

2/12/15

Re: early spay and neuter

Kendra,

Basically, I conclude from these studies that early spay neuter is a safe procedure. The only con I see could be a slight increased risk of later age urinary incontinence (incidence of 5% to as much as 12.9%) which is highly manageable if it occurs. Another highly debated topic is hip dysplasia. It seems that spay/neuter prior to 5.5 months of age increases the risk of hip dysplasia from 4.7% to 6.7%, but the animals that develop hip dysplasia if spayed/neutered later than 5.5 months of age are more likely to be euthanized due to hip dysplasia (ie. Those cases of hip dysplasia are more severe and painful).

In conclusion, I still cannot identify any risk factors important enough for me to justify stopping what we are doing.

Please call with any questions.

Jason Herrmann, DVM

Long-term risks and benefits of early-age gonadectomy in dogs

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Objective—To evaluate the long-term risks and benefits of early-age gonadectomy, compared with traditional-age gonadectomy, among dogs adopted from a large animal shelter.

Design—Retrospective cohort study.

Animals—1,842 dogs.

Procedure—Dogs underwent gonadectomy and were adopted from an animal shelter before 1 year of age; follow-up was available for as long as 11 years after surgery. Adopters completed a questionnaire about their dogs' behavior and medical history. When possible, the dogs' veterinary records were reviewed. Associations between the occurrence of 56 medical and behavioral conditions and dogs' age at gonadectomy were evaluated.

Results—Among female dogs, early-age gonadectomy was associated with increased rate of cystitis and decreasing age at gonadectomy was associated with increased rate of urinary incontinence. Among male and female dogs with early-age gonadectomy, hip dysplasia, noise phobias, and sexual behaviors were increased, whereas obesity, separation anxiety, escaping behaviors, inappropriate elimination when frightened, and relinquishment for any reason were decreased.

Conclusions and Clinical Relevance—Because early-age gonadectomy appears to offer more benefits than risks for male dogs, animal shelters can safely gonadectomize male dogs at a young age and veterinary practitioners should consider recommending routine gonadectomy for client-owned male dogs before the traditional age of 6 to 8 months. For female dogs, however, increased urinary incontinence suggests that delaying gonadectomy until at least 3 months of age may be beneficial. (*J Am Vet Med Assoc* 2004; 224:380–387)

the number is in the millions.¹⁻⁴ In recent years, some shelters are finding that most of their unadopted dogs are adolescent or adult dogs that are relinquished because of behavior that was unacceptable to the adopter.⁵⁻⁷ These data suggest that unplanned litters of puppies must be reduced while also minimizing the frequency of preventable behavioral problems that might lead to relinquishment. Routine early-age gonadectomy of dogs has been viewed as an important step in reducing the number of dogs relinquished to shelters for 2 reasons. Comprehensive early-age gonadectomy by shelters ensures that no adopted dogs will breed and may reduce the incidence of certain medical or behavioral conditions that lead to relinquishment of adopted dogs.^{8,9}

To date, studies have established safe anesthetic protocols for early-age gonadectomy in dogs¹⁰ and revealed that gonadectomy at 7 weeks of age is associated with more rapid anesthetic recovery and fewer perioperative complications, compared with gonadectomy at 7 months of age.¹¹ One study¹² revealed no adverse medical or behavioral consequences in dogs with follow-up to 1 year of age. Another study¹³ found only 1 risk of early-age gonadectomy; dogs gonadectomized before 24 weeks of age were more likely to become infected with parvovirus, which was probably attributable to early-age exposure in 1 shelter. In a recent survey, however, 84% of practicing veterinarians perceived at least 1 risk associated with gonadectomy before 4 months of age that is not associated with gonadectomy performed at an older age, including 29% who thought that early-age gonadectomy increased the risk of at least 1 medical condition later in life.¹⁴

The purpose of the study reported here was to evaluate the long-term risks and benefits of early-age gonadectomy (before 5.5 months of age), compared with traditional-age gonadectomy, among dogs adopted from a large animal shelter.

Materials and Methods

Sampling and data collection—The sampling methods and contact procedures for this study have been described.¹⁵ In brief, study dogs were among those adopted from the Erie County, New York, Society for the Prevention of Cruelty to Animals between 1989 and 1998. During these years, this shelter was a full-service shelter with animal-control contracts. The shelter screened dogs for aggression before offering them for adoption, and aggressive dogs were euthanized. All adopted study dogs had been gonadectomized between 6 weeks and 12 months of age and retained in the adoptive household for at least 3 months after adoption. The adopters of study dogs were contacted between January 2000 and January 2001 and asked to complete a questionnaire about their dogs.

The study questionnaire contained 95 questions grouped into 5 sections.¹ Each adopter was asked whether

Reliable estimates of the number of healthy dogs that are euthanatized by animal shelters in the United States each year are difficult to determine, but

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the dog was still in the household and, if not, what happened to the dog (section 1); the dog's behaviors and activities and, where appropriate, whether the adopter considered the behaviors a serious problem (section 2); the dog's medical history, including the dates of diagnoses for common medical problems (section 3); the adopter's household characteristics (eg, income and education; section 4); and the veterinarian who had cared for the dog and permission to review the dog's veterinary records (section 5). Because of uncertainty in pinpointing the exact time of onset of behavioral conditions in section 3, adopters were asked to identify only whether or not a behavior had occurred during the lifetime of the dog.

