyroidism
- increases the risk of obesity by a factor of 1.6-2, a common health problem in dogs with many associated health problems
- causes urinary "spay incontinence" in 4-20% of female dogs
- increases the risk of persistent or recurring urinary tract infections by a factor of 3-4
- increases the risk of recessed vulva, vaginal dermatitis, and vaginitis, especially for female dogs spayed before puberty
- doubles the small risk (<1%) of urinary tract tumors
- increases the risk of orthopedic disorders
- increases the risk of adverse reactions to vaccinations

One thing is clear – much of the spay/neuter information that is available to the public is unbalanced and contains claims that are exaggerated or unsupported by evidence. Rather than helping to educate pet

owners, much of it has contributed to common misunderstandings about the health risks and benefits associated of spay/neuter in dogs.

The traditional spay/neuter age of six months as well as the modern practice of pediatric spay/neuter appear to predispose dogs to health risks that could otherwise be avoided by waiting until the dog is physically mature, or perhaps in the case of many male dogs, foregoing it altogether unless medically necessary.

The balance of long-term health risks and benefits of spay/neuter will vary from one dog to the next. Breed, age, and gender are variables that must be taken into consideration in conjunction with non-medical factors for each individual dog. Across-the-board recommendations for all pet dogs do not appear to be supportable from findings in the veterinary medical literature.

FINDINGS FROM STUDIES

This section summarizes the diseases or conditions that have been studied with respect to spay/neuter in dogs.

Complications from Spay/Neuter Surgery

All surgery incurs some risk of complications, including adverse reactions to anesthesia, hemorrhage, inflammation, infection, etc. Complications include only immediate and near term impacts that are clearly linked to the surgery, not to longer term impacts that can only be assessed by research studies.

At one veterinary teaching hospital where complications were tracked, the rates of intraoperative, postoperative and total complications were 6.3%, 14.1% and 20.6%, respectively as a result of spaying female dogs[1]. Other studies found a rate of total complications from spaying of 17.7%[2] and 23%[3]. A study of Canadian veterinary private practitioners found complication rates of 22% and 19% for spaying female dogs and neutering male dogs, respectively[4].

Serious complications such as infections, abscesses, rupture of the surgical wound, and chewed out sutures were reported at a 1- 4% frequency, with spay and castration surgeries accounting for 90% and 10% of these complications, respectively.[4]

The death rate due to complications from spay/neuter is low, at around 0.1%[2].

Prostate Cancer

Much of the spay/neuter information available to the public asserts that neutering will reduce or eliminate the risk that male dogs develop prostate cancer. This would not be an unreasonable assumption, given that prostate cancer in humans is linked to testosterone. But the evidence in dogs does not support this claim. In fact, the strongest evidence suggests just the opposite.

There have been several conflicting epidemiological studies over the years that found either an increased risk or a decreased risk of prostate cancer in neutered dogs. These studies did not utilize control populations, rendering these results at best difficult to interpret. This may partially explain the conflicting results.

More recently, two retrospective studies were conducted that did utilize control populations. One of these studies involved a dog population in Europe[5] and the other involved a dog population in America[6]. Both studies found that neutered male dogs have a four times *higher* risk of prostate cancer than intact dogs.

Based on their results, the researchers suggest a cause-and-effect relationship: "this suggests that castration does not initiate the development of prostatic carcinoma in the dog, but does favor tumor progression"[5] and also "Our study found that most canine prostate cancers are of ductal/urothelial origin....The relatively low incidence of prostate cancer in intact dogs may suggest that testicular hormones

are in fact protective against ductal/urothelial prostatic carcinoma, or may have indirect effects on cancer development by changing the environment in the prostate."[6]

This needs to be put in perspective. Unlike the situation in humans, prostate cancer is uncommon in dogs. Given an incidence of prostate cancer in dogs of less than 0.6% from necropsy studies[7], it is difficult to see that the risk of prostate cancer should factor heavily into most neutering decisions. There is evidence for an increased risk of prostate cancer in at least one breed (Bouviers)[5], though very little data so far to guide us in regards to other breeds.

Testicular Cancer

Since the testicles are removed with neutering, castration removes any risk of testicular cancer (assuming the castration is done before cancer develops). This needs to be compared to the risk of testicular cancer in intact dogs.

Testicular tumors are not uncommon in older intact dogs, with a reported incidence of 7%[8]. However, the prognosis for treating testicular tumors is very good owing to a low rate of metastasis[9], so testicular cancer is an uncommon cause of death in intact dogs. For example, in a Purdue University breed health survey of Golden Retrievers[10], deaths due to testicular cancer were sufficiently infrequent that they did not appear on list of significant causes of "Years of Potential Life Lost for Veterinary Confirmed Cause of Death" even though 40% of GR males were intact. Furthermore, the GRs who were treated for testicular tumors had a 90.9% cure rate. This agrees well with other work that found 6-14% rates of metastasis for testicular tumors in dogs[11].

The high cure rate of testicular tumors combined with their frequency suggests that fewer than 1% of intact male dogs will die of testicular cancer.

In summary, though it may be the most common reason why many advocate neutering young male dogs, the risk from life threatening testicular cancer is sufficiently low that neutering most male dogs to prevent it is difficult to justify.

An exception might be bilateral or unilateral cryptorchids, as testicles that are retained in the abdomen are 13.6 times more likely to develop tumors than descended testicles[12] and it is also more difficult to detect tumors in undescended testicles by routine physical examination.

Osteosarcoma (Bone Cancer)

A multi-breed case-control study of the risk factors for osteosarcoma found that spay/neutered dogs (males or females) had twice the risk of developing osteosarcoma as did intact dogs[13].

This risk was further studied in Rottweilers, a breed with a relatively high risk of osteosarcoma. This retrospective cohort study broke the risk down by age at spay/neuter, and found that the elevated risk of osteosarcoma is associated with spay/neuter of young dogs[14]. Rottweilers spayed/neutered before one year of age were 3.8 (males) or 3.1 (females) times more likely to develop osteosarcoma than intact dogs. Indeed, the combination of breed risk and early spay/neuter meant that Rottweilers spayed/neutered before one year of age had a 28.4% (males) and 25.1% (females) risk of developing osteosarcoma. These results are consistent with the earlier multi-breed study[13] but have an advantage of assessing risk as a function of age at neuter. A logical conclusion derived from combining the findings of these two studies is that spay/neuter of dogs before 1 year of age is associated with a significantly increased risk of osteosarcoma.

The researchers suggest a cause-and-effect relationship, as sex hormones are known to influence the maintenance of skeletal structure and mass, and also because their findings showed an inverse relationship between time of exposure to sex hormones and risk of osteosarcoma.[14]

The risk of osteosarcoma increases with increasing breed size and especially height[13]. It is a common cause of death in medium/large, large, and giant breeds. Osteosarcoma is the third most common cause of death in Golden Retrievers[10] and is even more common in larger breeds[13].

Given the poor prognosis of osteosarcoma and its frequency in many breeds, spay/neuter of immature dogs in the medium/large, large, and giant breeds is apparently associated with a significant and elevated risk of death due to osteosarcoma.

Mammary Cancer (Breast Cancer)

Mammary tumors are by far the most common tumors in intact female dogs, constituting some 53% of all malignant tumors in female dogs in a study of dogs in Norway[15] where spaying is much less common than in the USA.

50-60% of mammary tumors are malignant, for which there is a significant risk of metastasis[16]. Mammary tumors in dogs have been found to have estrogen receptors[17], and the published research[18] shows that the relative risk (odds ratio) that a female will develop mammary cancer compared to the risk in intact females is dependent on how many estrus cycles she experiences:

# of estrus cycles before spay	Odds Ratio
None	0.005
1	0.08
2 or more	0.26
Intact	1.00

The same data when categorized differently showed that the relative risk (odds ratio) that females will develop mammary cancer compared to the risk in intact females indicated that:

Age at Spaying	Odds Ratio
≤ 29 months	0.06
≥ 30 months	0.40 (not statistically significant at the $P<0.05$ level)
Intact	1.00

Please note that these are RELATIVE risks. This study has been referenced elsewhere many times but the results have often been misrepresented as absolute risks.

A similar reduction in breast cancer risk was found for women under the age of 40 who lost their estrogen production due to "artificial menopause"[19] and breast cancer in humans is known to be estrogen activated.

Mammary cancer was found to be the 10th most common cause of years of lost life in Golden Retrievers, even though 86% of female GRs were spayed, at a median age of 3.4 yrs[10]. Considering that the female subset accounts for almost all mammary cancer cases, it probably would rank at about the 5th most common cause of years of lost life in female GRs. It would rank higher still if more female GRs had been kept intact up to 30 months of age.

Boxers, cocker spaniels, English Springer spaniels, and dachshunds are breeds at high risk of mammary tumors[15]. A population of mostly intact female Boxers was found to have a 40% chance of developing mammary cancer between the ages of 6-12 years of age[15]. There are some indications that purebred dogs may be at higher risk than mixed breed dogs, and purebred dogs with high inbreeding coefficients may be at higher risk than those with low inbreeding coefficients[20]. More investigation is required to determine if these are significant.

In summary, spaying female dogs significantly reduces the risk of mammary cancer (a common cancer), and the fewer estrus cycles experienced at least up to 30 months of age, the lower the risk will be.

Female Reproductive Tract Cancer (Uterine, Cervical, and Ovarian Cancers)

Uterine/cervical tumors are rare in dogs, constituting just 0.3% of tumors in dogs[21].

Spaying will remove the risk of ovarian tumors, but the risk is only 0.5%[22].

While spaying will remove the risk of reproductive tract tumors, it is unlikely that surgery can be justified to prevent the risks of uterine, cervical, and ovarian cancers as the risks are so low.

Urinary Tract Cancer (Bladder and Urethra Cancers)

An age-matched retrospective study found that spay/neuter dogs were two times more likely to develop lower urinary tract tumors (bladder or urethra) compared to intact dogs[23]. These tumors are nearly always malignant, but are infrequent, accounting for less than 1% of canine tumors. So this risk is unlikely to weigh heavily on spay/neuter decisions.

Airedales, Beagles, and Scottish Terriers are at elevated risk for urinary tract cancer while German Shepherds have a lower than average risk[23].

Hemangiosarcoma

Hemangiosarcoma is a common cancer in dogs. It is a major cause of death in some breeds, such as Salukis, French Bulldogs, Irish Water Spaniels, Flat Coated Retrievers, Golden Retrievers, Boxers, Afghan Hounds, English Setters, Scottish Terriesr, Boston Terriers, Bulldogs, and German Shepherd Dogs[24].

In an aged-matched case controlled study, spayed females were found to have a 2.2 times higher risk of splenic hemangiosarcoma compared to intact females[24].

A retrospective study of cardiac hemangiosarcoma risk factors found a >5 times greater risk in spayed female dogs compared to intact female dogs and a 1.6 times higher risk in neutered male dogs compared to intact male dogs.[25] The authors suggest a protective effect of sex hormones against hemangiosarcoma, especially in females.

