Evaluating the Benefits & Risks of Neutering

What Is Neutering?

Neutering involves removing the source of the hormones that control reproduction and that determine the typical physical and behavioral characteristics that distinguish males and females. In dogs and cats, this is usually done by surgically removing the testicles in males (castration) and the ovaries in females (spaying). In the United States, the uterus is typically removed along with the ovaries in females, and virtually all dogs and cats are spayed or castrated. In Europe and some other parts of the world neutering is far less common, and when females are spayed only the ovaries are usually removed.

The primary purpose of neutering is to prevent reproduction, but like most medical interventions the procedure has a variety of other effects, both beneficial and undesirable. The decision whether or not to neuter a pet involves comparing the benefits and the risks in the context of the circumstances in which the pet lives. Veterinarians, breeders, and pet owners often have strong opinions about neutering, and unfortunately these are all too often based on tradition, habit, rumor, or misconceptions. There is a large and complex scientific literature addressing the pros and cons of neutering, and this review is an attempt to extract from it some sound information with which to formulate rational guidelines for making decisions about neutering.

A number of reviews of the pros and cons of neutering have appeared in scientific publications and posted on the Internet by interested laypersons.[70,93,148-153] Some of these are excellent summaries of the issues, others are inaccurate or misleading. This survey is an attempt to look at the totality of the scientific information currently available and after reviewing it to draw some pragmatic conclusions about the benefits and risks of neutering dogs and cats.

Interpreting Scientific Studies

Scientific studies are superior to tradition, intuition, and personal experience as a form of evidence. However, they have limitations which affect the applicability of the data and conclusions they generate to individual patients. The ideal study of the risks and benefits of neutering would involve taking a large number of dogs of many breeds, dividing them into two identical groups, neutering one group but not the other, and then ensuring they live otherwise identical lives and examining the differences between the neutered and intact groups. No such study will ever be done for practical, scientific, and ethical reasons.

Most of the studies which do examine the possible influence of neutering on health and disease are retrospective. They examine animals that have already developed a condition of interest and then look at whether more of the affected animals are neutered or intact than a control group of similar animals without the condition. While this is useful information, it can be misleading for many reasons. Groups studied in one location may be very different from pets in other areas, in terms of age, breed, and other risk factors, and conclusions about the study group may not apply to pets in general.

For example, a study of a small group of dogs of a single breed which has a high rate of a certain type of cancer might show neutered dogs more likely than intact dogs to have that cancer. But this might have nothing to do with the risks for a different breed which rarely gets that type of cancer. Or neutered pets studied in an affluent city may get more veterinary care, and better care in general, than intact dogs roaming loose in a rural area, so differences between the groups in some disease might be due to factors other than neutering.

A good scientific study will try to control for such factors and the authors will identify potential problems with their data. Whenever possible, I have tried to include such considerations in evaluating the evidence in this review, but it is often unclear what if any confounding factors might influence the results of a given study, so conclusions should ideally be based on multiple studies of large numbers of animals by different investigators in different places. It is this need for replication and the accumulation of data over time that leads to periodic re-evaluations of medical practices. Contrary to the impression often given by the media, this is not because science frequently makes radical and erratic changes of direction but because the process of deepening our understanding and modifying our practices accordingly is complex and never-ending.

Another factor to consider in interpreting studies about the risks and benefits of neutering is how we measure and describe risk. Differences in the risk of a given condition between groups are often described in terms of relative risk. For example, intact animals may be seen to have a given disease 5 times as often as neutered animals (500% greater risk). If this difference is determined to be statistically significant (meaning it is unlikely to be due to chance, *not* that it is significant or important in a more ordinary sense), then we can say intact animals have a greater relative risk of the disease (5 times greater). However, this says nothing about the absolute risk involved. If the disease that intact animals are more likely to get occurs in only 1 out of every 1,000 neutered animals (0.001%), then the extra risk of being intact makes the absolute risk for an intact animal 0.005%, still a vanishingly small number. Thus, while differences in relative risk may sound dramatic, if the condition is uncommon then the real chances of an individual getting it may not be meaningfully different regardless of neuter status.

In contrast, if the condition is common, then even a small change in the relative risk may mean very significant changes in the absolute risk. If 75% of neutered animals get a certain disease, and intact animals have a relative risk of 0.5 (50% lower risk), then the real chances of getting the disease are much lower (35%) even though the difference in relative risk is much less than in the previous example.

Again I have attempted, whenever possible, to assess both the relative and absolute risk associated with neuter status when discussing specific conditions. Unfortunately, the true incidence of many conditions (how common they are) isn't always known in veterinary populations, and when a figure is reported in one study, it may or may not be relevant to the patients from a different study, region, breed, and so on.

Benefits of Neutering

General Benefits-
The primary benefit of neutering is the prevention of unwanted reproduction. Though the number of unwanted cats and dogs euthanized at animal shelters has decreased form an estimated 23.4 million in 1970 to about 4.5 million by the year 2000 [1], this still represents a significant problem. Reducing the number of unwanted puppies and kittens has been and remains an important part of reducing the relinquishment and euthanasia of these animals.[2] Failure to neuter is an important component to the pet population problem. [55] Furthermore, being intact is a significant risk factor for both cats and dogs being given up by their owners[3,4], so neutering can reduce both the number of unwanted puppies and kittens and reduce the risk of owned animals being relinquished.