Methods for abstracting information from the veterinary records have been described.¹⁵ Seventy-one veterinary clinics in the region were visited, and the records of participating dogs were abstracted by use of a standardized form that contained 121 items, including the number of visits to that clinic, the dog's status on the last visit, the dog's vaccination and weight history, occurrence of medical and behavioral problems, and, for each problem, the date of first diagnosis and the number of episodes.⁴

Outcomes of interest—Fifty-six outcomes were evaluated. The following 19 outcomes were defined by combined information from the questionnaire and veterinary records: overall mortality rate from any cause, acariasis (any skin mite), aggression towards people, allergic skin disease, arthritis, balanoposthitis, cardiac disease (any etiology), diabetes mellitus, fractures, hepatic disease (any etiology), hip dysplasia, hyperactivity, hypoadrenocorticism, hypothyroidism, neoplasia, parvoviral infection, pneumonia, urinary incontinence, and vaginitis. The following 16 outcomes were defined by information from the questionnaire only: aggression towards animals, body condition (degree of obesity), destructive behaviors that persisted past 1 year of age, digging holes in the yard, escaping while owner was home, excessive barking, excitement around visitors, excessive jumping, excessive licking or chewing of skin, noise phobias, playful behaviors, relinquishment, separation anxiety, sexual behaviors, shyness, and urination in the house when frightened or excited. The following 21 outcomes were defined from the veterinary records only: abscesses, aggression towards veterinarian or veterinary staff, allergies to foods, autoimmune disorders, chronic renal failure, demodicosis, fight-bite wounds, gingivitis, hit by car, infectious tracheobronchitis (kennel cough), intervertebral disk disease, lacerations, orthopedic problems of the stifle joint (either cranial cruciate ligament tear or patellar luxation), pancreatic disorders, perivulvar dermatitis, pica, pyoderma, repeated infections, soft tissue injuries (or undiagnosed lameness), urinary tract infections (or cystitis), and urolithiasis.

For those outcomes based on combined information, the condition was considered present if indicated on either the questionnaire, veterinary record, or both. If indicated on the veterinary record, that date of diagnosis was used. If indicated on only the questionnaire (or if the veterinary record was not abstracted), then the questionnaire date was used. For analysis of overall mortality and relinquishment rates, all responses (including partial responses) were used. For all other outcomes, analysis was based on respondents completing most or all of the questionnaire.

For bone fractures, analysis was performed first with all fractures and then with fractures of only long bones (ie, humerus, radius, ulna, femur, tibia, or fibula). Body condition was assessed by asking adopters who still had their dog to compare the dog's present body shape with a series of 5 images validated by previous studies.¹⁶ The 2 heaviest images (obese and heavy dogs) were compared with clinically normal and thin dogs; very thin dogs were excluded from this analysis. To remove dogs that may have already had the con-

dition at the time of adoption, cases of canine parvovirus infection, kennel cough, and pyoderma were limited to those cases with onset after 1 year of age. Neoplastic conditions were considered malignant if the veterinarian provided a specific diagnosis, the owner described metastasis, or the dog was euthanized for the condition. All neoplastic conditions were evaluated together and then mammary neoplasia was evaluated alone. The outcome of repeated infection was defined by 2 or more infections of the same body system as recorded in the veterinary records. Urinary incontinence was considered an outcome only for dogs that required medical treatment. For medical conditions that may have had repeated episodes (eg, tracheobronchitis), only the time until the first occurrence was used.

When evaluating behaviors for which we asked about severity of the behavior, dogs that had the condition at any time (regardless of severity) were compared with those that never had the condition. Dogs that had a severe problem with the behavior were compared with those that never had the behavior; in this comparison, dogs that had the behavior were not included if it was not considered a serious problem. A behavioral condition was considered a serious problem if the adopter considered it so or if the veterinary record indicated that the adopter had sought treatment for the condition. Dogs with aggression were first analyzed together and then dogs with aggression towards other dogs, family members, or strangers or that displayed any biting, biting children, and biting that required the person to receive medical care were examined individually. All cases of excessive barking were analyzed together and then barking or growling at visitors, barking that bothered household members, and barking that bothered neighbors were analyzed separately. Separation anxiety was considered present if indicated on the veterinary records or if the adopter reported a serious problem with 1 or more of the following sets of behaviors when the dog was left alone or about to be left alone: shaking, shivering, or trembling; vomiting or drooling; whining, barking, or howling; chewing, damaging, or destroying objects or furniture; and chewing or scratching at doors, walls, or windows. All sexual behavior was evaluated together and then separately by sexual behavior directed towards people, towards other dogs, and towards inanimate objects.

Statistical methods—Methods for multivariable analyses of the data have been described.¹⁵ In brief, incidence density rates (for medical conditions) or proportions of dogs with each outcome (for behavioral conditions) were calculated. Multivariable analyses were used to determine whether age at gonadectomy was related to occurrence of each outcome, while controlling for the effect of any potentially confounding variables. Most behavioral outcomes were evaluated with logistic regression, and most medical outcomes were analyzed by use of survival analysis (Cox proportional hazard model).

Age at gonadectomy was used on a continuous scale (from 1.4 to 12 months) when this variable had a linear relationship with the log-odds (for logistic regression) or log-hazard (for survival analysis). When this linear relationship was not present, age at gonadectomy was categorized into 2 groups. Group 1 consisted of dogs gonadectomized at < 5.5 months of age. This is the age at which many shelters routinely perform gonadectomy on dogs but at which few practicing veterinarians perform gonadectomy.¹⁴ Group 2 consisted of dogs gonadectomized at or after 5.5 months of age. This is the most common age for gonadectomy and is accepted by most practicing veterinarians.¹⁴ Most dogs have completed their vaccinations at this age also.

For all outcomes, the following variables were considered in multivariable models as possible confounders with age at gonadectomy: sex, purebred or mixed-breed, owner sur-

render or stray on admission to the shelter, whether the dog was kept in the shelter > 5 days before adoption, and presence of another dog in the household. In addition, for all behavioral outcomes and appropriate medical conditions, relinquishment for a behavioral problem (on shelter admission), frequency of exercise, and whether the dog had received any structured training outside the household were also considered in each model. For all analyses, a value of $P \leq 0.05$ was considered significant when evaluating age at gonadectomy. If the interaction between sex and age at neutering was significant with a value of $P \leq 0.1$, the model-building process was repeated separately for male and female dogs.