In breeds where hermangiosarcoma is an important cause of death, the increased risk associated with spay/neuter is likely one that should factor into decisions on whether or when to sterilize a dog.

Hypothyroidism

Spay/neuter in dogs was found to be correlated with a three fold increased risk of hypothyroidism compared to intact dogs. [26].

The researchers suggest a cause-and-effect relationship: They wrote: "More important [than the mild direct impact on thyroid function] in the association between [spaying and] neutering and hypothyroidism may be the effect of sex hormones on the immune system. Castration increases the severity of autoimmune thyroiditis in mice" which may explain the link between spay/neuter and hypothyroidism in dogs.

Hypothyroidism in dogs causes obesity, lethargy, hair loss, and reproductive abnormalities.[27]

The lifetime risk of hypothyroidism in breed health surveys was found to be 1 in 4 in Golden Retrievers[10], 1 in 3 in Akitas[28], and 1 in 13 in Great Danes[29].

Obesity

Owing to changes in metabolism, spay/neuter dogs are more likely to be overweight or obese than intact dogs. One study found a two fold increased risk of obesity in spayed females compared to intact females[30]. Another study found that spay/neuter dogs were 1.6 (females) or 3.0 (males) times more likely to be obese than intact dogs, and 1.2 (females) or 1.5 (males) times more likely to be overweight than intact dogs[31].

A survey study of veterinary practices in the UK found that 21% of dogs were obese.[30]

Being obese and/or overweight is associated with a host of health problems in dogs. Overweight dogs are more likely to be diagnosed with hyperadrenocorticism, ruptured cruciate ligament, hypothyroidism, lower urinary tract disease, and oral disease[32]. Obese dogs are more likely to be diagnosed with hypothyroidism, diabetes mellitus, pancreatitis, ruptured cruciate ligament, and neoplasia (tumors)[32].

Diabetes

Some data indicate that neutering doubles the risk of diabetes in male dogs, but other data showed no significant change in diabetes risk with neutering[33]. In the same studies, no association was found between spaying and the risk of diabetes.

Adverse Vaccine Reactions

A retrospective cohort study of adverse vaccine reactions in dogs was conducted, which included allergic reactions, hives, anaphylaxis, cardiac arrest, cardiovascular shock, and sudden death. Adverse reactions were 30% more likely in spayed females than intact females, and 27% more likely in neutered males than intact males[34].

The investigators discuss possible cause-and-effect mechanisms for this finding, including the roles that sex hormones play in body's ability to mount an immune response to vaccination.[34]

Toy breeds and smaller breeds are at elevated risk of adverse vaccine reactions, as are Boxers, English Bulldogs, Lhasa Apsos, Weimaraners, American Eskimo Dogs, Golden Retrievers, Basset Hounds, Welsh Corgis, Siberian Huskies, Great Danes, Labrador Retrievers, Doberman Pinschers, American Pit Bull Terriers, and Akitas.[34] Mixed breed dogs were found to be at lower risk, and the authors suggest genetic hetereogeneity (hybrid vigor) as the cause.

Urogenital Disorders

Urinary incontinence is common in spayed female dogs, which can occur soon after spay surgery or after a delay of up to several years. The incidence rate in various studies is 4-20%[35,36,37] for spayed females compared to only 0.3% in intact females[38]. Urinary incontinence is so strongly linked to spaying that it is commonly called "spay incontinence" and is caused by urethral sphincter incompetence[39], though the biological mechanism is unknown. Most (but not all) cases of urinary incontinence respond to medical treatment, and in many cases this treatment needs to be continued for the duration of the dog's life.[40]

A retrospective study found that persistent or recurring urinary tract (bladder) infections (UTIs) were 3-4 times more likely in spayed females dogs than in intact females[41]. Another retrospective study found that female dogs spayed before 5 ½ months of age were 2.76 times more likely to develop UTIs compared to those spayed after 5 ½ months of age.[42]

Depending on the age of surgery, spaying causes abnormal development of the external genitalia. Spayed females were found to have an increased risk of recessed vulva, vaginal dermatitis, vaginitis, and UTIs.[43] The risk is higher still for female dogs spayed before puberty.[43]

Pyometra (Infection of the Uterus)

Pet insurance data in Sweden (where spaying is very uncommon) found that 23% of all female dogs developed pyometra before 10 years of age[44]. Bernese Mountain dogs, Rottweilers, rough-haired Collies, Cavalier King Charles Spaniels and Golden Retrievers were found to be high risk breeds[44]. Female dogs that have not whelped puppies are at elevated risk for pyometra[45]. Rarely, spayed female dogs can develop "stump pyometra" related to incomplete removal of the uterus.

Pyometra can usually be treated surgically or medically, but 4% of pyometra cases led to death[44]. Combined with the incidence of pyometra, this suggests that about 1% of intact female dogs will die from pyometra.

Perianal Fistulas

Male dogs are twice as likely to develop perianal fistulas as females, and spay/neutered dogs have a decreased risk compared to intact dogs[46].

German Shepherd Dogs and Irish Setters are more likely to develop perianal fistulas than are other breeds.[46]

Non-cancerous Disorders of the Prostate Gland

The incidence of benign prostatic hypertrophy (BPH, enlarged prostate) increases with age in intact male dogs, and occurs in more than 80% of intact male dogs older than the age of 5 years[47]. Most cases of BPH cause no problems, but in some cases the dog will have difficulty defecating or urinating.

Neutering will prevent BPH. If neutering is done after the prostate has become enlarged, the enlarged prostate will shrink relatively quickly.

BPH is linked to other problems of the prostate gland, including infections, abscesses, and cysts, which can sometimes have serious consequences.

Orthopedic Disorders

In a study of beagles, surgical removal of the ovaries (as happens in spaying) caused an increase in the rate of remodeling of the ilium (pelvic bone)[48], suggesting an increased risk of hip dysplasia with spaying. Spaying was also found to cause a net loss of bone mass in the spine [49].

Spay/neuter of immature dogs delays the closure of the growth plates in bones that are still growing, causing those bones to end up significantly longer than in intact dogs or those spay/neutered after maturity[50]. Since the growth plates in various bones close at different times, spay/neuter that is done after some growth plates have closed but before other growth plates have closed might result in a dog with unnatural proportions, possibly impacting performance and long term durability of the joints.

Spay/neuter is associated with a two fold increased risk of cranial cruciate ligament rupture[51]. Perhaps this is associated with the increased risk of obesity[30].

Spay/neuter before 5 ½ months of age is associated with a 70% increased aged-adjusted risk of hip dysplasia compared to dogs spayed/neutered after 5 ½ months of age, though there were some indications that the former may have had a lower severity manifestation of the disease[42]. The researchers suggest "it is possible that the increase in bone length that results from early-age gonadectomy results in changes in joint conformation, which could lead to a diagnosis of hip dysplasia."

In a breed health survey study of Airedales, spay/neuter dogs were significantly more likely to suffer hip dysplasia as well as "any musculoskeletal disorder", compared to intact dogs[52], however possible confounding factors were not controlled for, such as the possibility that some dogs might have been spayed/neutered because they had hip dysplasia or other musculoskeletal disorders.

Compared to intact dogs, another study found that dogs neutered six months prior to a diagnosis of hip dysplasia were 1.5 times as likely to develop clinical hip dysplasia.[53]

Compared to intact dogs, spayed/neutered dogs were found to have a 3.1 fold higher risk of patellar luxation.[54]

Geriatric Cognitive Impairment

Neutered male dogs and spayed female dogs are at increased risk of progressing from mild to severe geriatric cognitive impairment compared to intact male dogs[55]. There weren't enough intact geriatric females available for the study to determine their risk.

Geriatric cognitive impairment includes disorientation in the house or outdoors, changes in social interactions with human family members, loss of house training, and changes in the sleep-wake cycle[55].

The investigators state "This finding is in line with current research on the neuro-protective roles of testosterone and estrogen at the cellular level and the role of estrogen in preventing Alzheimer's disease in human females. One would predict that estrogens would have a similar protective role in the sexually intact female dogs; unfortunately too few sexually intact female dogs were available for inclusion in the present study to test the hypothesis"[55]

CONCLUSIONS

An objective reading of the veterinary medical literature reveals a complex situation with respect to the long-term health risks and benefits associated with spay/neuter in dogs. The evidence shows that spay/neuter correlates with both positive AND adverse health effects in dogs. It also suggests how much we really do not yet understand about this subject.

On balance, it appears that no compelling case can be made for neutering most male dogs to prevent future health problems, especially immature male dogs. The number of health problems associated with neutering may exceed the associated health benefits in most cases.

For female dogs, the situation is more complex. The number of health benefits associated with spaying may exceed the associated health problems in many (not all) cases. On balance, whether spaying improves the odds of overall good health or degrades them probably depends on the age of the dog and the relative risk of various diseases in the different breeds.

The traditional spay/neuter age of six months as well as the modern practice of pediatric spay/neuter appear to predispose dogs to health risks that could otherwise be avoided by waiting until the dog is physically mature, or perhaps in the case of many male dogs, foregoing it altogether unless medically necessary.

The balance of long-term health risks and benefits of spay/neuter will vary from one dog to the next. Breed, age, and gender are variables that must be taken into consideration in conjunction with non-medical factors for each individual dog. Across-the-board recommendations for all dogs do not appear to be supportable from findings in the veterinary medical literature.

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Determining the optimal age for gonadectomy of dogs and cats

Margaret V. Root Kustritz, DVM, PhD, DACT

Elective gonadectomy of dogs and cats, most commonly performed as an OHE of females and castration of males, is one of the most common veterinary procedures performed in the United States.[1] Increasingly, dog owners and members of the veterinary profession throughout the world have questioned the optimal age for performance of these surgeries or whether they should even be performed as elective surgeries. The objective for the information reported here was to provide a review of the scientific evidence, which could be used by veterinarians to counsel clients appropriately on this issue.

Abbreviations

OHE	Ovariohysterectomy
TCC	Transitional cell carcinoma
CCL	Cranial cruciate ligament
FLUTD	Feline lower urinary tract disease
BPH	Benign prostatic hypertrophy-hyperplasia

Traditional Age at Gonadectomy

Currently, most veterinarians in the United States recommend that elective gonadectomy be performed in dogs and cats at 6 to 9 months of age. However, there does not appear to be any scientific evidence to document that this is the optimal age. In fact, the age at which pets have traditionally been spayed and neutered has varied through the years and with geographic location. In the early 1900s, OHE was performed at 3 to 6 months of age and castration as early as 4 weeks of age.[2] Over time, the recommended age for elective gonadectomy of small animals increased to 6 to 9 months of age. It has been hypothesized that this was the result of an increasing popularity of dogs and cats as pets as American citizens found themselves with more disposable income, a subsequent desire by those pet owners for reproduction control in their animals, and the intent of veterinarians to provide the safest possible anesthesia and surgery for these new "family members." Despite great advances in anesthetic and surgical techniques and multiple studies that provide evidence for the safety of anesthesia and surgery in dogs and cats of younger ages, veterinarians in the United States still cling to the recommendation to perform gonadectomy at 6 to 9 months of age, with the added stipulation that bitches and queens should be spayed before their first estrus.