The feral or stray cat population, though notoriously difficult to assess, contains an estimated 30-40 million animals, most the product of unplanned breeding.[1] There is a great deal of controversy over the welfare of feral cats and the impact they may have on wildlife and public health.[5-8] It is generally agreed, however that feral cats suffer more disease and parasitism and have shorter lives than owned cats and that reducing the number and reproduction of unowned cats is a worthwhile goal.[9] Neutering of owned, and likely also feral cats, promotes this goal.[57]

Health Benefits of Neutering-
1. Risks of Reproduction-
Reproduction itself has potential risks which can be eliminated by neutering. Dogs of both sexes are susceptible to infection with *Brucella canis*, a bacterium which can cause disease in dogs and humans. This bacterium can be transmitted during breeding or acquired from contact with aborted fetuses and other material from infected females. The incidence of this disease varies by country and region, from 1-18% in the United States to upwards of 25% in some other countries. Clinical symptoms other than infertility are uncommon, though some dogs can experience serious infectious of the bone, eyes, or nervous system. [9]

The most common complication of pregnancy for females is dystocia, when the normal process of labor and delivery fails. Rates of dystocia in dogs vary greatly by breed, from as low as 5% of whelpings to over 85% in breeds with large heads.[10] One large study in Sweden, where most dogs are intact, found that 2% of female dogs in the sample experienced a dystocia and the overall incidence was 5.7 cases/1000 dog years at risk, though some breeds were at much greater risk and some experienced no dystocias. [11] This study was of dogs covered by health insurance, which about half of dogs in that country are, so it may or may not be applicable to dogs in other countries or those whose owners do not utilize pet health insurance.

In cats, the risk also varies by breed, with one study reporting an overall dystocia rate of 5.8% of deliveries, ranging from 0.4% in a colony of mixed breed cats to 18.2% for Devon rex cats.[12]

Though dystocia can sometimes be treated medically, allowing natural delivery to proceed, the majority of dogs and cats with dystocia require surgical treatment.[10-13] Most females recovery fully from c-sections, though the risks of such surgery are likely greater than those of a planned spay surgery due to the emergency nature of the procedure and the often compromised health of the female due to the dystocia.

Much less common risks of pregnancy, such as pregnancy toxemia, diabetes mellitus, uterine torsion, uterine rupture, and pregnancy-associated pyelonephritis (kidney infection) can all be prevented by neutering.[13]

2. Mammary Tumors-
Mammary tumors are very common in intact female dogs. Incidence is reported in a number of different ways, which makes comparison between studies difficult. A study in Norway, where almost all female dogs are intact, found an overall incidence of malignant mammary tumors of 53.3%, with significant variation in risk by breed.[14] A UK study found mammary tumors to be the second most common type of tumor, with an incidence 205 tumor per 100,000 dogs per year.[15] A Swedish study found an incidence in intact females of 1% at 6yrs of age, 6% at 8yrs, and 13% at 10 years when the study was terminated.[16] The incidence of mammary tumors in female cats is roughly half that seen in dogs.[17] Mammary cancer is extremely rare in male dogs. [17]

In dogs, the chances of developing a mammary tumor increase with age and vary with breed.[13,17] There is no apparent protective effect of having a litter for dogs or cats. [17,20]

About half of canine mammary tumors are malignant, whereas 85-90% of feline mammary tumors are malignant.[17,18] Mammary cancer is usually treated with surgery and often chemotherapy, and it is often fatal despite treatment, with 59% of dogs with malignant tumors in one study eventually dying of causes related to their cancer. [21]

Spaying dramatically reduces the risk of mammary cancer in both dogs and cats. In dogs the risk has been reported as 0.5% when spayed before the first heat, 8% if spayed before the second heat, and 26% if spayed after the second heat.[19] One study in cats found those spayed prior to 6 months of age had a 91% reduction in mammary cancer risk, and the risk was reduced 86% in those spayed before 1 year.[20] Spaying dogs later than the second heat does not reduce the risk of developing mammary cancer, but spaying at the time of surgical removal of the mammary tumor or within 2 years before diagnosis of mammary cancer is associated with longer survival.[21]

3. Pyometra-
Pyometra is a bacterial infection of the uterus. It occurs as a consequence of changes in the uterine environment brought about by repeated estrus (heat) cycles.[13] Pyometra can be treated medically, though with a very high rate of recurrence in the following heat cycle. [22,23] It is more commonly and successfully treated by spaying the affected dog.[13]

A study in Sweden, where elective spaying is rarely practiced, found that overall 25% of the females in the study developed pyometra by 10 years of age, and it is expected the risk would continue to increase in even older females. The risk varied considerably by breed, with some breeds having a 10% rate of pyometra and others up to 50%. Risk increased with age for all breeds.[24] Pyometra has been reported in cats, but no published figures regarding the incidence are available. Mortality from pyometra treated surgically is variable, from 4.2-17% in dogs and 8% in cats.[13]