When making comparisons that did not require multivariable modeling, the χ^2 test was used for categorical data and the Student t test was used for normally distributed continuous data.¹⁷ Criteria for assessing causal relationships have been described.¹⁵

Results

Of 3,501 sampled dog adoptions, no current contact information could be found for 1,106 (31.6%) adopters. Two hundred ninety-six (8.5%) dogs were determined to be ineligible (in most instances because the adopter kept the dog < 3 months, the dog did not survive for ≥ 3 months, or the dog was determined to have been gonadectomized prior to admission to the shelter). Of the remaining 2,099 eligible dog adopters for whom we believed we had correct contact information, 1,659 (79.0%) completed the questionnaire, whereas 183 (8.7%) provided partial information about their dog. Among the 2,099 adopters, the dogs of responders (partial and complete) did not differ significantly (all comparisons, $P > 0.25$) from those of non-responders by age at gonadectomy, proportion that were strays, proportion that were originally relinquished for a behavioral problem, or time from adoption until contact for study. More responders adopted a female dog than did nonresponders ($P = 0.06$). For 977 (58.8%) dogs, the adopter provided consent to review veterinary records, and the records were successfully located.

Among adopters who completed the questionnaire, slightly more than half of their dogs were female and less than half had come into the shelter as strays (Table 1). Median follow-up time (ie, from adoption until questionnaire completion, the dog's death, or relinquishment) was 4.5 years (range, 0.3 to 11.3 years). Median age at end of follow-up was 5.0 years (range, 0.5 to 12.2 years); 167 dogs had follow-up past 10 years of age.

Table 1—Characteristics of 1,842 dogs (No. [%] with characteristic) adopted from a humane shelter in a study of long-term risks and benefits of early-age gonadectomy

Characteristic	Age at gonadectomy (mo)	
	< 5.5 (n = 948)	≥ 5.5 (894)
Sex		
Female	499 (52.6)	484 (54.1)
Male	449 (47.4)	410 (45.9)
Status on shelter admission ^a		
Owner surrender or impoundment	715 (77.4)	521 (60.0)
Stray	209 (22.6)	348 (40.0)

^aInformation missing for certain dogs.

Overall, 4 medical conditions and 8 behavioral conditions were significantly associated with age at gonadectomy (Table 2 and 3). None of the potential confounding variables remained in the final models. For conditions in which age at gonadectomy was categorized, the hazard ratios (HRs) and odds ratios (ORs) in the tables can be interpreted as an estimate of the relative risk of developing the condition for dogs gonadectomized at < 5.5 months of age, compared with dogs gonadectomized from ≥ 5.5 to 12 months of age. For conditions analyzed with age at gonadectomy on a con-

Table 2—Medical conditions other than obesity associated with age at gonadectomy in 1,659 dogs

Condition	Age at gonadectomy (mo)	Incidence density ^a	Hazard ratio ^b	95% CI	Overall P value
Cystitis ^c	< 5.5	1.38	2.76	1.08, 7.14	0.02
	≥ 5.5	0.43	1.0	NA	
Hip dysplasia	< 5.5	1.36	1.70	1.04, 2.78	0.03
	≥ 5.5	0.98	1.0	NA	
Urinary incontinence ^c	Continuous	1.19	1.20 ^d	1.06, 1.35	< 0.01

^aIncidence density/100 dog years at risk. ^bHazard ratio adjusted for dog's age at time of disease onset. ^cFor female dogs only. ^dHazard ratio/1-month decrease in age at gonadectomy. 95% CI = 95% Confidence interval for the hazard ratio. NA = Not applicable (referent category).

Table 3—Behavioral conditions associated with age at gonadectomy in 1,659 dogs

Behavior	Age at gonadectomy (mo)	Dogs with behavior (%)	Odds ratio	95% CI	Overall P value
Aggression towards household members ^a	< 5.5	29.0	1.32	1.05, 2.10	0.02
	≥ 5.5	21.5	1.0	NA	
Barking that bothered household members ^{ab}	Continuous	34.2	1.08 ^c	1.02, 1.12	< 0.01
Barking or growling at visitors ^{ab}	Continuous	65.4	1.08 ^c	1.02, 1.13	< 0.01
Escaping from home (serious problem)	Continuous	9.6	0.93 ^c	0.87, 0.98	< 0.01
Noise phobia ^b	Continuous	52.6	1.04 ^c	1.01, 1.08	< 0.01
Separation anxiety	< 5.5	14.2	0.72	0.55, 0.94	0.02
	≥ 5.5	18.7	1.0	NA	
Sexual behaviors ^b	Continuous	27.3	1.05 ^c	1.01, 1.09	< 0.01
Urination when frightened ^c	< 5.5	9.4	0.74	0.54, 1.01	0.06
	≥ 5.5	12.3	1.0	NA	

^aMale dogs only. ^bNot significant ($P > 0.05$) when considered a serious problem. ^cOdds ratio/1-month decrease in age at gonadectomy. See Table 2 for remainder of key.

tinuous scale, the OR or HR can be interpreted as the change in risk for each month earlier that the dogs were gonadectomized. In Tables 2 and 3, an OR or HR < 1.0 indicates that the condition decreased with early-age gonadectomy, while an OR or HR > 1.0 indicated that the condition increased with early-age gonadectomy.

The incidence densities can be converted to cumulative incidences by use of the formula $1 - \exp(-t[ID/100])$, where t is the number of years of follow-up, ID is the incidence density/100 dog years from Table 2, and \exp is the inverse of the natural logarithm.¹⁸ Use of this formula assumes that the risk of disease was constant throughout the dogs' lives and that there were no competing risks (ie, no other diseases caused death during the time of observation).

Overall mortality rate was not associated with age at gonadectomy, although overall relinquishment was lowest among dogs gonadectomized before 5.5 months of age. Among dogs gonadectomized before 5.5 months of age, 7.5% were relinquished (after the first 3 months), whereas among those gonadectomized \geq 5.5 months, 10.4% were relinquished (age-adjusted HR, 0.65; $P = 0.01$).