In some parts of the world, elective gonadectomy is considered unethical and is strongly discouraged or disallowed by professional veterinary associations.[2] Elective gonadectomy is illegal in at least 1 country.[3] In 1 article[4] published in Europe, elective gonadectomy is decried as "the tool of despots and tyrants throughout history," and the author of that article claims that gonadectomized dogs are "canine eunuchs, condemned to live their lives in a physical and mental twilight." That author also questions how a profession that publicly declares itself the guardian of animal welfare can, with impunity, perform elective surgery on animals for human convenience.[4]

Cultural and personal factors, including religious affiliation, ethnic background, intended working life of the animal, urban or rural location of the household, and literacy status, also may be associated with the likelihood that an owner will request gonadectomy for a pet.[5-7] Species and sex also play a role; in retrospective surveys, cats are more likely to be spayed or castrated than dogs, and bitches and queens are more likely to have undergone elective gonadectomy than stud dogs or tomcats.[8-9]

Surgical and anesthetic techniques for elective gonadectomy in dogs and cats of various ages are provided in the veterinary literature.[10-12] The reported incidence of postoperative complications in 1,016 dogs and 1,459 cats after elective surgery was 6.1% and 2.6%, respectively, with most of these considered minor problems, including inflammation at the incision site and gastrointestinal tract upset.[13] Complications were more common in dogs that underwent surgery when they were > 2 years of age.[13] In a study[14] in which investigators evaluated complications in 142 dogs undergoing OHE performed by fourth-year veterinary students, incidence of intraoperative complications was 6.3% and incidence of postoperative complications was 14.2%. Again, most of these were minor, including self-resolving hemorrhage and inflammation at the incision site and gastrointestinal tract upset. In that study,[14] the high incidence of postoperative complications was associated with an increase in surgery time, which was in turn positively correlated with increasing body weight of the animal. In studies[15-17] in which incidence of intraoperative and postoperative complications for elective gonadectomies performed at various ages was compared, the only com-

From the Department of Veterinary Clinical Sciences, College of Veterinary Medicine, University of Minnesota, Saint Paul, MN 55108.

plication associated with age at time of surgery was an increased incidence of postoperative infectious disease in dogs undergoing elective gonadectomy when they were < 12 weeks old. This may have been an artifact of the source from which dogs were recruited for the study.[17]

Societal Benefits of Elective Gonadectomy

The primary societal benefits of elective gonadectomy in dogs and cats are fewer animals relinquished to humane organizations and the fact that a specific animal's contribution to pet overpopulation is minimized. Multiple studies[9,18-20] have revealed that sexually intact dogs and cats are more likely to be relinquished to humane organizations than are those that are gonadectomized. In only 1 study[21] was it reported that there was an increased percentage of gonadectomized animals among those relinquished to humane organizations; animals in that study were relinquished for behavioral reasons, and it was considered likely that they had been gonadectomized as a possible treatment for behavioral problems, but with no subsequent improvement after surgery.

Millions of dogs and cats are euthanized at humane organizations annually in the United States, with estimates of 5.4 to 9.1 million dogs and 5.7 to 9.5 million cats euthanized in 1990.[22,23] Crude estimates of annual death rates in dogs and cats are 7.9% and 8.3%, respectively.[24] Statistics from humane organizations housing at least 100 animals/y, combined with these death rates, suggest that < 400,000 dogs and cats should be euthanized at humane organizations annually.[25] Not all animals euthanized at humane organizations are euthanized because of overpopulation[26]; however, the aforementioned study[25] indicates that > 2 million dogs and cats were euthanized at those shelters alone and substantiates the loss of animal life and stress to workers at humane organizations associated with overpopulation of dogs and cats in the United States.

Sexually intact animals adopted from humane organizations may be returned or may reproduce, both of which would repopulate those shelters. In 1 study,[8] 36.4% of relinquished animals were from unwanted litters. In a survey[24] of dog- and cat-owning households in the United States, 56% of 154 canine litters and 68% of 317 feline litters were unplanned. There is a lack of knowledge about reproduction among animal owners; the most common reason reported for the unplanned canine litters was that the owner did not know the bitch was in heat.[24] Up to 57% of bitch owners were unaware that bitches may cycle twice each year, up to 83% of cat owners were unaware that queens are seasonally polyestrous, and up to 61% of dog and cat owners were not certain or truly believed that their pet would be better if it had a litter before OHE was performed.[9,27,28]

Owners that adopt animals from humane organizations routinely sign a spay-neuter contract. However, compliance with such contracts is typically < 60%.[8,29] Up to 90% of veterinarians support mandatory gonadectomy of dogs and cats prior to adoption.[30] Few venues exist for educating veterinarians in early-age gonadectomy of dogs and cats, with most being self-taught.[30,31] Enhanced training of veterinarians in early-age gonadectomy and pediatric anesthetic techniques, mandatory gonadectomy of dogs and cats prior to adoption, and increased education of dog and cat owners about small animal reproductive physiology can only be of benefit in addressing these societal issues.

Benefits and Detriments of Elective Gonadectomy for Behavioral Concerns

Sexually dimorphic behaviors are those most commonly displayed by 1 sex, with mounting and urine spraying as primary examples.[32] Aggression may be a sexually dimorphic behavior. Most commonly, only those forms of aggression associated with the presence of females in estrus (aggression between females or between males housed with those females) are considered sexually dimorphic. Gonadectomy and the subsequent decrease in gonadal steroid hormones have been correlated with a decrease in sexually dimorphic behaviors.[18,33-37] Likelihood that gonadectomy will impact sexually dimorphic behaviors is not correlated with duration of the problem behavior and may or may not be associated with prior sexual experience of the affected animal.[35,36,38-41] Trainability of working dogs is not altered by gonadectomy and does not vary with age of the dog at the time of gonadectomy.[8]

Sexual behavior of male cats makes them extremely undesirable, and often unsafe, household pets.[42] A decrease in sexually dimorphic behaviors after castration of male cats is an extremely powerful benefit of elective gonadectomy. Sexual behaviors of queens, bitches, and stud dogs, although still possibly undesirable, are less commonly so severe as to make these animals untenable as household pets.

Nonsexually dimorphic behaviors are not typically affected by gonadectomy. One large-scale study[43] of dogs revealed a possible increase in noise phobias and decrease in separation anxiety and submissive urination associated with gonadectomy performed before the dogs were 5 months old.

An increase in reactivity toward humans with strange (unfamiliar) dogs and in aggression toward family members has been reported after OHE of bitches in several studies.[44-46] The reason for this possible tendency has not been defined but may be attributable to a decrease in estrogen and oxytocin concentrations, both of which may exert antianxiety effects in some species.[47] This tendency also may be a breed-specific phenomenon.

Cognitive function may be altered by gonadectomy. Comparison of the progression of cognitive dysfunction in sexually intact and castrated male dogs revealed a slowing of progression in sexually intact males.[48] Sample size was small in that study, with only 6 dogs in the sexually intact male group. Androgen deprivation has been associated with increased amyloid deposition in brains of humans and rodents and with decreased synapses in brains of rodents and nonhuman primates.[49] However, in a study[50] in which investigators directly examined brain tissue for DNA damage, a significantly greater percentage of neurons had extensive DNA damage in sexually intact Beagles than in castrated Beagles between 9 and 10.5 years of age.

Benefits and Detriments of Elective Gonadectomy for Various Conditions

Several conditions in dogs and cats can be impacted by elective gonadectomy, including neoplasia and orthopedic diseases. Knowledge of the benefits and detriments associated with elective gonadectomy enables veterinarians to provide the best counsel to clients and also to promote animal health.

Mammary gland neoplasms—Mammary gland neoplasms are the most common tumors of female dogs, with a reported incidence of 3.4%, and they are the third most common tumors of female cats, with a reported incidence of 2.5%.[51,55] Mammary gland neoplasms are the most common types of malignant tumors in dogs.[53] Mean percentage of mammary gland tumors in female dogs that are malignant is 50.9%.[53,56-58] In female cats, > 90% of mammary gland tumors are malignant.[53,59,60] Metastases are reported in up to 77% of dogs with mammary gland carcinomas, with the lungs being the site of metastasis in 30.8% of affected dogs.[61,62] In 1 study,[62] 59.7% of dogs in which a mammary gland tumor was diagnosed were euthanized at the time of diagnosis.

Increasing age and breed are risk factors for development of mammary gland neoplasms, with a mean age at diagnosis of approximately 10 years in dogs and cats.[52,63,64] Breeds reported to be at increased risk for developing mammary gland tumors include the Boxer, Brittany, Cocker Spaniel, Dachshund, English Setter, English Springer Spaniel, German Shepherd Dog, Maltese, Miniature Poodle, Pointer, Toy Poodle, and Yorkshire Terrier. Cat breeds reported to be at increased risk of tumor development are the Japanese domestic breeds and Siamese (**Table 1**).[52,64,65]

Maintenance of sexually intact status is a major risk factor for development of mammary gland tumors in dogs and cats.[60,66] Overall, sexually intact dogs and cats have 7 times the risk of developing mammary gland neoplasms when they get older, compared with the risk for spayed dogs and cats.[67] Compared with the incidence in sexually intact dogs, dogs spayed before their first estrus have a 0.5% risk, dogs spayed after 1 estrus have an 8.0% risk, and dogs spayed after 2 estrous cycles have a 26.0% risk of developing mammary gland neoplasms when they get older.[68] However, performing an OHE may even have a substantial sparing effect in older dogs, with a reduced but still evident reduction for mammary gland neoplasms in dogs spayed as late as 9 years of age.[69]

An exact cause-and-effect relationship between sexually intact status and mammary gland neoplasia has not been defined. Estrogen and progesterone have direct and indirect stimulatory effects on mammary gland tissue, and receptors for both hormones have been identified in normal and neoplastic mammary gland tissues.[69-71] In 1 report,[69] it was suggested that mammary gland neoplasms may be more likely to develop in bitches that had overt pseudopregnancy more than 3 times during their life, which would support the hypothesis that there is a hormonal effect or a direct effect of malignant transformation of metabolically active mammary gland tissue.

Prostatic neoplasms—The reported incidence of prostatic tumors in dogs is 0.2% to 0.6%, and prostatic neoplasms in dogs are almost always malignant adenocarcinomas.[72-74] There is neoplastic differentiation in tissues of ductal or urothelial origin, which are androgen-independent tissues.[75] However, castrated dogs are at an increased risk for development of prostatic neoplasms, with the increase in risk ranging from 2.4 to 4.3 times that of sexually intact male dogs (**Table 2**).[72,74,76] Mean age of dogs at diagnosis is approximately 10 years, with slightly younger dogs having prostatic adenocarcinoma with metastases to bones.[74,77,78] An exact cause-and-effect relationship has not been defined, but it has been suggested[75] that deprivation of androgens does not act to initiate neoplasia; rather, androgen deprivation permits progression of disease.