Spaying essentially eliminates the risk of pyometra in dogs and cats. Infections in the small portion of the uterus not removed during ovariohysterectomy do occur if some ovarian tissue or other source of progesterone is present, but this is rare.[13] In Europe, it is common to remove only the ovaries and leave the uterus. This effectively protects against pyometra since the hormones responsible for the condition are not present.[25]

4. Cancer of Reproductive Organs-
Tumors of the ovaries are uncommon in dogs and cats with reported incidences of 6.25% in dogs and between 0.7%-3.6% in cats. There are several different types of ovarian tumors with variable degrees of malignancy. Little reliable information exists regarding the mortality associated with these tumors.[26]

Uterine tumors are very rare in dogs and cats, accounting for <2% of feline tumors and <0.5% of all canine tumors. Tumors of the uterus can generally be successfully removed by spaying the animal, though recurrence and spread to other organs has been reported.[26]

Tumors of the vulva or vagina in female dogs are not common, though they represent 2-3% of all canine tumors. They occur primarily in intact females, often have receptors for ovarian hormones present in the tumor cells, and they are less likely to recur in dogs spayed at the time of tumor removal. [26-28,144] This suggests that the risk of such tumors is decreased in spayed females. Most vulvar and vaginal tumors are benign and can be cured by surgical removal, though the minority that are malignant have a poor prognosis and often recur or metastasize.[26]

Various rates of occurrence have been reported for testicular tumors, but random samples of testicles from dogs autopsied for reasons not related to testicular disease have shown that 16-27% of dogs had tumors, and many of these had more than one.[29] The testicles are the second most common site for cancer in intact male dogs.[145] Testicles which do not descend into the scrotum but remain in the abdomen or inguinal ring (cryptorchid testicles) are more likely to develop tumors, especially in dogs under 10 years of age.[30,31]

There are several types of testicular tumors. Most are slow to metastasize, with fewer than 15% of affected dogs showing spread to other organs. Some testicular tumors produce hormones, including estrogen which can cause feminization and bone marrow disease. Castration is the treatment of choice for testicular cancer, and it is usually curative. [13,26]

5. Prostate Disease-
The most common disease of the canine prostate is benign hyperplasia (BPH), an overgrowth of tissue that causes enlargement of the gland.[13,32] This incidence of this disorder increases with age, from 15-40% for dogs under 7 years of age and 60-100% of dogs over 7 years of age.[32-34] While most dogs have few symptoms from BPH, some will experience difficulty urinating or defecating or bloody preputial secretions. BPH is a predisposing and complicating factor for prostatitis, a bacterial infection of the prostate. [13] Prostatitis has been reported to occur in up to 28.5% of intact male dogs.[32,35] It is a serious and uncomfortable, though rarely life-threatening disease. Both BPH and prostatitis are rare in neutered dogs and both are effectively prevented and treated by castration.[13,32]

6. Behavioral Benefits-
Behavioral problems are an important reason for relinquishment of pet dogs and cats by owners. [1,5,44] The most common problematic behaviors include aggression towards people or other animals, inappropriate elimination, and fearful behaviors.[45] To the extent that neutering increases or reduces the risks for these behaviors it can have an important impact on the relationship between pet and owner and ultimately on the pet's survival.

The biological and environmental influences on animal behavior are complex and difficult to unravel. Specific behavior patterns are influenced by many environmental and individual factors which all interact, so epidemiological correlations are often unreliable in predicting the outcome of interventions in individual cases. However, there are some consistent patterns that emerge from studies on normal and problematic behaviors in dogs and cats which illustrate the potential behavioral benefits and risks associated with neutering.

Some studies have reported intact male dogs to be disproportionately involved in aggressive behavior. [46,47]. Others have reported marked reductions in aggression and other problem behaviors in male dogs as an effect of castration. In one study, roaming behavior decreased 90%, aggression between males decreased 62%, urine marking decreased 50%, and mounting decreased 80% following castration,[48] and several other studies have found similar results.[49,50,54] Some studies have also reported intact dogs to be more likely to bite humans than neutered animals.[52]

Castration also dramatically reduces fighting, urine spraying, and roaming in male cats.[52-54] One study has found intact cats to be more aggressive and less affectionate than neutered cats.[102]

7. Miscellaneous-
Almost every epidemiologic study of any disease examines differences in incidence between males and females and intact and neutered animals. If a significant correlation is found, this may or may not have meaningful clinical implications. There are likely many more such associations reported than I have listed here, but these are some that seem to

have clear significance when considering whether or not to neuter and about which pet owners often have questions and concerns.