Medical outcomes—A significant relationship with age at gonadectomy was found for cystitis, hip dysplasia, and urinary incontinence (Table 2). In addition, the prevalence of overweight body condition declined with decreasing age at gonadectomy (OR/1-month decrease in age at gonadectomy, 0.94; $P = 0.04$). Overall, 26.9% of dogs still in the adoptive household were overweight at the time of the study.

Among all dogs, early-age gonadectomy was associated with significantly increased incidence of hip dysplasia. Among dogs gonadectomized before 5.5 months of age, 6.7% developed hip dysplasia, whereas among those gonadectomized at \geq 5.5 months of age, 4.7% developed the condition (difference in proportions, $P = 0.10$). The HR had a lower P value ($P = 0.03$) because the early-age gonadectomized dogs with hip dysplasia received the diagnosis at an earlier age (median age, 33 months) than the older gonadectomized dogs with hip dysplasia (median age, 44 months); thus, the rate of development was faster. Only 54% of the dogs with a diagnosis of hip dysplasia were reported to also have arthritis or joint problems requiring veterinary attention. The dogs with hip dysplasia that had been gonadectomized at \geq 5.5 months of age were 3 times as likely to be euthanatized for the condition as those with hip dysplasia and gonadectomized before 5.5 months of age ($P = 0.02$).

For cystitis and urinary incontinence, there was significant interaction between age at gonadectomy and sex, suggesting different risks between males and females. Incidence of cystitis was significantly higher among females that were gonadectomized before 5.5 months of age. Four female dogs had 2 episodes of cystitis, but none had > 2 episodes, so the condition was not chronic for any dogs. Among female dogs, decreasing age at gonadectomy on a continuous scale was associated with increasing incidence of urinary incontinence that required medical treatment. Females gonadectomized before 3 months of age appeared to be at highest risk, compared with those

gonadectomized at \geq 3 months of age (HR, 3.46; $P < 0.001$). The corresponding projected cumulative incidence during the first 6 years of life (when most cases of urinary incontinence were diagnosed) was 12.9% for female dogs gonadectomized before 3 months of age and 5.0% for female dogs gonadectomized at \geq 3 months of age. None of the 49 female dogs with urinary incontinence, however, were relinquished to a shelter or given to another owner for any reason, and their rate of euthanasia was not higher than the overall rate.

Among all dogs, early-age gonadectomy was associated with significantly reduced incidence of pneumonia. When the questionnaire and veterinary information were compared, however, many cases identified as pneumonia by owners appeared to have been kennel cough diagnosed in the periadoption period. When the cases of pneumonia as reported by owners were restricted to those with onset after 1 year of age or those confirmed by veterinary records, the association with age at gonadectomy was no longer significant.

For all cases of parvoviral enteritis, dogs gonadectomized before 5.5 months of age had significantly greater incidence. Approximately one-third of cases of parvoviral enteritis were diagnosed within the first week after adoption and probably resulted from exposure to the virus before gonadectomy and adoption. When cases were restricted to those with onset after 1 year of age or those with onset after the periadoption period, the association disappeared.

Behavioral outcomes—Seven behavioral outcomes were significantly associated with age at gonadectomy (Table 3). One other outcome, urination when frightened, had a value of $P = 0.06$. Among male and female dogs, decreasing age at gonadectomy was associated with increased rates of noise phobias and sexual behaviors, whereas escaping considered a serious problem declined with decreasing age at gonadectomy. Separation anxiety and urination in the house when frightened were less frequent among dogs gonadectomized before 5.5 months of age. Urination when frightened was strongly associated with separation anxiety; dogs with separation anxiety were approximately twice as likely as other dogs to also urinate in the house when frightened ($P < 0.01$). For 3 other behaviors (aggression towards family member, barking or growling at visitors, and excessive barking that bothered a household member), a significant interaction was detected between age at gonadectomy and sex, suggesting different risks between males and females. In analyses stratified by sex, these 3 behaviors were significantly associated with age at gonadectomy for males but not females. Aggression towards family members was more frequent among male dogs gonadectomized before 5.5 months of age, and decreasing age at gonadectomy was associated with higher rates of barking or growling at visitors and excessive barking that bothered household members. These 3 behaviors were also significantly ($P < 0.01$) associated with each other. For dogs that did not have aggression, there was no association between age at gonadectomy and excessive barking.

When analysis was restricted to dogs with a serious problem, barking and growling at visitors, barking that bothered household members, noise phobias, sex-

ual behaviors, and urination when frightened were no longer significantly associated with age at gonadectomy. In contrast, decreasing age at gonadectomy was associated with lower rates of escaping from home considered a serious problem, but the association was not significant when all cases of escaping were analyzed. Among the 8 behavioral outcomes associated with age at gonadectomy, 4 were associated with increased risk of relinquishment: aggression towards family members, escaping considered a serious problem, separation anxiety, and urination when frightened. Only 1 behavior, aggression towards family members, was associated with increased risk of euthanasia.

Outcomes unrelated to age at gonadectomy—For the 43 other outcomes studied, no association was found between age at gonadectomy and the outcome. Nine of these outcomes were rare in our study (< 10 dogs with the condition), including autoimmune disorders, chronic renal failure, diabetes mellitus, hepatic disease, mammary neoplasia, pancreatic disorders, parvoviral enteritis with onset after 1 year of age, patellar luxation, and urolithiasis. Therefore, the statistical power for finding any subtle difference between groups for these outcomes was low. Nevertheless, for any dog gonadectomized before 1 year of age, the risk of any of these conditions developing (before the age of 11) appeared to be low. The upper 95% confidence interval (CI) of the expected cumulative incidences for any of these conditions in the first 11 years of life was < 1.5% (ie, < 1.5% of dogs would be expected to develop any of these conditions).

