Invited lecture/Review

Canine Spaying-Potential Health Benefits and Risks

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Abstract:

Ovariectomy is the most popular and reliable method of reproductive control in dogs. There are many health benefits to spaying. If spayed early enough, the risk of mammary gland neoplasia decreases significantly, and ovariectomy also eliminates the possibility of pyometra. On the other hand, spaying and the absence of gonadal hormones is also associated with an increased prevalence of many health problems. Urinary incontinence, various orthopaedic disorders, endocrinologic disorders such as hypothyroidism, many neoplastic disorders (including hemangiosarcoma, osteosarcoma, lymphoma) and immune-mediated disorders are among the most common health problems associated with early spaying and spaying in general.

Keywords: Spaying; Health benefits; Health risks; Neoplasia; Gonadal hormones exposure; Urinary incontinence

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1. Introduction

Ovariectomy (i.e., removal of the ovaries in female dogs) remains the most reliable method of permanent spaying for reproductive control in dogs (Rooster and Porters, 2017). This method allows us to control pet overpopulation and thus reduce the number of animals in shelters (Kustritz, 2007). Dog owners are often advised to have their dogs spayed for health reasons. Removal of both gonads eliminates pregnancy and parturition related diseases as well as diseases of the ovaries such as cysts and, although rare, ovarian tumours (carcinoma, adenocarcinoma, and teratoma). Although spaying has many positive health effects, research shows not only the benefits associated with spaying, but also many long-term health risks. Some of the long-term risks could include urinary incontinence, a predisposition to various neoplasms, and orthopaedic disorders.

Whether spaying improves or decreases the chances of overall good health depends on the age of the dog at the time of spaying and the relative risk for various health conditions in different breeds. The purpose of this article is to summarise many of the potential health benefits and risks associated with spaying at different ages by reviewing epidemiologic research studies on dogs.

2. Positive effects of spaying

2.1. Mammary gland neoplasia

Ovariectomy is an important preventive measure against mammary gland neoplasia because it reduces the risk of their development, especially when it is performed before the first oestrus cycle. In a study of 599 patients with 160 bitches, that developed mammary gland neoplasia, only 2 tumours were detected in bitches that were spayed early. 13 cases of mammary gland tumours were noted in bitches spayed late and 145 in intact bitches. Spaying after the third oestrus cycle, or when the bitch is older than 4 years, does not significantly reduce the risk of developing a mammary tumour (Borrego, 2017; Beaudu-Lange et al., 2021). Ovariectomy before the first heat could be counterproductive because of other health effects. When deciding to spay early despite other risks, it is important to consider breeds that are predisposed to develop mammary gland neoplasia such as Brittany Spaniel, Dachshund, English Setter, English Springer Spaniel, German Shepherd, Maltese, Miniature Poodle, Pointer, Boxer, Cocker Spaniel and Yorkshire Terrier (Kustritz, 2012). In contrast, Beauvais et al., (2012) reported that there is no clear evidence that spaying reduces the incidence of mammary gland neoplasia.

2.2. Pyometra

Pyometra is bacterial infection of the uterus that frequently occurs in dioestrus in intact females. Pyometra is more commonly diagnosed in certain breeds, such as Bernese Mountain Dogs, Rottweilers, Golden Retrievers, Bernese Mountain Dogs, Cavalier King Charles Spaniels, Rough Collies and Beagles. Approximately 25% of all intact female dogs develop pyometra by the age of 10 under the influence of progesterone endometrial growth and glandular secretion increase. In addition, progesterone stimulates cervical closure and prevents drainage, decreases myometrial activity, and inhibits leukocyte activity in the endometrium. This creates an ideal environment for bacterial growth (Bergström, 2017). The origin of contamination in most cases is the normal vaginal flora. The most commonly isolated bacteria in pyometra are E. coli, followed by Staphylococcus, Streptococcus, Pseudomonas and Proteus spp. (Memon, 2013). Over the years, cystic endometrial hyperplasia develops with an increased number of cystic glands, resulting in thickening of the endometrium in all intact bitches. This is due to the repeated luteal phases. Cystic hyperplasia is often followed by pyometra, which is why older bitches are more commonly affected. After spaying progesterone secretion decreases and prevents the development of an ideal environment for bacterial growth (Bergström, 2017).