Perineal hernias are protrusions of abdominal organs through a weakened area in the pelvic muscles. The disease is not uncommon, but no precise incidence has been reported. However, in one study 93% of cases were intact males, and an association with prostatic disease is suspected, so neutering is likely protective for this problem.[41,56] Perineal hernias can usually be successfully treated with surgery, and castration at the time of hernia repair is recommended.[42]

Perianal fistulas are a chronic immune-mediated disease seen most commonly in German Shepherds and Irish Setters and rarely in other breeds. It occurs predominately in intact male dogs, which suggests some hormonal influence, though a specific causal connection has not been identified. In one study, males outnumbered females 2:1 and intact dogs were 86% of affected patients. [43] The disease is chronic and often causes significant discomfort. It can frequently be controlled with medical therapy, though sometimes surgical treatment may also be necessary.

There is some suggestion in research on laboratory animals as well as epidemiologic studies of dogs and cats that neutered animals may live longer than intact animals.[58-61,63,146,147] However, there are also studies which suggest that the longer females of some breeds retain their ovaries the more likely they are to achieve unusual longevity for their breed.[62] The possible effects of differences in the care neutered and intact animals receive have not been examined, and this complicates any interpretation of differences in longevity.

Risks of Neutering

1.Neutering Surgery Risks-
Like all surgeries, neutering involves some risks. Total complication rates for routine castration or spaying have been reported from 2.6%-20% of cases.[64-67]. The majority of these are minor and require no treatment. [64,67] Complication rates vary considerably from practice to practice and are generally reported to be higher in studies of surgeries performed by students in training.[64,67] Reported death rates are less than 0.1%.[64]

2.Cancers-
Prostate cancer in dogs has previously been reported to have an low incidence of less than 1%[13], but several recent studies have suggested it may be more common, though not always clinically recognized, and these papers have reported rates of 3.6-13%.[32,35] Most such cancers are malignant, with metastases reported in 40-80% of cases at the time of diagnosis.[13,36]. There is some uncertainty about the role of castration in prostate cancer development. While some reports have found fewer prostate cancers in castrated dogs than in intact dogs [36-38], most recent studies have found either no effect of castration on the rate of prostate cancers [39] or an increased risk for castrated dogs.[35,40] Most canine prostate cancers examined seem to lack receptors for male

hormones, so it appears that unlike in humans these hormones are not responsible for the initiation or progression of prostatic cancers, but it is unclear whether castration is overall beneficial, neutral, or a risk factor for their development.[30,40] Prostate cancer is an aggressive cancer with a poor long-term prognosis.[30]

Osteosarcoma is a bone tumor usually seen in large breed dogs.[68,69] Overall incidence has been reported as 0.2%, but for at risk breeds rates of 4.4%-6.2% are often reported.[70,72] A rate of 12.5% was reported in one study, though the authors suggested this might have been an overestimate. [71] Neutered dogs have been reported to be at higher risk for osteosarcoma than intact dogs.[68,71]. In one study, no difference was found in overall risk for intact versus neutered animals of either sex, but neutering before 1 year of age was found to increase the risk, and it was found that the longer an individual had been intact the lower their osteosarcoma risk.[71] However, the neutered animals in this study (especially the spayed females) lived longer than the intact animals, which may have contributed to an increased incidence of cancer in the neutered group.

It is possible that neutering, especially before sexual maturity, raises the risk of osteosarcoma, at least in predisposed breeds. Osteosarcoma is an aggressive cancer with a poor long-term prognosis, and it is generally treated with surgery and chemotherapy.[69]

Hemagiosarcoma is a cancer of the cells that normally form blood vessels.[73] The overall incidence has not been reported, but it makes up 5% of all non-skin cancers in dogs.[73] It is less common in the cat, found in 0.5% of cats autopsied and 2% of cancers in this species.[73] It most commonly occurs in the spleen, and certain breeds (such as German Shepherds, Labrador Retrievers, and Golden Retriever) are at greater risk than others.[73,74,76] Hemangiosarcoma can also develop in the heart, with a reported incidence of 0.19%.[75]

Spayed females have been reported to have 2 times the risk of splenic hemangiosarcoma and 5 times the risk of cardiac hemangiosarcoma of intact females.[74,75] Castrated males have either been found to have no increased risk of splenic hemangiosarcoma[74] and only a slightly higher risk (1.55 times) than that of intact males for cardiac hemangiosarcoma.[75] Hemangiosarcoma is an aggressive cancer with a poor long-term prognosis, and it is usually treated with removal of the spleen (if this is the primary site) and chemotherapy.[73]

Transitional cell carcinoma is a cancer of the lower urinary tract, usually found in the bladder and uncommonly in the urethra of dogs.[77] It represents 1%-2% of canine cancers and is rare in the cat.[77,78] It is more common in females than males, prevalence varies by breed, and neutered animals have been reported to be at 2-4 times greater risk than intact animals.[78,79] Transitional cell carcinoma is an aggressive cancer with a fair long-term prognosis, and it is usually treated with chemotherapy and sometimes surgery or radiation therapy.[77]

3. Orthopedic Disease-

Rupture of the cranial cruciate ligament in the knee is a common problem of large breed dogs, with a reported incidence of 1.8%-4.5%, though the incidence in predisposed breeds has been reported to be as high as 8.9%.[80-82,86] In addition to breed and obesity, neutering increases the risk of cranial cruciate ligament rupture, [80,81,82,86] One study suggested neutering may increase the angle between the bones in the knee in a way that promotes cruciate rupture, but this effect was only seen in dogs neutered earlier than 6 months of age.[85] Cruciate ligament rupture is treated with a variety of surgical approaches, and it has an excellent long-term prognosis.[83,84]