Discussion

No association was found between frequency of the outcome and age at gonadectomy for most of the medical and behavioral conditions evaluated in this study. This was true even for many conditions speculated to be increased with early-age gonadectomy, such as diabetes mellitus and immune deficiency. Diabetes mellitus appears to be rare among gonadectomized dogs, at least during the first 11 years of life. In our study, dogs gonadectomized before 5.5 months of age were not significantly more likely than dogs gonadectomized at ≥ 5.5 months of age to have any conditions that might be associated with long-term immune suppression, including parvoviral enteritis with onset after 1 year of age, demodicosis, infectious tracheobronchitis, or repeated infections of the same body system. One other study¹³ that followed 269 dogs adopted from shelters for a median of 48 months found that gonadectomy before 5.5 months of age was associated with increased incidence of parvoviral enteritis. In that study, as with ours, however, the increased rate of parvovirus infection probably represented increased susceptibility of dogs < 6 months of age during the peri-adoption period and not long-term immune suppression or long-term susceptibility as a result of early-age gonadectomy.

In our study, age at gonadectomy was not associated with frequency of long-bone fractures or arthritis. The incidence of hip dysplasia, however, was increased among the early-age gonadectomized dogs, although

the diagnosis of hip dysplasia was reported with signs such as arthritis in only a portion of those dogs. It is possible that the increase in bone length that results from early-age gonadectomy¹² results in changes in joint conformation, which could lead to a diagnosis of hip dysplasia. The early-age gonadectomized dogs in our study received a diagnosis of hip dysplasia at an earlier age than dogs gonadectomized from 5.5 to 12 months of age. Initially, we suspected that the earlier age at diagnosis might invalidate some of the hip dysplasia cases in the early-age gonadectomized dogs because results of other studies^{19,20} suggest that diagnosis at a young age can be unreliable. The difference in median age of diagnosis between groups (33 vs 44 months), however, was small, and most diagnoses in both age groups were made after the dogs were at least 12 months old. Therefore, the increased rate of hip dysplasia among the early-age gonadectomized dogs in our study cannot be fully attributed to a false-positive diagnosis because of the age at which they were evaluated. The lower rate of euthanasia among early-age gonadectomized dogs with hip dysplasia suggests that early-age gonadectomy may be associated with a less severe form of hip dysplasia. Whether this association is real or represents a type-I error is unclear. Also, a rigorous set of diagnostic criteria for hip dysplasia was not used, which probably resulted in misclassification of some dogs. In contrast to our results, Howe et al¹³ found no association between age at gonadectomy and the frequency of musculoskeletal problems.

Gonadectomy in female dogs has been repeatedly associated with increased risk of acquired urinary incontinence,²¹⁻²⁴ but studies^{13,25,26} have obtained conflicting results about the exact biological mechanism involved and whether early-age gonadectomy increases the risk more than gonadectomy at a traditional age. Howe et al¹³ found no association between early-age gonadectomy and incidence of urinary incontinence, but only 3 dogs in that study (among 153 females) developed the condition. In contrast, Thrusfield et al²⁵ found increased incidence of urinary incontinence among female dogs gonadectomized before their first estrous cycle, but that study had a low response rate, was potentially biased, and did not evaluate age at gonadectomy directly; the association was of borderline significance. Nevertheless, the overall incidence rate for urinary incontinence among gonadectomized female dogs (1.74 cases/100 dog years) was consistent with our estimate (1.19 cases/100 dog years). A Swiss study²⁶ concluded that spaying before the first estrous cycle decreased the overall incidence of urinary incontinence. The methodology was questionable, however, because the authors reported data only from dogs spayed before their first estrous cycle and made comparisons with dogs spayed after the first estrous cycle from another study²³ in which the incidence of urinary incontinence was quite high.

Acquired urinary incontinence can be a lifelong condition requiring daily medication,^{22,23} and problems with urination in the house are common reasons for relinquishment of dogs to shelters.^{6,27} Development of urinary incontinence in the dogs in our study, however, did not appear to be severe enough to cause the

adopters to relinquish their dogs or have them euthanized at increased rates. Perhaps these dogs were retained in the household because the condition developed several years after gonadectomy when the adopters had already made a strong bond with their dogs (unlike urination that is caused by delayed house-breaking as an adolescent), or perhaps early-age gonadectomy is associated with a less severe form of urinary incontinence. Cystitis was also more common among the early-age gonadectomized female dogs, but none of those dogs had > 2 episodes of cystitis, so this does not appear to reflect a long-term susceptibility to the condition.

The proportion of overweight dogs was lowest among the early-age gonadectomized dogs in our study, in contrast to what had been suspected by some veterinarians.^{9,28,29} Prevention of obesity is important because of its association with increased risk of other medical problems such as musculoskeletal disorders.¹⁶ Analysis of overweight body condition was limited, however, to only those dogs still alive and retained in the adoptive household at the time of the study (70% of dogs with completed questionnaires). Therefore, we would not have identified any dogs with obesity that had led to relinquishment, euthanasia, or a fatal medical condition.

Although aggression and excessive barking were increased with early-age gonadectomy among male dogs, these associations were probably an artifact of the shelter's screening procedure for aggression and not a result of early-age gonadectomy. Dogs that had aggression on admission to the shelter, particularly those > 6 months of age, were euthanized. Therefore, many of the late-age gonadectomized dogs that were prone to aggressive behavior were removed by the screening procedure, making it appear that the late-age gonadectomized dogs were less likely to have aggression. Because aggression and barking behaviors were highly correlated, removing older dogs that were prone to aggression also removed older dogs prone to excessive barking. Two other studies^{30,31} have revealed a decrease in aggression among male dogs after castration, so it seems likely that our association is attributable to differential screening of different age groups. Results of a previous study³² suggested that aggression in female dogs increases after gonadectomy, but we did not confirm this result.