Other types of tumors—Testicular tumors are the second most common tumor type in dogs, with a reported incidence of 0.9%.[b] Mean age of dogs at diagnosis is approximately 10 years.[63,64,79] Most tumors are readily diagnosed during physical inspection. Malignancy is considered low for all types of testicular tumors; therefore, castration is curative.[80]

Ovarian and uterine tumors are uncommon in dogs and cats. Although malignant tumors of both tissues have been reported, metastasis is rare and OHE is curative in most situations.[81-84]

Table 1—Benefits and detriments of OHE for various conditions in female cats.

Condition	Incidence	Substantial morbidity?	Specific breeds at risk?
Benefits			
Mammary gland neoplasms	2.5% in all cats; greatly reduced when spayed before first estrus	Yes	Yes*
Ovarian or uterine tumors	Low	No	No
Pyometra	Increases with age	No	No
Detriments			
Complications of surgery	2.6%	No	No
Obesity	High	No	No
FLUTD	0.6%	No	No
Diabetes mellitus	0.5%	No	Yes†

*Japanese domestic breeds and Siamese. †Burmese.

Table 2 Benefits and detriments of gonadectomy for various conditions in male dogs.

Condition	Incidence	Substantial morbidity?	Specific breeds at risk?
Benefits			
Testicular neoplasms	0.9%	No	No
BPH or prostatitis	75% 80% by 6 years of age	No	No
Detriments			
Complications of surgery	6.1%	No	No
Prostatic neoplasms	0.2% 0.6%	Yes	No
TCC	< 1%	No	Yes*
Osteosarcoma	0.2%	Yes	Yes†
Hemangiosarcoma	0.2%	Yes	Yes‡
CCL rupture	1.8%	Yes	Yes§
Obesity	2.8%	No	Yes‖
Diabetes mellitus	0.5%	No	Yes¶

*Airedale Terrier, Beagle, Collie, Scottish Terrier, Shetland Sheepdog, West Highland White Terrier, and Wire Fox Terrier. †Doberman Pinscher, Great Dane, Irish Setter, Irish Wolfhound, Rottweiler, and Saint Bernard. ‡Boxer, English Setter, German Shepherd Dog, Golden Retriever, Great Dane, Labrador Retriever, Pointer, Poodle, and Siberian Husky. §Akita, American Staffordshire Terrier, Chesapeake Bay Retriever, German Shepherd Dog, Golden Retriever, Labrador Retriever, Mastiff, Neapolitan Mastiff, Newfoundland, Poodle, and Saint Bernard. ‖Beagle, Cairn Terrier, Cavalier King Charles Spaniel, Cocker Spaniel, Dachshund, Labrador Retriever. ¶Airedale Terrier, Cocker Spaniel, Dachshund, Doberman Pinscher, Golden Retriever, Irish Setter, Miniature Schnauzer, Pomeranian, and Shetland Sheepdog.

The most common tumor of the urinary tract of dogs is TCC of the bladder.[85,86] Overall incidence of TCC in dogs is reported to be, at most, 1% of all malignant tumors.[89] Breeds at increased risk for development of a TCC include the Airedale Terrier, Beagle, Collie, Scottish Terrier, Shetland Sheepdog, West Highland White Terrier, and Wire Fox Terrier (Table 3).[90] Gonadectomized animals have a risk for development of TCC approximately 2 to 4 times that of sexually intact animals.[85,86] An exact cause-and-effect relationship has not been defined.

Osteosarcoma is a highly malignant tumor, with a reported incidence of 0.2%.[64] Risk of development of osteosarcoma increases with age and may increase with increasing body weight.[91,92] Breeds reported to be at increased risk for development of an osteosarcoma include the Doberman Pinscher, Great Dane, Irish Setter, Irish Wolfhound, Rottweiler, and Saint Bernard.[91,93] In 1 study[92] in which historical data that consisted of owners' assessments of body condition score and body weight were used for analysis, incidence of osteosarcoma was not correlated with body weight. However, owner assessment of body condition score is poorly correlated with veterinarian assessment of body condition score.[94]

Gonadectomy can increase the risk of development of osteosarcoma by 1.3 to 2.0 times.[91,95] In 1 study[92] in which investigators evaluated 683 purebred Rottweilers, there was a significant increase in the incidence of osteosarcoma in female and male dogs that had undergone gonadectomy when < 1 year of age, however, the overall incidence of osteosarcoma in this population of dogs was much higher than that in the general population, which suggested a hereditary component. Furthermore, life span of dogs did not differ (mean ± SD life span of sexually intact and castrated male dogs was 9.3 ± 2.5 years and 9.2 ± 2.5 years, respectively) or was noticeably increased (mean life span in sexually intact and spayed female dogs was 7.5 ± 2.4 years and 9.8 ± 2.4 years, respectively) in gonadectomized dogs.[92] An exact cause-and-effect relationship has not been defined.

Hemangiosarcoma is the most common cardiac tumor in dogs, with a reported incidence of 0.2%.[96] Breeds at increased risk for development of hemangiosarcoma include the Boxer, English Setter, German Shepherd Dog, Golden Retriever, Great Dane, Labrador Retriever, Pointer, Poodle, and Siberian Husky, with large breeds (in general) at increased risk, compared with the risk for small breeds.[97] For both cardiac and splenic hemangiosarcoma, relative risk is increased for gonadectomized animals, with spayed females reportedly having 2.2 times the risk of splenic hemangiosarcoma and 5 times the risk of cardiac hemangiosarcoma, compared with the risk for sexually intact females, and castrated males having 2.4 times the risk, compared with the risk for sexually intact males.[96,98] An exact cause-and-effect relationship has not been defined.

Orthopedic abnormalities—Postmenopausal women or those who have undergone OHE have explicit concerns about osteoporosis. However, there is no decrease in mineral density of bone in dogs after OHE.[99-101]

Timing of closure of the physes of long bones is controlled in part by gonadal hormones. In both dogs and cats, gonadectomy at any age prior to physeal closure delays that closure and is associated with statistically significant, although not readily visible or clinically relevant, lengthening of associated long bones.[34,102-106] However, no specific correlation has been found between age at gonadectomy and incidence of long-bone fractures, including physeal fractures.[35] In 1 study,[107] there was an increase in the incidence of capital physeal fractures in the femurs of castrated male cats; however, the cats with fractures were also overweight.

Table 3—Benefits and detriments of OHE for various conditions in female dogs.

Condition	Incidence	Substantial morbidity?	Specific breeds at risk?
Benefits			
Mammary gland neoplasms	3.4% in all dogs; greatly reduced when spayed before first estrus	Yes	Yes*
Ovarian or uterine tumors	Low	No	No
Pyometra	15.2% by 4 years of age; 23% to 24% by 10 years of age	Yes	Yes†
Detriments			
Complications of surgery	6.1%	No	No
Aggression	Variable	Potentially	Yes‡
TCC	< 1%	No	Yes§
Osteosarcoma	0.2%	Yes	Yes‖
Hemangiosarcoma	0.2%	Yes	Yes¶
CCL rupture	1.8%	Yes	Yes#
Obesity	2.8%	No	Yes**
Diabetes mellitus	0.5%	No	Yes††
Urinary incontinence	4.9% 20.0%; increased when spayed at < 3 months of age	No	Yes‡‡

*Boxer, Brittany, Cocker Spaniel, Dachshund, English Setter, English Springer Spaniel, German Shepherd Dog, Maltese, Miniature Poodle, Pointer, Toy Poodle, and Yorkshire Terrier. †Bernese Mountain Dog, Cavalier King Charles Spaniel, Chow Chow, Collie, English Cocker Spaniel, Golden Retriever, Rottweiler, and Saint Bernard. ‡English Springer Spaniel. §Airedale Terrier, Beagle, Collie, Scottish Terrier, Shetland Sheepdog, West Highland White Terrier, and Wire Fox Terrier. ‖Doberman Pinscher, Great Dane, Irish Setter, Irish Wolfhound, Rottweiler, and Saint Bernard. ¶Boxer, English Setter, German Shepherd Dog, Golden Retriever, Great Dane, Labrador Retriever, Pointer, Poodle, and Siberian Husky. #Akita, American Staffordshire Terrier, Chesapeake Bay Retriever, German Shepherd Dog, Golden Retriever, Labrador Retriever, Mastiff, Neapolitan Mastiff, Newfoundland, Poodle, and Saint Bernard. **Beagle, Cairn Terrier, Cavalier King Charles Spaniel, Cocker Spaniel, Dachshund, and Labrador Retriever. ††Airedale Terrier, Cocker Spaniel, Dachshund, Doberman Pinscher, Golden Retriever, Irish Setter, Miniature Schnauzer, Pomeranian, and Shetland Sheepdog. ‡‡Boxer, Doberman Pinscher, Giant Schnauzer, Irish Setter, Old English Sheepdog, Rottweiler, Springer Spaniel, and Weimaraner.

Hip dysplasia is a hereditary condition in dogs that affects females and males with equal frequency and can be controlled (to some extent) by environmental factors, including diet.[106-111] The reported incidence of hip dysplasia is 1.7%, with an increased incidence in large- and giant-breed dogs, most particularly in the Chesapeake Bay Retriever, English Setter, German Shepherd Dog, Golden Retriever, Labrador Retriever, Samoyed, and Saint Bernard breeds.[112] In 1 large study[43] of 1,842 dogs, there was an increased incidence of hip dysplasia in dogs spayed or castrated prior to 5 months of age; however, it was not clear whether the diagnosis of hip dysplasia was confirmed by a veterinarian in all affected dogs.

Rupture of the CCL is more common in women than in men and may be more likely to occur during certain phases of the menstrual cycle, which suggests a hormonal effect on joint stability.[113] Dog breeds reported to be at increased risk of CCL rupture include the Akita, American Staffordshire Terrier, Chesapeake Bay Retriever, German Shepherd Dog, Golden Retriever, Labrador Retriever, Mastiff, Neapolitan Mastiff, Newfoundland, Poodle, Rottweiler, and Saint Bernard.[114,115] Reported incidence of CCL rupture is 1.8%, and it reportedly is more prevalent in gonadectomized female and male dogs than in sexually intact dogs.[115-117] An exact cause-and-effect relationship has not been defined, but heredity plays a role in the predisposition toward CCL injury, as might body weight and body condition score. To my knowledge, there have been no studies for which the results would implicate alterations in physeal closure with subsequent asynchrony of long-bone growth and abnormalities in joint formation as a cause of CCL rupture in dogs.[115,118]

Obesity—Obesity is the most common nutritional disorder of dogs and cats, with a reported incidence of 2.8% among the entire dog population.[119] It is a multifactorial problem. Risk factors include breed, with an increased incidence of obesity in Beagles, Cairn Terriers, Cavalier King Charles Spaniels, Cocker Spaniels, Dachshunds, and Labrador Retrievers; housing; increasing age[6]; ownership by an overweight person or a person ≥ 40 years old; and, possibly, sex of the dog.[94,119-122]

The most commonly reported risk factor for obesity is gonadectomy, with spayed or castrated dogs and cats much more commonly designated by veterinarians as being overweight or obese, compared with the weight designations for sexually intact animals.[33,121-127] In 1 study,[128] 34% of castrated male and 38% of spayed female dogs were considered overweight or obese. It is unclear whether age at the time of gonadectomy has an effect on subsequent obesity. Studies[34,102,103] in dogs failed to detect differences in food intake, body weight, or depth of back fat when comparing dogs gonadectomized at 7 or 8 weeks of age and dogs gonadectomized at 7 months of age. A retrospective study[13] of 1,842 dogs revealed a decrease in the incidence of obesity in dogs gonadectomized prior to 5 months of age when compared with those gonadectomized at > 5 months of age. Similarly, although cats are more likely than dogs

to become obese after gonadectomy, no correlation has been found between age at gonadectomy and final body weight or amount of body fat.[34]

Metabolic rate decreases after gonadectomy in cats.[125,126] A cause-and-effect relationship between gonadectomy and obesity in dogs is less clearly defined. Spayed female dogs have an increase in food intake and increase in indiscriminate appetite after OHE, compared with those of sham-operated or age-matched control dogs.[44,129] Estrogen may act as a satiety factor, which would explain these changes.[122] This does not address the correlation between obesity and castration in male dogs. In both dogs and cats, obesity is not a mandatory consequence of gonadectomy; instead, it is controllable with an appropriate diet, feeding regimen, and exercise regimen.[130]

Urinary tract disorders—Spayed female dogs reportedly have an increased risk of developing urinary tract infections.[43,131] A cause-and-effect relationship has not been defined.