Hip dysplasia is a developmental abnormality of the hip joint that can result in arthritis and clinical discomfort. It is rare in small breeds, with rates of affected dogs less than 1%, but it can be seen in as many as 40%-75% of large breed dogs.[86-89] Hip dysplasia is estimated to lead to clinically significant arthritis is fewer than 5% of affected dogs, but there are many factors involved including breed, weight, and the degree of anatomic abnormality of the hip joint, which makes predicting the outcome for any individual difficult.[89] The incidence of hip dysplasia is most strongly associated with breed and family history.[86,90,91].

Some studies have identified neutering as increasing the risk of hip dysplasia.[86,92]. As discussed below, the age at neutering may also be a factor influencing the development of hip dysplasia.[93] It is unclear if the increased risk is directly due to the effects of neutering or due to an increased incidence of obesity in neutered dogs. Hip dysplasia can be treated if detected early with surgical therapies that reduce the chances of clinically significant arthritis later in life.[94,95] In older dogs who have already developed arthritis and clinical symptoms, these can be managed surgically or medically, with medications, weight reduction, and other therapies.[96-98] Because of the genetic basis of the disorder, the ideal approach to eliminating it is to neuter those dogs that carry the predisposing genes to eliminate the disease from the population.[99,100]

Fractures of the capital physis of the femur (the growth plate where the femur attaches to the pelvis at the hip joint) can occur in growing animals both due to trauma and spontaneously. A number of studies have found a large majority of spontaneous capital physeal fractures in cats occur in obese neutered males.[179-182] It is clear that neutering delays closure of the growth plates in male cats[183], and so it may be an independent risk factor for such fractures, though neutering also increases the incidence of obesity, and the relative contribution of obesity and neutering to the risk of these fractures has not been elucidated.

4. Behavioral Risks-
Though neutering has been associated with a decreased incidence of some kinds of aggression, there is limited evidence that it may sometimes be associated with an increase in aggressive behavior. There is one study that identified more owner-directed aggression reported in Springer Spaniels that were neutered than in intact Springers.[101] How reliable such an owner survey might be or how applicable to other breeds is unclear. Similarly, one study found evidence of an increase in aggression towards owners among spayed female dogs who were spayed before 11 months of age and who had already

showed some aggressive behaviors before neutering.[103] However, there were some differences between the control group and the spayed dogs in addition to having surgery, and these make the results less reliable.

One study found female German Shepherds who were neutered were more reactive to the presence of unfamiliar humans and dogs than were intact dogs.[104]. Another study found neutered dogs to be more active than intact dogs and castrated males to be more excitable than intact males but found no other measurable behavioral differences between the groups.[105] The clinical significance or applicability of these findings to behavior problems is unclear.

One study has examined the relationship between neutering and the development of age-related behavioral changes thought to be similar to Alzheimer's disease or other forms of senile dementia in humans.[106] Such changes are relative common, being reported in 28% of dogs 10-12 years old and 68% of dogs 15-16 years old.[107] When multiple comparisons were made between intact males, castrated males, and spayed females (no intact females were included in the study), the only association found was for castrated males who had already shown signs of behavioral impairment when first assessed to progress to more severe impairment at a higher rate than intact males or spayed females. The significance of this finding is not clear.

5. Miscellaneous-
Urinary incontinence is common in middle-aged to older female dogs associated with spaying, with a reported incidence of 5-30%. Rates are lower in small dogs and higher in large breed dogs.[93,108-111] It can usually be successfully treated with medication.[108,112]

Several reports have found spayed females to be at increased risk for urinary tract infections compared to intact females[113,114], but other studies have not found such a relationship.[115] No associated with urinary tract infections has been found for neutering of male dogs.[113] Most urinary tract infections can be successfully treated with antibiotics.

Feline Lower Urinary Tract Disease (FLUTD) is a collection of symptoms ranging from mild bloody urine and straining while urinating to potentially life-threatening urinary tract obstruction.[116] Causes include bladder inflammation (cystitis), urinary tract infection, urinary tract stones, tumors, and others.[116] FLUTD has been reported to occur in 1.3%-4.6% of cats in private practice and 7%-8% of cats in veterinary teaching hospitals.[117,118] While some studies have found no association between FLUTD conditions and neutering [70,119], and it does not appear that neutering affects the size of the urethra in male cats (a possible risk factor for obstruction)[120], several epidemiologic studies have found that neutering status does raise the risk of some causes of FLUTD.[121,122]. Castrated males were at an increased risk compared to intact males for all causes of FLUTD except infection and urinary incontinence. Spayed females had an increased risk for urinary tract stones, urinary tract infections, and urinary tract tumor,

but not other causes of FLUTD. Intact females had a decreased risk for most causes.[122] While most cases of FLUTD are treatable and not life-threatening, urinary tract obstruction in males is a very serious condition. This occurred in about 12% of cats with FLUTD symptoms, and the risk is higher in castrated males cats.[122,123]