Two previous studies^{30,31} determined that gonadectomy leads to a decrease in roaming behaviors. Therefore, it seems reasonable that early-age gonadectomy could lead to a decrease in roaming, which might explain the lower frequency of escaping behaviors found among the early-age gonadectomized dogs in our study.

Noise phobias have not previously been associated with sex, neuter status, or age at gonadectomy.^{13,33} One explanation for our findings is that the noise phobias were present in the early-age gonadectomized dogs because of anxiety in the periadoption period. With our study design, we could not determine whether the noise phobias were long-term effects of early-age gonadectomy or temporary behaviors associated with being adopted at a young age. Data on the age of onset

of noise phobias are mixed; in 1 study,³³ 41% of dogs had onset before 1 year of age, whereas a review study³⁴ concluded that onset was almost exclusively after 1 year of age.

A study³⁵ of dogs evaluated at a referral behavior clinic suggested that gonadectomized dogs and dogs adopted from a shelter were more likely to have separation anxiety, and another study³⁶ found that dogs with separation anxiety adopted from shelters were less likely to respond to treatment. The diagnosis of separation anxiety has not been associated with age of acquisition,³⁵ although dogs acquired after 6 months of age with separation anxiety were found to be less likely to respond to treatment.³⁶ This second finding suggests that the greater incidence we found with gonadectomy at ≥ 5.5 months of age may be attributable to adoption (rather than gonadectomy) in that age range. The correlation between urination when frightened and separation anxiety suggests that these conditions may share a common mechanism for development. Other studies^{35,37} have found correlations between separation anxiety and other anxious behaviors.

The greater incidence in sexual behaviors among early-age gonadectomized dogs was surprising. The sexual behaviors were not correlated with aggression, so this difference could not be explained simply by the shelter's screening procedures for aggression. We are not aware of any biological mechanism that would explain this association. It is possible that some of the playful behaviors of the puppies were interpreted as sexual behaviors by the adopters. Only 2.5% of adopters thought that their dogs ever had a serious problem with sexual behaviors.

Because some behavioral conditions were less frequent with early-age gonadectomy but others were more frequent, we examined whether any of these conditions were associated with relinquishment or euthanasia. Not surprisingly, aggression towards family members among male dogs was associated with increased relinquishment and euthanasia rates. As discussed, these results have limited applicability because of the shelter's screening policy for aggression. Escaping considered a serious problem and urination when frightened were also associated with increased risk of relinquishment. These results were consistent with findings in which both escaping behavior and house soiling were common reasons for relinquishment.⁶ Risk of relinquishment was greater among dogs with separation anxiety, and separation anxiety is known to be associated with a high euthanasia and relinquishment rate in general.³⁶ The association between urination when frightened and relinquishment may have occurred because affected dogs were also more likely to have separation anxiety and not because of urination per se. Excessive barking among males, noise phobias, and sexual behaviors were not associated with relinquishment in our study. Among these, only excessive barking was reported as a common reason for relinquishment in the other study.⁶ Thus, other than aggression and excessive barking among males, which could not be evaluated well with our study, all behavioral conditions with serious con-

sequences were less frequent among the early-age gonadectomized dogs.

Our study provides several improvements over previous studies of early-age gonadectomy, including a much larger sample size, longer follow-up times, and verification of medical and behavioral conditions with veterinary records for a large portion of the dogs. Nevertheless, as with any epidemiologic study, biases are possible. The dogs of adopters for whom we found no contact information or who did not respond to our study, for example, could have differed systematically from the dogs of contacted adopters. It is not expected, however, that the likelihood of the adopters' moving would be related to the health or behavior of their dogs. Because of the retrospective data collection, it was not possible to collect veterinary information for some dogs that died early in life and whose veterinary records were subsequently destroyed. Veterinarians and adopters were usually aware of a dog's age at gonadectomy, so prior beliefs about the effects of early-age gonadectomy could have led to differential diagnostic testing or differential care-seeking.

For our study, some dogs were undoubtedly misclassified as to the presence or absence of their conditions. We have no reason to believe, however, that dogs in the 2 groups were differentially misclassified, suggesting that associations may have been underestimated or missed because of misclassification (rather than overestimated).³⁸ Because the diagnostic criteria for medical conditions undoubtedly varied between veterinarians, the incidence rates in Table 2 should be viewed as only very rough estimates of rates that would be found with standardized criteria.

Our study could not have detected conditions with peak onset after 11 years of age. For these conditions, however, it is difficult to suggest plausible biological mechanisms that would support a cause-and-effect relationship between gonadectomy at an early age and development of the outcome. Similarly, this study could not have detected conditions that would have led to relinquishment, euthanasia, or death within the first 3 months after surgery. For extremely rare conditions, our study did not have the statistical power to detect subtle differences between the groups.

With the approximately 60 comparisons made in the analyses for this study, some of our significant results are likely to be attributable to type-I errors. Because of the limited evidence to support a causal relationship between age at gonadectomy and noise phobias, separation anxiety, or sexual behaviors, these associations seem likely to be a consequence of type-I errors.

For most behavioral and medical conditions, we found no difference between early-age gonadectomized and traditional-age gonadectomized dogs. On the basis of our results, we see no reason that animal shelters or practicing veterinarians should delay gonadectomy of male puppies because of concerns about long-term health or behavior. Gonadectomy of male dogs at 4 to 5 months of age rather than waiting until after 6 months of age may be better for the long-term health and well-being of the dogs and would eliminate the possibility of accidental matings. Another study¹¹

found that gonadectomy at this age was faster and had fewer perioperative complications; it is also likely less expensive.