Female dogs spayed before onset of puberty may be more likely to maintain a juvenile or recessed vulva. In 1 study,[104] bitches spayed at 7 weeks of age had a vulva with a more immature appearance, compared with the vulva in bitches spayed at 7 months of age. It is the author's experience that bitches spayed as adults will have vulvar atrophy, which achieves the same result. A juvenile vulva in an otherwise healthy dog is of no clinical relevance. Overweight bitches with a recessed vulva, especially those with concurrent urinary incontinence, are more likely to develop perivulvar dermatitis.

Male dogs castrated at 7 weeks of age had less penile development than did dogs castrated when they were older.[102] Male cats castrated before onset of puberty may have a decreased ability to extrude the penis.[132,133] Clinical relevance of this phenomenon is not known.

Feline lower urinary tract disease is a syndrome consisting of hematuria, dysuria or pollakiuria, and possible urethral obstruction and is most commonly classified as idiopathic. The reported incidence of FLUTD is 0.6%.[134] Despite numerous vehemently declared anecdotes of an increase in the incidence of urethral obstruction in male cats castrated when young, numerous studies[35,132,135] have failed to detect a correlation between gonadectomy of cats at any age and a decrease in diameter of the urethra or an increase in incidence of FLUTD, with or without urethral obstruction. In 1 large study,[136] investigators identified gonadectomy as a risk factor for development of FLUTD in both female and male cats and also identified an increased risk of development of FLUTD in overweight or obese cats. In that study, sexually intact female cats had a relatively reduced risk for development of FLUTD.

Urethral sphincter mechanism incompetence, formerly known as estrogen-responsive urinary incontinence, is a common problem of spayed female dogs.[137-139] The condition is evident with equal frequency in ovariohysterectomized or ovariectomized female dogs, with the reported incidence ranging from 4.9% to 20.0%.[43,138-140] Studies[17,141] have failed to detect a correlation between age at time of OHE and likelihood of developing incontinence. In a study[43] of 983 female dogs, bitches were significantly less likely to develop incontinence when spayed at > 3 months of age. Other risk factors include body weight, with dogs weighing > 20 kg (44 lb) at increased risk; breed, with Boxers, Doberman Pinschers, Giant Schnauzers, Irish Setters, Old English Sheepdogs, Rottweilers, Springer Spaniels, and Weimaraners at increased risk and Labrador Retrievers at decreased risk in European studies; and urethral length or resting position of the urinary bladder.[137,140,142-145] An exact cause-and-effect relationship has not been defined, with research currently focusing on altered gonadotropin secretion after gonadectomy.[146-150] Typically, urethral sphincter mechanism incompetence is easily controlled with medical treatments.

Adrenal gland disease—To the author's knowledge, there are no reports of an increase in the incidence of adrenal gland disease associated with sexually intact status in dogs and cats. In the United States, almost all ferrets are gonadectomized when extremely young; the incidence of adrenal gland disease in ferrets is higher in the United States than in European countries where ferrets are not routinely spayed or castrated.[151,152] In 1 study[152] in Europe, a correlation was detected between age at gonadectomy and age at onset of adrenal gland disease, with ferrets gonadectomized at a younger age having clinical signs of adrenal gland disease earlier in life. Sexually intact ferrets also have adrenal gland disease.[153] Possible causes for this include lack of down-regulation of sex steroids or an increase in circulating concentrations of gonadotropins that causes adrenal gland hyperplasia and possibly contributes to neoplastic transformation.[154-158]

Pyometra—Incidence of pyometra in dogs and cats in the United States has not been reported, perhaps because of the prevalence of OHE in these species before they reach an age when they would be likely to develop pyometra. In other countries, 15.2% and 23% to 24% of bitches developed pyometra by 4 and 10 years of age, respectively.[157,158] Pyometra is more common in nulliparous bitches than in bitches with a history of carrying a pregnancy successfully to term.[158,159] There is a significant likelihood that cats will have clinical evidence of uterine disease when queens reach 5 years of age.[160] Dog breeds reported to be at increased risk of developing pyometra include the Bernese Mountain Dog, Cavalier King Charles Spaniel, Chow Chow, Collie, English Cocker Spaniel, Golden Retriever, Rottweiler, and Saint Bernard.[158,159] In animals with pyometra, OHE is curative, with reported mortality rates of 0% to 17% in dogs and 8% in cats.[161,162]

Nonneoplastic prostatic disease—Benign prostatic hypertrophy-hyperplasia is a common disorder in sexually intact male dogs. In 1 study,[163] investigators evaluated male dogs. Of 300 sexually intact male dogs, 231 (63.4%) had BPH; all castrated male dogs in that study had profound prostatic atrophy. Development of BPH is positively correlated with age.[164-166] By 2.4 years of age, half of all sexually intact dogs will have histologic or clinical evidence of BPH, with the incidence increasing to 75% to 80% by 6 years of age and 95% to 100% by 9 years of age.[164,166,167] In addition, BPH predisposes dogs to prostatitis.[168] Neither BPH nor prostatitis is commonly associated with substantial morbidity, and

castration is an integral part of the treatment of both conditions.[169,170]

Endocrine disorders—The reported incidence of diabetes mellitus in dogs is 0.5%.[171] Risk factors include breed, with Miniature Poodles, Miniature Schnauzers, Pugs, Samoyeds, and Toy Poodles at increased risk; sex, with female dogs more commonly affected than male dogs; and increasing age.[171,172] In 1 study,[172] a possible increase in the risk of developing diabetes mellitus was detected in castrated male dogs; however, it was not defined whether this could have been associated with obesity in these animals. In cats, the reported incidence of diabetes mellitus is 0.4% and risk factors include breed, with Burmese cats at increased risk; sex, with males at increased risk; and increasing age.[173-175] Gonadectomized male and female cats have an increased risk, with gonadectomized cats having 8.7 times greater odds of developing diabetes mellitus than for sexually intact cats.[173,174]

The incidence of hypothyroidism in dogs is 0.2% to 0.3%.[176,177] A breed predisposition has been described for the Airedale Terrier, Cocker Spaniel, Dachshund, Doberman Pinscher, Golden Retriever, Irish Setter, Miniature Schnauzer, Pomeranian, and Sherland Sheepdog breeds.[176,177] Those studies[176,177] have revealed an increased risk of development of hypothyroidism for spayed female and castrated male dogs, compared with the risk for sexually intact dogs. A cause-and-effect relationship has not been defined. Hypothyroidism typically is easily controlled with medical treatment.

Life span—Life expectancy at birth for women in the United States is 80.4 years, whereas that for men is 75.2 years.[178] Results for dogs vary,[179-181] with females living longer than males in some studies and the reverse being found in other studies. Negative correlations have been detected between body weight and longevity and between height and longevity in dogs.[182] Several studies[179-181] have revealed an increase in longevity for gonadectomized animals when compared with that for sexually intact animals. In sockeye salmon, life span is significantly longer in fish castrated before gonadal development.[183] Results of these studies argue against the evolutionary theory, which holds that it is not prudent for a population to carry individuals that have aged past reproductive usefulness.[50] In dogs and cats, this may be a reflection of enhanced care of animals by owners who have made the investment of surgery or a decrease in risk-associated behaviors (such as roaming) in gonadectomized animals.

Conclusions

How does a veterinarian reconcile all of these data to make the best possible recommendation regarding optimal age at which to neuter male and female dogs and cats? The author provides the following assertions:

- Animals housed at humane societies should be treated as a population. Societal benefit resulting from gonadectomy of unowned dogs and cats in the United States outweighs all other concerns. Male and female dogs and cats should be spayed or castrated before being offered for adoption by humane organizations.
- Pets should be considered individually, with the understanding that for these pets, population control is a less important concern than is health of each animal. Dogs and cats should be maintained as household pets. Responsible owners should ensure that their pets are provided appropriate and regularly scheduled veterinary care.
- The behavior of most sexually intact male cats makes them undesirable or dangerous as pets. Because castration substantially reduces these sexually dimorphic behaviors, it is recommended that all male cats not intended for breeding be castrated prior to puberty and that all breeding males be castrated as soon as their use as a breeding male has ceased.
- For female cats and male and female dogs, veterinarians and owners must consider the benefits and detriments of gonadectomy for each animal (Tables 1–3). Factors to be considered include incidence of various conditions associated with gonadectomy; degree of morbidity, with substantial morbidity defined as a condition prevalent in > 1% of the population, associated with > 50% of the malignancy or mortality rates, or not easily controlled by noninvasive treatments or good husbandry; breed; and intended working or breeding life of each animal.

As an example, consider a discussion between a veterinarian and the owner of an 8-week-old female Labrador Retriever that is not intended for breeding. This dog would benefit greatly from OHE before her first estrus as a means of preventing mammary gland tumors, which are extremely common and cause substantial morbidity (Table 3). Because of her breed, detriments of OHE include an increased predisposition to CCL injury, hemangiosarcoma, and obesity. However, there is a low incidence of hemangiosarcoma, and obesity can be readily controlled with good husbandry, which leaves CCL injury as the most important possible detriment. Because the incidence of CCL rupture is lower than that of mammary gland neoplasia, a veterinarian may choose to recommend OHE and educate the owner about maintenance of optimal body condition and other management techniques that will minimize potential for CCL injury. An OHE should be performed before the dog's first estrus. To minimize the potential for development of urinary incontinence, the veterinarian may choose to wait to perform the OHE until after the dog has reached 3 months of age.