2.3. Diabetes mellitus

Diabetes mellitus is a metabolic disease, more commonly diagnosed in older animals with predisposition of females. Type II diabetes may be caused by increased progesterone levels. The mechanism of action is indirect by stimulating mammary glands to secrete growth hormone, which causes insulin resistance. Prevention of progesterone-induced diabetes mellitus in bitches can be achieved by ovariectomy (Bigliardi et al., 2014).

3. Adverse effects of spaying

3.1. Urinary incontinence

Urinary incontinence is defined as involuntary leakage of urine. It can be acquired or congenital (Pegram et al., 2019). The most common cause of acquired urinary incontinence is incompetence of the urethral sphincter mechanism. This spayed related side effect occurs in up to 20% of females due to decreased urethral muscle activity and periurethral tissue and urethral changes. This is probably caused by the decrease in oestrogen levels and increase in Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH) levels after removal of the ovaries. In comparison, urinary incontinence occurs in less than 1% of intact bitches (Rooster and Porters, 2017). Predisposed breeds include Old English Sheepdog, Giant Schnauzer, Weimaraner, Doberman Pinscher, Rottweiler, and Boxer (Byron, 2017). Research on whether age of spaying affects the prevalence of urinary incontinence in female dogs found no relevant association (Bleser et al., 2011).

3.2. Orthopaedic disorders

Spaying increases the risk of orthopaedic diseases, especially in larger breeds, with the exception of Great Dane and Irish Wolfhound (Hart et al., 2020). Bitches spayed early (before 6 months of age) were found to have a 20% incidence of at least one of the orthopaedic disorders (hip dysplasia, elbow dysplasia, and cranial cruciate ligament rupture) was seen in a sample of 472 Golden Retriever females. In contrast, only a 5% prevalence was found in intact Golden Retriever females (Hart et al., 2014). Bitches spayed early (before 6 months of age) were found to have a 20% incidence of at least one of the orthopaedic disorders (hip dysplasia, elbow dysplasia, and cranial cruciate ligament rupture) which was seen in a sample of 472 Golden Retriever females.

In 2008, Witsberger reported higher prevalence of cranial cruciate ligament insufficiency in spayed female dogs. An increased prevalence for cranial cruciate ligament injuries was also mentioned by Kutzler in 2020. The incidence in spayed dogs doubled compared to unaltered dogs. The possible mechanism for the higher incidence of cranial cruciate ligament insufficiency in spayed females is an altered angle of the tibial plateau, which affects the act of forces on ligament. Forces on the cranial part of the tibia are increased, which may result in injury to the cranial cruciate ligament. Altered steepness of the tibial plateau is thought to be associated with the expanded growth of the cranial portion of the tibia and early closure of the distal tibial growth plate. Overgrowth of the proximal tibia can be caused by early spaying. A study of 58 dogs with tibial plateau angle higher than 35 degrees plateau and 58 control dogs, found out that dogs from case group were more likely to have been spayed prior to six months of age (Duerr et al., 2007; Griffon et al., 2010). In addition, a study on Golden Retrievers found that spayed females were at substantially higher risk of cranial cruciate ligament rupture (Hart et al., 2014).

Susceptibility to canine hip dysplasia in castrated dogs was evidenced by Witsberger (2008), but not for female dogs. Furthermore, in a study that included 339 female Golden Retrievers with hip dysplasia no association was found between female sterilisation and hip dysplasia (Torres de la Riva et al., 2013). A report by Hart et al. in 2014 showed that the association between the incidence of hip dysplasia and spaying wasn't compelling.

Another orthopaedic disorder affected by spaying is intervertebral disc herniation. A study of the effects spaying on this condition was conducted on Dachshunds and concluded that the risk of intervertebral disc herniation was significantly higher in spayed bitches (Dorn and Seath, 2018).

The side effects of spaying on joint disorders were described primarily for larger breeds, whereas smaller breeds such as Cavalier King Charles Spaniel, Yorkshire Terrier, Pomeranian, Boston Terrier, Chihuahua, Corgi, and Maltese showed no negative effects of gonadectomy on joint disorders (Hart, et al., 2014).