For female dogs, the best time to neuter is more difficult to determine. Because urinary incontinence was greater among puppies gonadectomized before 3 months of age and incontinence can be a lifelong condition requiring ongoing treatment, it is reasonable to conclude that female dogs should not be gonadectomized until at least 3 to 4 months of age. This may be particularly prudent for a shelter that does not have an excess of puppies and is focused on reducing medical and behavioral conditions that could lead to relinquishment of adolescent and adult dogs. Conversely, for shelters with excess puppies, the advantages of gonadectomy of all dogs before adoption may outweigh the risk of urinary incontinence. For veterinary practitioners, the ideal time for gonadectomy of female dogs is probably after the completion of vaccinations at 4 to 5 months but before the dog's first estrous cycle, after which there is higher risk for mammary cancer and unplanned litters.

*The study questionnaire and veterinary abstract form are available from the first author.

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Prepuberal Gonadectomy - Early-Age Neutering of Dogs and Cats

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Summary

Early-age neutering of puppies and kittens (as early as 6 - 7 weeks of age) is increasing in popularity in the United States. This increase likely results from accumulating information on the safety of the procedure and lack of long-term adverse side effects. As veterinarians become comfortable and familiar with the procedure, they are likely to encourage more clients to consider early-age neutering. Puppies and kittens neutered at early ages have shorter recovery times than those neutered at more traditional ages; mortality and morbidity rates have also been reported as lower. Early-age neutering is also one tool used to combat pet overpopulation, a problem whereby millions of healthy dogs and cats are euthanized each year in the U.S. because they are unwanted. Thus, the prepuberal gonadectomy may be good for individual animals and for controlling birth rates in populations of dogs and cats.

Introduction

Prepuberal gonadectomy is not a new procedure. Veterinarians in the U.S. have often recommended that female dogs and cats be neutered prior to the first estrus (i.e., prepuberal) to reduce the risk of mammary neoplasia and eliminate the possibility of unwanted pregnancy. What is new, however, is the age of the prepuberal animal that many veterinarians are now neutering. Traditionally, female dogs and cats not intended for breeding were neutered at approximately 6 months of age and male dogs and cats were neutered at approximately 6 to 9 months of age. However, in an attempt to reduce the number of unwanted pets in the U.S., veterinarians began to question whether it was also safe to neuter puppies and kittens at an even younger age [1].

Although animal shelters often request neuter contracts be signed at the time of adopting a pet, many new owners fail to comply with the contract. This compliance failure occurs even when financial reimbursement is available for the neuter surgery. In a survey published by the Massachusetts Society for the Prevention of Cruelty to Animals (MSPCA) and conducted by the Dorr Research Corporation of Boston, 73% and 87% of 500 households with dogs and cats, respectively, stated that their pets were neutered, but nearly 20% of the neutered animals had produced at least one litter of offspring prior to being sterilized [2]. Prepuberal gonadectomy performed prior to adoption, on puppies and kittens, could offer a tool for animal shelters that desire to adopt only neutered animals to control pet overpopulation.

Concerns by Veterinary Profession - Risks vs. Benefits

Although the anesthetic and surgical procedures for prepuberal gonadectomy have been reported as safe, veterinarians have also been concerned about long-term health risks. Veterinarians questioned whether the immune system of puppies and kittens would be adversely affected by the stress of anesthesia and surgery at early ages, and at a time when animals are being immunized against potentially fatal infectious diseases. Veterinarians also were concerned about the risk of urinary-tract obstruction in male cats and the risk of urinary incontinence in female dogs neutered at early ages. Based on clinical experience, some practitioners were also concerned that neutered animals might have a propensity for obesity or have abnormal growth patterns. Until the 1990's, few studies had been published that critically evaluated these concerns among dogs and cats neutered at different ages prior to, and following, puberty.

Propensity to Disease

In studies conducted at animal shelters, puppies and kittens neutered at early ages had no higher risk to infectious diseases than older animals. One study involved dogs and cats from 2 animal shelters undergoing neuter surgeries in association with the fourth-year student surgical teaching program of an university teaching hospital [3]. Twelve of 1988 (0.6%) animals died or were euthanized because of severe infections of the respiratory tract or as the result of parvovirus infection during the 7-day postoperative period. All of the deaths were in animals from the shelter with the shortest animal holding period. Animals neutered at > 24 weeks of age had a significantly higher ($P < 0.004$) minor complication rate than animals neutered at < 12 weeks of age, but did not differ from animals neutered at 12 to 23 weeks of age. Minor complications during or after gonadectomy included complications such as incisional swelling or suture reactions, scrotal swelling, cardiac rate and rhythm abnormalities, and mild gastrointestinal upsets. Differences in major complications were not detected among the groups. Overall, younger patients did relatively better than older animals, even when immunity to infectious diseases may not have been possible due to their young ages, or when veterinary students were performing delicate pediatric surgeries.

Growth

Many veterinarians once held the belief that puppies and kittens neutered at early ages might be stunted in growth. Several research studies have now refuted these once-held beliefs. In a 15-month study conducted at the University of Florida, the effects of prepubertal gonadectomy on skeletal growth, weight gain, food intake, body fat, and secondary sex

characteristics were investigated in 32 mixed-breed dogs [4]. Growth rates were unaffected ($P>0.05$) by gonadectomy, but the growth period in final radial/ulnar length was extended in all neutered male dogs (neutered at 7 weeks or 7 months) and in bitches neutered at 7 weeks of age. Thus, animals were not stunted in growth but were actually slightly (as determined by radiographs) taller. In a similar study at the same university [5], thirty-one cats were neutered at 7 weeks or 7 months or left intact. No differences ($P>0.05$) were detected between neutered cats, regardless of when they were neutered, for mature radius length or time of distal radial physal closure. Distal radial physal closure was delayed ($P<0.05$) in neutered cats when compared to intact cats. Similar findings in cats were reported by work from the University of Minnesota [6]. In males and females, distal radial physal closure was delayed ($P<0.01$) in both groups of neutered cats (neutered at 7 weeks or 7 months of age) compared to intact animals. In female cats, proximal radial physal closure was also significantly delayed ($P=0.02$) in cats neutered at 7 weeks of age.