Hypothyroidism is a condition in which the thyroid gland atrophies or is damaged by the immune system and fails to produce adequate amounts of thyroid hormone.[124,125] It occurs in an estimated 0.2%-0.3% of dogs.[126,127] Some studies have found that neutered dogs are at higher risk than intact dogs for developing hypothyroidism.[126,127] However, other studies have not found any such association.[129] Supplementation of thyroid hormone resolves the disease in most cases.[127,128]

Diabetes mellitus is a complex disease that comes in a variety of forms and has a variety of causes. Briefly, an affected animal will have blood sugar levels that are too high and will usually need insulin injections to control their blood sugar and prevent the many serious secondary problems associated with uncontrolled diabetes.[130] Incidence in cats has been reported from 0.08%-2%, with Burmese cats having a higher rate of occurrence than other breeds or mixed-breed cats.[131-134] Incidence in dogs is estimated at 0.19-0.64%, with significant breed variations.[135,136] Diabetes is more common in male cats than females, and neutering is associated with an increased risk of diabetes in both male and female cats in some studies.[132] However when age and weight are controlled for no effect of neutering is seen in others.[134] For dogs, diabetes is usually believed to be more common in females than males [130,136] though this is not found in all populations.[133]

Castrated males were at higher risk for diabetes than intact males in one study, though weight was not controlled for.[137] Some authors have suggested that intact females may be at greater risk of diabetes due to the antagonistic effects of ovarian hormones on insulin, and spaying is an important part of regulating diabetes in female dogs. [133] Weight is clearly a risk factor for diabetes in cats, thought there is some debate about whether this is true in dogs, and since neutered animals are prone to be heavier than intact animals matched by breed and age, this may be a confounding factor creating the appearance of a direct effect of neutering on diabetes risk.[130-133,136] Diabetes is a serious chronic disease that can often be managed for long periods but cannot be cured.

Pancreatitis is an inflammatory condition of the pancreas, an organ involved in digestion and also insulin production.[138] It can occur as a sudden severe disease or as a long-term chronic, waxing and waning disease. The true incidence of pancreatitis is unknown, and although autopsy surveys have found evidence of inflammation in anywhere from less than 1% to more than 50% of dog pancreases, no study has yet examined how common clinical pancreatitis is.[139-141] In dogs, there is some evidence that neutered animals may be at higher risk than intact animals for sudden-onset form.[142,143]

Obesity is a common and growing clinical problem in dogs and cats. Though clear and consistent definitions do not exist, various reports have suggested that among dogs 18%-

44% are overweight and 2.9%-7.6% are obese.[154-156] Among cats, an estimated 19%-40% are overweight and 7.8% are obese.[157-159] Being overweight is a significant risk factor for many serious diseases.[134,160-162] Almost all studies agree that neutered cats and dogs are more likely to be overweight or obese than intact cats and dogs.[154-156,158-160,163-169] However, the exact relationship between neutering and excess body weight has not been clearly established.

Some studies have indicated that neutered animals have a lower metabolic rate and so burn fewer calories regardless of activity, which would make them prone to being overweight.[170-173] But other studies, which controlled for the proportion of an animal's weight made up of fat, which is not very metabolically active, have found comparable metabolic rates in intact and neutered animals.[167-169,174] There is evidence that the reason neutered animals gain excess weight is that they eat more and expend less energy than intact animals despite having the same resting metabolic rate.[53,165,169,171,172] There are also many other risk factors for obesity, including sex, breed, and variables associated with owners and their habits, that affect the chances of an animal becoming overweight regardless whether it is neutered or intact.[154,159,160,175]

It is clear that obesity is preventable. Proper restriction of the amount of food, and hence the number of calories available to dogs and cats is all that is necessary to prevent obesity regardless of neuter status. [154,160]

Optimal Age for Neutering

For decades, the traditional age for neutering dogs and cats has been 6-9 months. There is no clear scientific basis for choosing this age, and it has been suggested that this practice arose as a response to anesthetic mortality in very young animals in the first half of the 20th century.[70] Anesthetic procedures have evolved dramatically since that time, and it has since been demonstrated that not only is the procedure safe in puppies and kittens 7-12 weeks of age, but these younger patients actually recover faster and have fewer complications than those neutered at the traditional age.[65,102,176]

A large scale trial found no significant differences in the week immediately after surgery between patients neutered at the traditional age and earlier, apart from more minor surgical complications in the traditional age group.[65] Another study followed cats neutered at 7 weeks and at 7 months for 1 year and found no differences in any outcome.[102] Two large studies followed puppies and kittens neutered before and after 24 weeks of age for approximately 3 years.[177,178] For cats, of the numerous measures of health, behavior, and relationship with owner, the only difference detected was a greater incidence of urinary tract problems in the cats neutered at the traditional age.[177] In the dog study, puppies neutered earlier than 24 weeks did have a higher rate of infections, primarily parvovirus. This may have been due to differences in the management policies of the two shelters in which the subjects were neutered since the rate of parvovirus infections was higher at the shelter where most of the early neutering animals were spayed or castrated.[178] Dogs in the traditional age group had more

gastrointestinal problems than dogs in the early neuter group.[178] Interestingly, there was no difference in the incidence of urinary incontinence in female dogs in this study, which contrasts with another paper that found urinary incontinence occurred twice as often in females spayed after their first heat as those spayed before having a heat cycle.[111]