3.3. Endocrinologic disorders

In spayed dogs, the LH blood level is thirty times normal due to the absence of gonadal hormones and decreased compensatory feedback to the hypothalamus and anterior pituitary gland. LH receptors are also present in tissues other than the reproductive system. In the thyroid gland LH receptors

are located near Thyroid-Stimulating Hormone (TSH) receptors. Constant stimulation of LH receptors could affect the normal function of TSH receptors, which would explain the decreased serum levels of thyroid hormones in spayed animals. Spaying could contribute to the development of hypothyroidism (Albright, 2020). In a study of the epidemiologic feature of canine hypothyroidism it was found that spayed females were much more likely to develop hypothyroidism compared to intact females (Milne, et al. 1981).

Although it was mentioned above that spaying eliminates progesterone-induced diabetes-mellitus, neuter can also trigger the development of diabetes mellitus. This was confirmed for castrated males, which were twice as likely to develop diabetes mellitus compared with the overall male population. The same results weren't observed in female dogs, where there was no higher incidence of diabetes mellitus in spayed bitches (Mattin, et al. 2014).

3.4. Obesity

Obesity is a major health concern in dogs, and the success rate of treatment with food restriction and increased physical activity is often limited. In a study of 229 dogs, more than half were found to be overweight or obese (Sapowicz, et al. 2016). Prevention of obesity is a key to success. For this reason, it is important to know the impact of spaying on a dog's weight (Bjørnvad, et al. 2019). Gonadectomy is thought to increase appetite and stimulate food intake. One possible mechanism would be an increase in cholecystokinin and glucagon trough stimulation of the LH receptors, as satiety results from food intake suppressing secretion of gastrointestinal hormones (Kutzler, 2020). This would explain the results of a study conducted in the United States that concluded that gonadectomy increased the risk of developing obesity in dogs (males and females) of all ages (Simpson, et al. 2019). In addition, research on 27627 dogs confirmed that spayed dogs have an increased risk of obesity, that is not influenced by the timing of gonadectomy (Lefebvre, et al. 2013). However, not all studies reach the same conclusion. For example, a study in Denmark did not identify sterilisation as an important risk factor for obesity in bitches (Bjørnvad et al., 2019).

3.5. Neoplastic disorders

3.5.1. Hemangiosarcoma

Hemangiosarcoma (HSA) is a highly malignant neoplasm with poor prognosis and is relatively commonly diagnosed in dogs, accounting for 2% of all neoplasms in dogs. Large breeds of dogs, such as German Shepherd and Golden Retriever, appear to be predisposed to HSA. Although the definitive aetiology of HSA in dogs remains unknown, many studies suggest that gonadectomy, among many other factors, is a risk factor for the development of HSA (Clifford, 2000). One study concluded that spayed females were four times more likely to be diagnosed with cardiac HSA than intact females (Ware and Hopper, 1999). Another study evaluated splenic HSA and found that spayed females were more than twice as likely to be diagnosed with splenic HSA when compared to sexually intact bitches (Prymak, et al. 1988). Finally, a study based on The Veterinary Medical Database was performed with a large population of both sexually intact and gonadectomized dogs diagnosed with HSA in all anatomical areas (spleen, heart, general, skin, etc.). Mentioned study concluded that spayed female dogs were significantly more likely to develop HSA in any anatomical site. Another piece of information to consider when deciding whether or not to spay is the breed factor; German Shepherd, Golden Retriever, and Boxer had the strongest association with a diagnosis of HSA regardless of the neuter status (Robinson, et al. 2020).

3.5.2. Osteosarcoma

Osteosarcoma is the most common type of bone cancer and is relatively common in dogs (Makielski, et al. 2019). In the United States approximately 10,000 dogs are diagnosed with bone sarcoma each year. There are many risk factors for osteosarcoma in dogs, with body size being the most important (Cooley, et al. 2002). A case related study done in 1998 supports this theory by finding that Irish Wolfhound, Saint Bernard, Great Dane, Rottweiler, and Irish Setter, all large dog breeds, are the most common dog breeds diagnosed with osteosarcoma. In the same study spayed female, and spayed male dogs were found to have a significantly higher risk of bone sarcoma. In the aforementioned study, it could not be determined whether the duration of exposure to gonadal hormones had an effect on the risk of developing osteosarcoma, because the information on the age at which the dog was spayed was not known (Ru, 1998).