The information provided here on the risks and detriments of gonadectomy is not intended to promote or to minimize the importance of gonadectomy as a means of controlling animal populations or possible impacts on animal health or behavior of a specific animal. The veterinary profession recognizes the need for individual assessment of risk and benefit when evaluating vaccination protocols for animals. Elucidation of the genome in various species may lead to individualized diagnostic and treatment plans for each animal in the future. It behooves us as veterinarians dedicated to the provision of the best possible care for animals to educate clients and evaluate each animal carefully when making recommendations regarding gonadectomy.

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Judith A. Brecka
Law Office of Judith A. Brecka
2018 Pico Blvd.
Santa Monica, CA 90405
(310) 452-1210 fax: (310) 314-7360

Facsimile Cover Sheet

January 30,2008

To: Ed P. Reyes,.(213)485-8907,Wendy Greuel (213)680-7805, Dennis P. Zine (213) 485-8088, Tom LaBonge (213) 624-7810Jack Weiss (213) 978-2250,Tony Cardenas (213) 847-0549, Richard Alarcon (213) 847-0707, Bernard Parks (213) 485-7683,Jan Perry (213) 473-5946,Herb J. Wesson, Jr. (213)485-9829, Bill Rosendahl (213) 473-6920,Grieg Smith (213)473-6925,Eric Garcette (213) 613-0819,Jose Huizar, (213) 847-0680, Janice Hahn (213) 626-5431, Mayor Villarigosa (213)978-0750,John White (213) 978-1079

From: Judith A. Brecka, Esq.
(310) 314-7360

RE: **opposition to council file #07-1212**
mandatory spay/neuter & microchipping of dogs and cats

Judith A. Brecka
Law Office of Judith A. Brecka
2018 Pico Blvd.
Santa Monica, CA 90405
(310) 452-1210 fax:(310) 314-7360

January 31, 2008

January 31, 2008

The Honorable Los Angeles City Council
Mayor Villaraigosa
John White, Legislative Assistant

Dear Council members, Mayor Villaraigosa and Mr. White:

Re: Council File #07-1212 **OPPOSITION**
MANDATORY SPAY/NEUTER/MICROCHIPPING OF DOGS AND CATS

I am the legislative liaison for the Staffordshire Bull Club of America, an organization of approximately 300 members. We are an AKC delegate club and oppose ordinances which force law abiding dog owners to spay or neuter or microchip their dogs.

The people of California vigorously opposed AB1634 when it was presented in the State Assembly and State Senate. I believe that it is an insult to all of California's registered voters when animal rights activists attempt to pass similar measures City by City and County by County. Animal rights activists only seek to eliminate of pets and all animal use.

If Santa Cruz is any example of what occurs when broad scope mandatory pet sterilization is passed, this will be a terrible financial burden on the City of Los Angles. Since Sants Cruz enacted similar ordinances, their animal licensing compliance has declined and their Animal Control; budget has increased. Costs of enforcement escalated into millions of dollars.

I oppose the Los Angeles Ordinance for Mandatory Spay/ Neuter/Microchipping of Dogs and Cats because I believe that no government should mandate serious potentially life threatening surgical procedures namely the sterilization for either animals or human. I am attaching a copy of an article written by Margaret V. Root Kustritz DVM that appeared in the JAVMA in December 1, 2007 which addresses my concerns.

Medical procedures performed on either humans or animals should never be mandated by any government.

Accordingly as a registered voter and a tax paying as the members our club are, I would respectfully ask that the ordinance be withdrawn or defeated. I ask that you vote **NO** on any ordinance that mandates that sterilization and amicro-chipping of any per dog or cat.

Sincerely,

Judith A. Brecka

Determining the optimal age for gonadectomy of dogs and cats

Margaret V. Root Kustritz, DVM, PhD, DACT

Elective gonadectomy of dogs and cats, most commonly performed as an OHE of females and castration of males, is one of the most common veterinary procedures performed in the United States.[1] Increasingly, dog owners and members of the veterinary profession throughout the world have questioned the optimal age for performance of these surgeries or whether they should even be performed as elective surgeries. The objective for the information reported here was to provide a review of the scientific evidence, which could be used by veterinarians to counsel clients appropriately on this issue.

Traditional Age at Gonadectomy

Currently, most veterinarians in the United States recommend that elective gonadectomy be performed in dogs and cats at 6 to 9 months of age. However, there does not appear to be any scientific evidence to document that this is the optimal age. In fact, the age at which pets have traditionally been spayed and neutered has varied through the years and with geographic location. In the early 1900s, OHE was performed at 3 to 6 months of age and castration as early as 4 weeks of age.[2] Over time, the recommended age for elective gonadectomy of small animals increased to 6 to 9 months of age. It has been hypothesized that this was the result of an increasing popularity of dogs and cats as pets as American citizens found themselves with more disposable income, a subsequent desire by those pet owners for reproduction control in their animals, and the intent of veterinarians to provide the safest possible anesthesia and surgery for these new "family members."[2] Despite great advances in anesthetic and surgical techniques and multiple studies that provide evidence for the safety of anesthesia and surgery in dogs and cats of younger ages, veterinarians in the United States still cling to the recommendation to perform gonadectomy at 6 to 9 months of age, with the added stipulation that bitches and queens should be spayed before their first estrus.

In some parts of the world, elective gonadectomy is considered unethical and is strongly discouraged or disallowed by professional veterinary associations.[3] Elective gonadectomy is illegal in at least 1 country.[3] In 1 article[4] published in Europe, elective gonadectomy is decried as "the tool of despots and tyrants throughout history," and the author of that article claims that gonadectomized dogs are "canine eunuchs, condemned to live their lives in a physical and mental twilight." That author also questions how a profession that publicly declares itself the guardian of animal welfare can, with impunity, perform elective surgery on animals for human convenience.[4]

Cultural and personal factors, including religious affiliation, ethnic background, intended working life of the animal, urban or rural location of the household, and literacy status, also may be associated with the likelihood that an owner will request gonadectomy for a pet.[2,5] Species and sex also play a role; in retrospective surveys, cats are more likely to be spayed or castrated than dogs, and bitches and queens are more likely to have undergone elective gonadectomy than stud dogs or tomcats.[2,5]

Surgical and anesthetic techniques for elective gonadectomy in dogs and cats of various ages are provided in the veterinary literature.[6–15] The reported incidence of postoperative complications in 1,016 dogs and 1,459 cats after elective surgery was 0.1% and 2.6%, respectively, with most of these considered minor problems, including inflammation at the incision site and gastrointestinal tract upset.[11] Complications were more common in dogs that underwent surgery when they were > 2 years of age.[11] In a study[11] in which investigators evaluated complications in 142 dogs undergoing OHE performed by fourth-year veterinary students, incidence of intraoperative complications was 6.3% and incidence of postoperative complications was 14.2%. Again, most of these were minor, including self-resolving hemorrhage and inflammation at the incision site and gastrointestinal tract upset. In that study,[11] the high incidence of postoperative complications was associated with an increase in surgery time, which was in turn positively correlated with increasing body weight of the animal. In studies[7,11] in which incidence of intraoperative and postoperative complications for elective gonadectomies performed at various ages was compared, the only com-

Abbreviations

OHE	Ovariohysterectomy
TCC	Transitional cell carcinoma
CCL	Cranial cruciate ligament
FLUTD	Feline lower urinary tract disease
BPH	Benign prostatic hypertrophy-hyperplasia

From the Department of Veterinary Clinical Sciences, College of Veterinary Medicine, University of Minnesota, Saint Paul, MN 55108.

plication associated with age at time of surgery was an increased incidence of postoperative infectious disease in dogs undergoing elective gonadectomy when they were < 12 weeks old. This may have been an artifact of the source from which dogs were recruited for the study.[11]

Societal Benefits of Elective Gonadectomy

The primary societal benefits of elective gonadectomy in dogs and cats are fewer animals relinquished to humane organizations and the fact that a specific animal's contribution to pet overpopulation is minimized. Multiple studies[7,10,30] have revealed that sexually intact dogs and cats are more likely to be relinquished to humane organizations than are those that are gonadectomized. In only 1 study[7] was it reported that there was an increased percentage of gonadectomized animals among those relinquished to humane organizations; animals in that study were relinquished for behavioral reasons, and it was considered likely that they had been gonadectomized as a possible treatment for behavioral problems, but with no subsequent improvement after surgery.

Millions of dogs and cats are euthanized at humane organizations annually in the United States, with estimates of 5.4 to 9.1 million dogs and 5.7 to 9.5 million cats euthanized in 1990.[7,31] Crude estimates of annual death rates in dogs and cats are 7.9% and 8.3%, respectively.[7] Statistics from humane organizations housing at least 100 animals/y, combined with these death rates, suggest that > 400,000 dogs and cats should be euthanized at humane organizations annually.[7] Not all animals euthanized at humane organizations are euthanized because of overpopulation[20]; however, the aforementioned study[31] indicates that > 2 million dogs and cats were euthanized at those shelters alone and substantiates the loss of animal life and stress to workers at humane organizations associated with overpopulation of dogs and cats in the United States.

Sexually intact animals adopted from humane organizations may be returned or may reproduce, both of which would repopulate those shelters. In 1 study,[6] 30.4% of relinquished animals were from unwanted litters. In a survey[31] of dog- and cat-owning households in the United States, 56% of 154 canine litters and 66% of 317 feline litters were unplanned. There is a lack of knowledge about reproduction among animal owners; the most common reason reported for the unplanned canine litters was that the owner did not know the bitch was in heat.[31] Up to 57% of bitch owners were unaware that bitches may cycle twice each year, up to 83% of cat owners were unaware that queens are seasonally polyestrous, and up to 61% of dog- and cat-owners were not certain or truly believed that their pet would be better if it had a litter before OHE was performed.[32–36]

Owners that adopt animals from humane organizations routinely sign a spay-neuter contract. However, compliance with such contracts is typically < 60%.[6,30] Up to 90% of veterinarians support mandatory gonadectomy of dogs and cats prior to adoption.[30] Few venues exist for educating veterinarians in early-age gonadectomy of dogs and cats, with most being self-taught.[30,37] Enhanced training of veterinarians in early-age gonadectomy and pediatric anesthetic techniques, mandatory gonadectomy of dogs and cats prior to adoption, and increased education of dog and cat owners about small animal reproductive physiology can only be of benefit in addressing these societal issues.

Benefits and Detriments of Elective Gonadectomy for Behavioral Concerns

Sexually dimorphic behaviors are those most commonly displayed by 1 sex, with mounting and urine spraying as primary examples.[38] Aggression may be a sexually dimorphic behavior. Most commonly, only those forms of aggression associated with the presence of females in estrus (aggression between females or between males housed with those females) are considered sexually dimorphic. Gonadectomy and the subsequent decrease in gonadal steroid hormones have been correlated with a decrease in sexually dimorphic behaviors.[10,11,39] Likelihood that gonadectomy will impact sexually dimorphic behaviors is not correlated with duration of the problem behavior and may or may not be associated with prior sexual experience of the affected animal.[35,36,38,40] Trainability of working dogs is not altered by gonadectomy and does not vary with age of the dog at the time of gonadectomy.[41]

Sexual behavior of male cats makes them extremely undesirable, and often unsafe, household pets.[42] A decrease in sexually dimorphic behaviors after castration of male cats is an extremely powerful benefit of elective gonadectomy. Sexual behaviors of queens, bitches, and stud dogs, although still possibly undesirable, are less commonly so severe as to make these animals untenable as household pets.