By far the largest, best designed studies in dogs and cats involved following over 1800 dogs and 1600 cats after neutering (either before or after 5.5 months of age) for an average of 4-4.5 years, but as long as 11 years in some cases.[93,149] For dogs, 7 out of 14 behavioral measures appeared affected by age at neutering, with early-neutering worsening 3 problem behaviors and improving 4. Animals in the early-neuter group exhibited higher rates of noise phobia and sexual behaviors. The early-neutered group also exhibited less separation anxiety, fearful urination in the house, and escaping. Early-castrated males (but not females) showed more aggression towards humans in the household and more barking. When only problems considered by owners to be serious were analyzed, the reduced risk of escaping for the early-neuter group was the only behavior still significantly associated with age at neutering.[93]

For medical conditions, 4 were significantly associated with age at neutering. Dogs neutered early had higher rates of hip dysplasia, though the dysplasia seen in the traditional-age group was clinically worse and this group was far more likely to be euthanized for the problem than the early-neuter group. Rates of cystitis and urinary incontinence were higher for females neutered before 5.5 months of age. The early-neuter group had lower rates of respiratory infections but higher rates of parvoviral infection. And finally, the early-neuter group had a lower rate of obesity than those dogs neutered at the traditional age. The remaining 43 outcome measures studied showed no difference between the two groups.[93]

For cats, early neutering increased shyness around strangers for both sexes, and it increased hiding behavior for males but not females. Early-neutered cats were showed less hyperactivity, and early-neutered males showed less aggression towards veterinarians, less urine spraying, and fewer sexual behaviors. There may also have been a decreased rate of scratching furniture in early-neutered cats, but these cats were more likely to be declawed so the effect may be an artifact. When only problems considered serious were analyzed, none of these behaviors was significantly associated with age at neuter.[149]

Early-neutered cats experienced lower rates of asthma and gingivitis, and males experienced fewer abscesses in the first 5-6 years after neutering. Cats neutered early may have experienced lower rates of cancer, but when only malignancies confirmed by a veterinarian were considered this effect was not significant. For the other 38 outcome measures studied, no difference between the groups was observed.[149]

Conclusions

It is apparent that spaying and castration have clear benefits for the pet population in general and both benefits and risks for individual dogs and cats. When the totality of the

evidence is considered, it is generally the case that common, serious problems in females are reduced by spaying and that less common or less serious problems may be exacerbated. It is, of course, impossible to predict for a particular pet what the medical or behavioral results of spaying or leaving her intact will be. However, the scientific evidence supports routine spaying of female dogs not intended for breeding because overall it is more likely to prevent than cause serious disease. The evidence is mixed regarding the risks and benefits of spaying dogs before 5-6 months of age, so no strong recommendation for or against the practice can be made. However, it is clear that spaying female dogs before their first heat is preferable to spaying them after this event. For cats, early spaying seems to have more benefits than risks.

In male dogs, the individual benefits of castration are not so clearly greater than the risks as they are for females. Overall, it seems that males are more likely to benefit than be harmed by being castrated, but the balance of the evidence is close. The population benefits, of course, argue in favor of routine neutering of male dogs. For male cats, however, neutering is clearly more likely to benefit rather than harm them. As is the case with females, early or traditional age at neutering seem roughly equivalent for dogs, but there seem to be more benefits than risks for early neutering of cats.

The decision to neutering an individual animal, and when to do so, should take into account both the scientific evidence of the risks and benefits as well as the unique circumstances of the pet and the owners. Rather than a dogmatic, one-size-fits-all approach, owners and veterinarians should examine the benefits and risks given all the available information and make appropriate, rational decisions in each case. There is, unfortunately, a tendency for lay people and veterinarians to react to the complexity and uncertainty of the research data by making broad, unsupportable generalizations or by sticking to habit and tradition. Our pets are better served by our remaining open-minded and reasonable and evaluating the quality and meaning of the available data carefully in light of the individual circumstances and characteristics of each individual animal.

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Evaluating the Benefits & Risks of Neutering
Brief Summary

Neutering involves removing the source of the hormones that control reproduction and that determine the typical physical and behavioral characteristics that distinguish males and females. In dogs and cats, this is usually done by surgically removing the testicles in males (castration) and the ovaries in females (spaying). The anesthesia and surgery itself is very safe, with only very rarely and serious complications. Owners often have many questions about the benefits and risks of neutering, and unfortunately not all of the information easily available on the Internet is accurate. This summary is based on a much more detailed literature review which can be found at http://www.skeptvet.com/web_documents/NeuterProsCons.pdf.