In another cohort study of Rottweilers, a breed predisposed to osteosarcoma, information on age at spaying was considered. The aforementioned study found, that dogs spayed within the first year had approximately a one-in-four risk of developing osteosarcoma and were significantly more likely to develop osteosarcoma than sexually intact dogs. For each additional month of sexual intactness, the probability of developing bone sarcoma decreased by 1.4% (Cooley, et al. 2002). Although these findings suggest that gonadal hormones have a protective effect against neoplastic proliferation in bone tissue, the possible mechanism is still largely unknown.

3.5.3. Lymphoma

Lymphoma is the most common hematopoietic neoplastic disorder in dogs (Vail, 2017). In humans, females have been found to have non-Hodgkin's lymphoma (NHL) less frequently than males. The incidence of NHL in females increases after the age of fifty, when menopause is regularly reached, suggesting that female gonadal hormones may have a protective effect against NHL. It has been hypothesized that the development of canine lymphoma in intact females is suppressed by endogenous gonadal hormones. The Veterinary Medical Database examined records of 14,000 cases of canine lymphoma registered over a thirty-eight year period and investigated whether sex was a risk factor for lymphoma. This cohort study found that intact female dogs were least likely to develop lymphoma and that spayed dogs of both sexes had a significantly higher risk. The same study also found that Bullmastiff, Boxer, Golden Setter, Scottish Terrier and Bernese Mountain dog had the highest risk of developing lymphoma, but did not investigate whether spaying affected these breeds differently than the general dog population. In the aforementioned study dogs were not differentiated by the age of gonadectomy (Villamil, et al. 2009).

3.6. Other disorders

Oestrogen has a trophic effect on the vaginal mucosa and muscular layers that decreases after sterilisation. In addition, anatomical changes of the lower genital tract have been noted in spayed bitches compared to intact females. Vulvar atrophy may also develop as a result of sterilisation, leading to perivulvar dermatitis. In addition, this change in local conditions could affect the composition of resident flora. In a study on the effect of hormone reduction on the vaginal mucosa, it was found that the vaginal mucosal layer in spayed bitches was fragile, as erythrocytes were found in 50% of the smears of intact bitches. In comparison, no erythrocytes were found in the smear samples of intact bitches. However, there were no significant differences between microbiota on the vaginal mucosa of spayed and intact bitches (Rota, et al. 2020).

Spaying is closely related to adverse effects of vaccines. Moore et al. 2005 described that spayed dogs are more likely to develop vaccine adverse reactions within three days of vaccination compared to intact dogs. Furthermore, gonadectomized dogs are more prone to develop immune-mediated thrombocytopenia, atopic dermatitis, inflammatory bowel disease and autoimmune haemolytic anaemia. Spayed females were also more likely to develop lupus erythematosus. Atopic dermatitis occurred in 83 of 9133 (0.91%) intact females and in 745 of 36574 (2.03%) spayed females. Autoimmune haemolytic anaemia was reported in 38 of 9133 (0,42%) intact females and 256 of 36574 (0,7%) spayed females (Sundburg, et al. 2016).

Spaying can result in coat changes. A study of 15 spayed female dogs in 2008 linked spaying with changes in hair follicles. n spayed dogs, more hair follicles were in the anagen phase and fewer in the telogen phase. However, coat changes were found in only 20% of the dogs in the form of increased woolly hair (Reichler, et al. 2008).

4. Conclusions

To conclude, although spaying is one of the most commonly performed surgical procedures in the veterinary field, the decision should not be straightforward. Spaying brings both positive and negative effects. The decision should take into account the breed, size and age of the dog on which the procedure will be performed, as the effects of spaying can vary for different breeds and age groups. Therefore, is why it is important that veterinarians are familiar with the latest research on this topic and can provide sound advice to dog owners on whether and when to spay their dog.

Conflicts of Interest: The authors declare no conflict of interest.

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