Nonsexually dimorphic behaviors are not typically affected by gonadectomy. One large-scale study[11] of dogs revealed a possible increase in noise phobias and decrease in separation anxiety and submissive urination associated with gonadectomy performed before the dogs were 5 months old.

An increase in reactivity toward humans with strange (unfamiliar) dogs and in aggression toward family members has been reported after OHE of bitches in several studies.[43–45] The reason for this possible tendency has not been defined but may be attributable to a decrease in estrogen and oxytocin concentrations, both of which may exert antianxiety effects in some species.[46] This tendency also may be a breed-specific phenomenon.

Cognitive function may be altered by gonadectomy. Comparison of the progression of cognitive dysfunction in sexually intact and castrated male dogs revealed a slowing of progression in sexually intact males.[47] Sample size was small in that study, with only 6 dogs in the sexually intact male group. Androgen deprivation has been associated with increased amyloid deposition in brains of humans and rodents and with decreased synapses in brains of rodents and nonhuman primates.[47] However, in a study[48] in which investigators directly examined brain tissue for DNA damage, a significantly greater percentage of neurons had extensive DNA damage in sexually intact Beagles than in castrated Beagles between 9 and 10½ years of age.

Benefits and Detriments of Elective Gonadectomy for Various Conditions

Several conditions in dogs and cats can be impacted by elective gonadectomy, including neoplasia and orthopedic diseases. Knowledge of the benefits and detriments associated with elective gonadectomy enables veterinarians to provide the best counsel to clients and also to promote animal health.

Mammary gland neoplasms—Mammary gland neoplasms are the most common tumors of female dogs, with a reported incidence of 3.4%, and they are the third most common tumors of female cats, with a reported incidence of 2.6%.[1–3] Mammary gland neoplasms are the most common types of malignant tumors in dogs.[4] Mean percentage of mammary gland tumors in female dogs that are malignant is 50.9%.[3,5–10] In female cats,[3] 90% of mammary gland tumors are malignant.[11,12] Metastases are reported in up to 77% of dogs with mammary gland carcinomas, with the lungs being the site of metastasis in 30.8% of affected dogs.[13,14] In 1 study,[15] 59.7% of dogs in which a mammary gland tumor was diagnosed were euthanized at the time of diagnosis.

Increasing age and breed are risk factors for development of mammary gland neoplasms, with a mean age at diagnosis of approximately 10 years in dogs and cats.[3,5,10] Breeds reported to be at increased risk for developing mammary gland tumors include the Boxer, Brittany, Cocker Spaniel, Dachshund, English Setter, English Springer Spaniel, German Shepherd Dog, Maltese, Miniature Poodle, Pointer, Toy Poodle, and Yorkshire Terrier. Cat breeds reported to be at increased risk of tumor development are the Japanese domestic breeds and Siamese (Table 1).[3,10,11]

Maintenance of sexually intact status is a major risk factor for development of mammary gland tumors in dogs and cats.[16–19] Overall, sexually intact dogs and cats have 7 times the risk of developing mammary gland neoplasms when they get older, compared with the risk for spayed dogs and cats.[17] Compared with the incidence in sexually intact dogs, dogs spayed before their first estrus have a 0.5% risk, dogs spayed after 1 estrus have an 8.0% risk, and dogs spayed after 2 estrous cycles have a 26.0% risk of developing mammary gland neoplasms when they get older.[19] However, performing an OHE may even have a substantial sparing effect in older dogs, with a reduced but still evident reduction for mammary gland neoplasms in dogs spayed as late as 9 years of age.[17]

An exact cause-and-effect relationship between sexually intact status and mammary gland neoplasia has not been defined. Estrogen and progesterone have direct and indirect stimulatory effects on mammary gland tissue, and receptors for both hormones have been identified in normal and neoplastic mammary gland tissues.[20–22] In 1 report,[23] it was suggested that mammary gland neoplasms may be more likely to develop in bitches that had overt pseudopregnancy more than 3 times during their life, which would support the hypothesis that there is a hormonal effect or a direct effect of malignant transformation of metabolically active mammary gland tissue.

Prostatic neoplasms—The reported incidence of prostatic tumors in dogs is 0.2% to 0.6%, and prostatic neoplasms in dogs are almost always malignant adenocarcinomas.[24,25] There is neoplastic differentiation in tissues of ductal or urothelial origin, which are androgen-independent tissues.[26] However, castrated dogs are at an increased risk for development of prostatic neoplasms, with the increase in risk ranging from 2.4 to 4.3 times that of sexually intact male dogs (Table 2).[27–29] Mean age of dogs at diagnosis is approximately 10 years, with slightly younger dogs having prostatic adenocarcinoma with metastases to bones.[27,28] An exact cause-and-effect relationship has not been defined, but it has been suggested[27] that deprivation of androgens does not act to initiate neoplasia, rather androgen deprivation permits progression of disease.

Other types of tumors—Testicular tumors are the second most common tumor type in dogs, with a reported incidence of 0.9%.[3] Mean age of dogs at diagnosis is approximately 10 years.[3,5,6,30] Most tumors are readily diagnosed during physical inspection. Malignancy is considered low for all types of testicular tumors; therefore, castration is curative.[30]

Ovarian and uterine tumors are uncommon in dogs and cats. Although malignant tumors of both tissues have been reported, metastasis is rare and OHE is curative in most situations.[31–33]

Table 1—Benefits and detriments of OHE for various conditions in dogs and cats.

Condition	Incidence	Substantial morbidity?	Specific breeds at risk?
Benefits			
Mammary gland neoplasms	2.5% in all cats; greatly reduced when spayed before first estrus	Yes	Yes*
Ovarian or uterine tumors	Low	No	No
Pyometra	Increases with age	No	No
Detriments			
Complications of surgery	2.6%	No	No
Obesity	High	No	No
FLUTD	0.6%	No	No
Diabetes mellitus	0.5%	No	Yes†

*Japanese domestic breeds and Siamese. †Burmese.

Table 2—Benefits and detriments of gonadectomy for various conditions in male dogs.

Condition	Incidence	Substantial morbidity?	Specific breeds at risk?
Benefits			
Testicular neoplasms	0.9%	No	No
BPH or prostatitis	75%–80% by 6 years of age	No	No
Detriments			
Complications of surgery	6.1%	No	No
Prostatic neoplasms	0.2%–0.6%	Yes	No
TCC	< 1%	No	Yes*
Osteosarcoma	0.2%	Yes	Yes†
Hemangiosarcoma	0.2%	Yes	Yes‡
CCL rupture	1.8%	Yes	Yes§
Obesity	2.8%	No	Yes‖
Diabetes mellitus	0.5%	No	Yes¶

*Airedale Terrier, Beagle, Collie, Scottish Terrier, Shetland Sheepdog, West Highland White Terrier, and Wire Fox Terrier. †Doberman Pinscher, Great Dane, Irish Setter, Irish Wolfhound, Rottweiler, and Saint Bernard. ‡Boxer, English Setter, German Shepherd Dog, Golden Retriever, Great Dane, Labrador Retriever, Pointer, Poodle, and Siberian Husky. §Akita, American Staffordshire Terrier, Chesapeake Bay Retriever, German Shepherd Dog, Golden Retriever, Labrador Retriever, Mastiff, Neapolitan Mastiff, Newfoundland, Poodle, and Saint Bernard. ‖Beagle, Cairn Terrier, Cavalier King Charles Spaniel, Cocker Spaniel, Dachshund, Labrador Retriever. ¶Airedale Terrier, Cocker Spaniel, Dachshund, Doberman Pinscher, Golden Retriever, Irish Setter, Miniature Schnauzer, Pomeranian, and Shetland Sheepdog.

The most common tumor of the urinary tract of dogs is TCC of the bladder.[95,109] Overall incidence of TCC in dogs is reported to be at most 1% of all malignant tumors.[109] Breeds at increased risk for development of a TCC include the Airedale Terrier, Beagle, Collie, Scottish Terrier, Shetland Sheepdog, West Highland White Terrier, and Wire Fox Terrier (Table 3).[109] Gonadectomized animals have a risk for development of TCC approximately 2 to 4 times that of sexually intact animals.[8,36] An exact cause and effect relationship has not been defined.

Osteosarcoma is a highly malignant tumor with a reported incidence of 0.2%.[64] Risk of development of osteosarcoma increases with age and may increase with increasing body weight.[110] Breeds reported to be at increased risk for development of an osteosarcoma include the Doberman Pinscher, Great Dane, Irish Setter, Irish Wolfhound, Rottweiler, and Saint Bernard.[110,111] In 1 study[37] in which historical data that consisted of owners' assessments of body condition score and body weight were used for analysis, incidence of osteosarcoma was not correlated with body weight. However, owner assessment of body condition score is poorly correlated with veterinarian assessment of body condition score.[112]

Gonadectomy can increase the risk of development of osteosarcoma by 1.3 to 2.0 times.[37,113] In 1 study[37] in which investigators evaluated 683 purebred Rottweilers, there was a significant increase in the incidence of osteosarcoma in female and male dogs that had undergone gonadectomy when < 1 year of age; however, the overall incidence of osteosarcoma in this population of dogs was much higher than that in the general population, which suggested a hereditary component. Furthermore, life span of dogs did not differ (mean ± SD life span of sexually intact and castrated male dogs was 9.3 ± 2.5 years and 9.2 ± 2.5 years, respectively) or was noticeably increased (mean life span in sexually intact and spayed female dogs was 7.5 ± 2.4 years and 9.8 ± 2.4 years, respectively) in gonadectomized dogs.[37] An exact cause-and-effect relationship has not been defined.

Hemangiosarcoma is the most common cardiac tumor in dogs, with a reported incidence of 0.2%.[96] Breeds at increased risk for development of hemangiosarcoma include the Boxer, English Setter, German Shepherd Dog, Golden Retriever, Great Dane, Labrador Retriever, Pointer, Poodle, and Siberian Husky, with large breeds (in general) at increased risk, compared with the risk for small breeds.[37] For both cardiac and splenic hemangiosarcoma, relative risk is increased for gonadectomized animals, with spayed females reportedly having 2.2 times the risk of splenic hemangiosarcoma and 5 times the risk of cardiac hemangiosarcoma, compared with the risk for sexually intact females, and castrated males having 2.4 times the risk, compared with the risk for sexually intact males.[36,38] An exact cause and effect relationship has not been defined.