It is apparent that spaying and castration have clear benefits for the pet population in general and both benefits and risks for individual dogs and cats. When the totality of the evidence is considered, it is generally the case that common, serious problems in females are reduced by spaying and that less common or less serious problems may be exacerbated. It is, of course, impossible to predict for a particular pet what the medical or behavioral results of spaying or leaving her intact will be. However, the scientific evidence supports routine spaying of female dogs not intended for breeding because overall it is more likely to prevent than cause serious disease. The evidence is mixed regarding the risks and benefits of spaying dogs before 5-6 months of age, so no strong recommendation for or against the practice can be made. However, it is clear that spaying female dogs before their first heat is preferable to spaying them after this event. For cats, early spaying seems to have more benefits than risks.

In male dogs, the individual benefits of castration are not so clearly greater than the risks as they are for females. Overall, it seems that males are more likely to benefit than be harmed by being castrated, but the balance of the evidence is close. The population benefits, of course, argue in favor of routine neutering of male dogs. For male cats, however, neutering is clearly more likely to benefit rather than harm them. As is the case with females, early or traditional age at neutering seem roughly equivalent for dogs, but there seem to be more benefits than risks for early neutering of cats.

The decision to neutering an individual animal, and when to do so, should take into account both the scientific evidence of the risks and benefits as well as the unique circumstances of the pet and the owners. Owners and veterinarians should examine the benefits and risks given all the available information and make appropriate, rational decisions in each case.

Effects of Spaying on Females: ↓=decreases/reduces, ↑=increase/exacerbates

Condition	**How Common?**	**How Serious?**	**Effect of Spaying**	**Comments**
Unwanted litters	Very Common	Very	Prevents	Large pet population problem, many euthanasias
Risks of reproduction	Uncommon	Variable	Prevents	Dystocia, Brucellosis, Diabetes, others
Mammary tumors	Very Common	Very	↓ dramatically	Poor prognosis
Uterus infection(pyometra)	Very Common	Very	Prevents	
Uterine tumors	Rare	Variable	Prevents	Some benign/removable, some malignant
Ovarian tumors	Uncommon	Variable	Prevents	
Vaginal tumors	Uncommon	Moderate	↓ dramatically	
Osteosarcoma	Uncommon*	Very	Possibly ↑	*Rare in most breeds, common in a few breeds
Hemangiosarcoma	Uncommon*	Very	↑	*Rare in most breeds, common in a few breeds
Urinary cancer	Uncommon	Very	↑	Incidence varies by breed
Cruciate rupture (ACL)	Common*	Moderate	↑	*Incidence varies by breed, surgically treatable
Hip dysplasia	Common*	Moderate	Probably ↑	*Rare in most breeds, common in a few breeds
Aggressive behavior	Common	Very	Possibly ↑	
Urinary incontinence	Very Common	Mild	↑	Easily treatable
Urinary tract infection	Common	Mild	Possibly ↑	Easily treatable
Hypothyroidism	Uncommon	Moderate	Possibly ↑	Easily treatable
Diabetes mellitus	Uncommon	Very	Possibly ↑	Incidence varies by breed
Acute pancreatitis	Uncommon	Very	Possibly ↑	
Obesity	Common	Very	↑	Easily prevented by not overfeeding
Lifespan	--	--	Possibly ↑	Spayed females may live longer than intact females

Effects of Castration on Males: ↓=decreases/reduces, ↑=increase/exacerbates

Condition	**How Common?**	**How Serious?**	**Effect of Castration**	**Comments**
Unwanted litters	Very Common	Very	Prevents	Large pet population problem, many euthanasias
Testicular tumors	Uncommon	Moderate	Prevents	Most benign and surgically removable
Prostate disease	Very Common	Variable	↓ dramatically	Some have few symptoms other have severe, chronic disease
Behavior problems	Common	Variable	↓ most	Less aggression roaming, urine marking;
Perineal hernias	Uncommon	Moderate	↓	Can usually be treated surgically
Perianal fistulas	Uncommon*	Moderate	↓	Incidence varies by breed, some respond well to treatment others are serious chronic problem
Prostate cancer	Uncommon	Very	Probably ↑	Poor prognosis
Osteosarcoma	Uncommon*	Very	Possibly ↑	*Rare in most breeds, common in a few breeds
Hemangiosarcoma	Uncommon*	Very	↑	*Rare in most breeds, common in a few breeds
Cruciate rupture (ACL)	Common*	Moderate	↑	*Incidence varies by breed, surgically treatable
Hip dysplasia	Common*	Moderate	Probably ↑	*Rare in most breeds, common in a few breeds
Femoral growth plate fracture	Uncommon	Moderate	Possibly ↑	Cats only; obesity may be confounding factor
Hypothyroidism	Uncommon	Moderate	Possibly ↑	Easily treatable
Diabetes mellitus	Uncommon	Very	Possibly ↑	Incidence varies by breed
Acute pancreatitis	Uncommon	Very	Possibly ↑	
Obesity	Common	Very	↑	Easily prevented by not overfeeding
Lifespan	--	--	Possibly ↑	Castrated may live longer than intact males