Orthopedic abnormalities—Postmenopausal women or those who have undergone OHE have explicit concerns about osteoporosis. However, there is no decrease in mineral density of bone in dogs after OHE.[100,101]

Timing of closure of the physes of long bones is controlled in part by gonadal hormones. In both dogs and cats, gonadectomy at any age prior to physeal closure delays that closure and is associated with statistically significant, although not readily visible or clinically relevant, lengthening of associated long bones.[9,10,114,115] However, no specific correlation has been found between age at gonadectomy and incidence of long-bone fractures, including physeal fractures.[9] In 1 study,[10] there was an increase in the incidence of capital physeal fractures in the femurs of castrated male cats; however, the cats with fractures were also overweight.

to become obese after gonadectomy, no correlation has been found between age at gonadectomy and final body weight or amount of body fat.[34]

Metabolic rate decreases after gonadectomy in cats.[35,36] A cause-and-effect relationship between gonadectomy and obesity in dogs is less clearly defined. Spayed female dogs have an increase in food intake and increase in indiscriminate appetite after OHE, compared with those of sham-operated or age-matched control dogs.[37,38] Estrogen may act as a satiety factor, which would explain these changes.[39] This does not address the correlation between obesity and castration in male dogs. In both dogs and cats, obesity is not a mandatory consequence of gonadectomy; instead, it is controllable with an appropriate diet, feeding regimen, and exercise regimen.[40]

Urinary tract disorders—Spayed female dogs reportedly have an increased risk of developing urinary tract infections.[23,41] A cause-and-effect relationship has not been defined.

Female dogs spayed before onset of puberty may be more likely to maintain a juvenile or recessed vulva. In 1 study,[42] bitches spayed at 7 weeks of age had a vulva with a more immature appearance, compared with the vulva in bitches spayed at 7 months of age. It is the author's experience that bitches spayed as adults will have vulvar atrophy, which achieves the same result. A juvenile vulva in an otherwise healthy dog is of no clinical relevance. Overweight bitches with a recessed vulva, especially those with concurrent urinary incontinence, are more likely to develop perivulvar dermatitis.

Male dogs castrated at 7 weeks of age had less penile development than did dogs castrated when they were older.[43] Male cats castrated before onset of puberty may have a decreased ability to extrude the penis.[44,45] Clinical relevance of this phenomenon is not known.

Feline lower urinary tract disease is a syndrome consisting of hematuria, dysuria or pollakiuria, and possible urethral obstruction and is most commonly classified as idiopathic. The reported incidence of FLUTD is 0.6%.[46] Despite numerous vehemently declared anecdotes of an increase in the incidence of urethral obstruction in male cats castrated when young, numerous studies[5,7,47,48] have failed to detect a correlation between gonadectomy of cats at any age and a decrease in diameter of the urethra or an increase in incidence of FLUTD, with or without urethral obstruction. In 1 large study,[5] investigators identified gonadectomy as a risk factor for development of FLUTD in both female and male cats and also identified an increased risk of development of FLUTD in overweight or obese cats. In that study, sexually intact female cats had a relatively reduced risk for development of FLUTD.

Urethral sphincter mechanism incompetence, formerly known as estrogen-responsive urinary incontinence, is a common problem of spayed female dogs.[1,2,49] The condition is evident with equal frequency in ovariohysterectomized or ovariectomized female dogs, with the reported incidence ranging from 4.9% to 20.0%.[1,49,50] Studies[1,49] have failed to detect a correlation between age at time of OHE and likelihood of developing incontinence. In a study[51] of 983 female dogs, bitches were significantly less likely to develop incontinence when spayed at > 3 months of age. Other risk factors include body weight, with dogs weighing > 20 kg (44 lb) at increased risk; breed, with Boxers, Doberman Pinschers, Giant Schnauzers, Irish Setters, Old English Sheepdogs, Rottweilers, Springer Spaniels, and Weimaraners at increased risk and Labrador Retrievers at decreased risk in European studies;[1] and urethral length or resting position of the urinary bladder.[1,49,50,52] An exact cause-and-effect relationship has not been defined, with research currently focusing on altered gonadotropin secretion after gonadectomy.[49,53,54] Typically, urethral sphincter mechanism incompetence is easily controlled with medical treatments.

Adrenal gland disease—To the author's knowledge, there are no reports of an increase in the incidence of adrenal gland disease associated with sexually intact status in dogs and cats. In the United States, almost all ferrets are gonadectomized when extremely young; the incidence of adrenal gland disease in ferrets is higher in the United States than in European countries where ferrets are not routinely spayed or castrated.[55,56] In 1 study[55] in Europe, a correlation was detected between age at gonadectomy and age at onset of adrenal gland disease, with ferrets gonadectomized at a younger age having clinical signs of adrenal gland disease earlier in life. Sexually intact ferrets also have adrenal gland disease.[57] Possible causes for this include lack of down-regulation of sex steroids or an increase in circulating concentrations of gonadotropins that causes adrenal gland hyperplasia and possibly contributes to neoplastic transformation.[55,58]

Pyometra—Incidence of pyometra in dogs and cats in the United States has not been reported, perhaps because of the prevalence of OHE in these species before they reach an age when they would be likely to develop pyometra. In other countries, 15.2% and 2.3% to 24% of bitches developed pyometra by 4 and 10 years of age, respectively.[1,2,59] Pyometra is more common in nulliparous bitches than in bitches with a history of carrying a pregnancy successfully to term.[1,60,61] There is a significant likelihood that cats will have clinical evidence of uterine disease when queens reach 5 years of age.[60] Dog breeds reported to be at increased risk of developing pyometra include the Bernese Mountain Dog, Cavalier King Charles Spaniel, Chow Chow, Collie, English Cocker Spaniel, Golden Retriever, Rottweiler, and Saint Bernard.[1,2,62] In animals with pyometra, OHE is curative, with reported mortality rates of 0% to 17% in dogs and 8% in cats.[60,63]

Nonneoplastic prostatic disease—Benign prostatic hypertrophy-hyperplasia is a common disorder in sexually intact male dogs. In 1 study,[64] investigators evaluated male dogs. Of 300 sexually intact male dogs, 231 (63.4%) had BPH; all castrated male dogs in that study had profound prostatic atrophy. Development of BPH is positively correlated with age.[64,65] By 2.4 years of age, half of all sexually intact dogs will have histologic or clinical evidence of BPH, with the incidence increasing to 75% to 80% by 6 years of age and 95% to 100% by 9 years of age.[64,66,67] In addition, BPH predisposes dogs to prostatitis.[68] Neither BPH nor prostatitis is commonly associated with substantial morbidity, and

castration is an integral part of the treatment of both conditions.[66,67,69]

Endocrine disorders—The reported incidence of diabetes mellitus in dogs is 0.5%.[71] Risk factors include breed, with Miniature Poodles, Miniature Schnauzers, Pugs, Samoyeds, and Toy Poodles at increased risk; sex, with female dogs more commonly affected than male dogs; and increasing age.[72,73] In 1 study,[74] a possible increase in the risk of developing diabetes mellitus was detected in castrated male dogs, however it was not defined whether this could have been associated with obesity in these animals. In cats, the reported incidence of diabetes mellitus is 0.4% and risk factors include breed, with Burmese cats at increased risk; sex, with males at increased risk; and increasing age.[72,75] Gonadectomized male and female cats have an increased risk, with gonadectomized cats having 8.7 times greater odds of developing diabetes mellitus than for sexually intact cats.[73,75]

The incidence of hypothyroidism in dogs is 0.2% to 0.5%.[76,77] A breed predisposition has been described for the Airedale Terrier, Cocker Spaniel, Dachshund, Doberman Pinscher, Golden Retriever, Irish Setter, Miniature Schnauzer, Pomeranian, and Shetland Sheepdog breeds.[76,78] Those studies[76,77] have revealed an increased risk of development of hypothyroidism for spayed female and castrated male dogs, compared with the risk for sexually intact dogs. A cause and effect relationship has not been defined. Hypothyroidism typically is easily controlled with medical treatment.

Life span—Life expectancy at birth for women in the United States is 80.1 years, whereas that for men is 75.2 years.[126] Results for dogs vary,[127–130] with females living longer than males in some studies and the reverse being found in other studies. Negative correlations have been detected between body weight and longevity and between height and longevity in dogs.[131] Several studies[127,128] have revealed an increase in longevity for gonadectomized animals when compared with that for sexually intact animals. In sockeye salmon, life span is significantly longer in fish castrated before gonadal development.[132] Results of these studies argue against the evolutionary theory, which holds that it is not prudent for a population to carry individuals that have aged past reproductive usefulness.[40] In dogs and cats, this may be a reflection of enhanced care of animals by owners who have made the investment of surgery or a decrease in risk-associated behaviors (such as roaming) in gonadectomized animals.

Conclusions

How does a veterinarian reconcile all of these data to make the best possible recommendation regarding optimal age at which to neuter male and female dogs and cats? The author provides the following assertions:

- Animals housed at humane societies should be treated as a population. Societal benefit resulting from gonadectomy of unowned dogs and cats in the United States outweighs all other concerns. Male and female dogs and cats should be spayed or castrated before being offered for adoption by humane organizations.
- Pets should be considered individually, with the understanding that for these pets, population control is a less important concern than is health of each animal. Dogs and cats should be maintained as household pets. Responsible owners should ensure that their pets are provided appropriate and regularly scheduled veterinary care.
- The behavior of most sexually intact male cats makes them undesirable or dangerous as pets. Because castration substantially reduces these sexually dimorphic behaviors, it is recommended that all male cats not intended for breeding be castrated prior to puberty and that all breeding males be castrated as soon as their use as a breeding male has ceased.
- For female cats and male and female dogs, veterinarians and owners must consider the benefits and detriments of gonadectomy for each animal (Tables 1–3). Factors to be considered include incidence of various conditions associated with gonadectomy; degree of morbidity with substantial morbidity defined as a condition prevalent in > 1% of the population, associated with > 50% of the malignancy or mortality rates, or not easily controlled by noninvasive treatments or good husbandry; breed; and intended working or breeding life of each animal.

As an example, consider a discussion between a veterinarian and the owner of an 8-week-old female Labrador Retriever that is not intended for breeding. This dog would benefit greatly from OHE before her first estrus as a means of preventing mammary gland tumors, which are extremely common and cause substantial morbidity (Table 3). Because of her breed, detriments of OHE include an increased predisposition to CCL injury, hemangiosarcoma, and obesity. However, there is a low incidence of hemangiosarcoma, and obesity can be readily controlled with good husbandry, which leaves CCL injury as the most important possible detriment. Because the incidence of CCL rupture is lower than that of mammary gland neoplasia, a veterinarian may choose to recommend OHE and educate the owner about maintenance of optimal body condition and other management techniques that will minimize potential for CCL injury. An OHE should be performed before the dog's first estrus. To minimize the potential for development of urinary incontinence, the veterinarian may choose to wait to perform the OHE until after the dog has reached 3 months of age.

The information provided here on the risks and detriments of gonadectomy is not intended to promote or to minimize the importance of gonadectomy as a means of controlling animal populations or possible impacts on animal health or behavior of a specific animal. The veterinary profession recognizes the need for individual assessment of risk and benefit when evaluating vaccination protocols for animals. Elucidation of the genome in various species may lead to individualized diagnostic and treatment plans for each animal in the future. It behooves us as veterinarians dedicated to the provision of the best possible care for animals to educate clients and evaluate each animal carefully when making recommendations regarding gonadectomy.

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