Obesity

Although obesity can occur in both neutered and intact animals, and is influenced by a number of factors such as diet and activity level, there are data to suggest that neutered cats may gain significantly more than those remaining intact. The information on whether dogs are more likely to experience weight gain following neutering is conflicted in the literature. When comparing neutered cats to sexually intact cats, intact cats were found to weigh less ($P<0.05$) than cats neutered at 7 months, but there was no difference between intact cats and those neutered at 7 weeks [5]. Root [6, 7] assessed obesity by body mass index at 24 months of age in 34 cats. Body condition scores and body mass index values were higher ($P<0.01$) in animals gonadectomized at 7 weeks or 7 months than in intact animals, indicating that animals gonadectomized at either age were more likely to be obese than intact cats. Heat coefficient, a measure of resting metabolic rate, was higher in intact cats than in gonadectomized cats. Based on these data, the author suggested that neutered male cats require an intake of 28% fewer calories than intact cats and neutered female cats require an intake of 33% fewer calories than intact female cats [7].

Information on over 8,000 dogs was gathered from 11 veterinary practices in the United Kingdom during a six month survey [8]. In this retrospective study, spayed female dogs were about twice as likely to be obese as intact female dogs. Salmeri et al., [4], however, found no differences in food intake, weight gains, or back-fat depth among neutered and intact animals during a 15-month prospective study.

Urinary Tract Health

Concerns over urinary obstruction in cats has long been used as an argument against early-age neutering. Gonadectomy appears to have little effect on urethral function in dogs or cats as determined by urethral pressure profilometry [4, 9]. Urethral diameters as determined by contrast retrograde urethrograms are similar among neutered cats (neutered at 7 weeks to 7 months of age) and those remaining intact [9]. The incidence of urethral obstruction in 263 cats adopted from shelters and neutered at < 24 weeks of age or ≥ 24 weeks of age did not differ [10]. Of 70 male cats neutered < 24 weeks of age, none had obstructive episodes, while two of 38 male cats neutered at ≥ 24 weeks of age had obstructive episodes. The incidence of estrogen-responsive urinary incontinence is increased among neutered female dogs, and there was concern that neutering puppies at an earlier age might further increase the risk for spayed bitches. Urinary incontinence in dogs neutered at traditional ages can develop within days of the surgery or not until several years later. Estrogen-responsive urinary incontinence was reported in 34 of 791 (4%) bitches neutered at conventional ages, and seven of 2,434 (0.3%) sexually intact bitches [11]. Howe et al., [12] evaluated 269 dogs adopted from shelters and neutered at < 24 weeks of age or > 24 weeks of age and found only three cases where owners reported urinary incontinence. One dog was neutered at < 24 weeks of age and two dogs were neutered at > 24 weeks of age. Thus, there is little information to date to suggest that the incidence of urinary incontinence is higher in bitches spayed at earlier ages over conventional ages.

Adrenal Tumors

There was some early concern that dogs and cats neutered at early ages might be at risk for developing adrenal gland tumors. Such concern seemed to arise from reports that functional adrenocortical tumors in ferrets were often found in neutered animals. In support of this suggestion, some studies have shown that gonadectomy within the first few days of life may lead to adrenal tumors in some strains of mice [13]. To date, there has been no documentation of sex steroid-producing adrenal tumors in dogs or cats associated with prepuberal gonadectomy.

Inflammation of the Penis, Prepuce, Vulva

The penis, prepuce and os penis appear infantile in puppies who are neutered at six to eight weeks of age when compared to puppies neutered at conventional ages or those remaining intact. To date, the infantile secondary sex characteristics have not been associated with an increased risk of balanoposthitis. Complete penile extrusion was possible in 100% of intact cats, 60% of cats neutered at 7 months of age, and no cats neutered at conventional ages [14]. The clinical significance of failure to extrude the penis is unknown, although it could increase the difficulty of catheterizing animals who require such a procedure.

The vulvas of puppies neutered prior to puberty appear smaller when compared to intact bitches. Vulvar size may also appear small in intact bitches during anestrus or in some bitches spayed later in life. Perivulvar dermatitis can result in bitches with recessed or small vulvas, especially if the bitch has excessive skin and adipose tissues partially cover the vulva. Although perivulvar dermatitis has been associated with weight gains and recessed vulvas following ovariectomy, there is no information to suggest that the occurrence is higher in bitches spayed at early ages over those neutered at conventional ages.

Surgical and Anesthetic Considerations

Anesthetic and surgical considerations for the pediatric patient include the potential for hypoglycemia, hypothermia, a

relatively small blood volume, and the delicate nature of the pediatric tissues. Since hepatic glycogen stores are minimal in neonates, prolonged fasting may result in hypoglycemia. Food should be withheld no longer than 8 hours, with 3 - 4 hours recommended for the youngest patients (6-8 weeks) [15, 16]. Additionally, animals may be fed a small meal within 1-2 hours after recovery from anesthesia [15,16]. Hypothermia can be lessened by using warm water blankets and by the use of warm intravenous fluids (if used). Minimizing operative time will also help lessen the severity of hypothermia. Excessive wetting of the pediatric patient during preparation of the surgical site should be avoided, and the use of warmed scrub solution (chlorhexidine) and avoidance of alcohol will be beneficial in helping preserve body heat [15,16]. Pediatric tissues are very friable and should be handled carefully. The relatively small blood volume of pediatric patients makes meticulous hemostasis very important. Fortunately, the small size of blood vessels and the presence of minimal abdominal and ovarian bursal fat allow for excellent visualization of the vasculature, and makes precise hemostasis simple to achieve.

Pediatric ovariohysterectomies may be performed similarly to adult ovariohysterectomy with some slight modifications [3, 15,17]. Puppy incisions are started relatively more caudal to the umbilicus than adult dogs. Generally, the uterus is more easily exposed in puppies if the incision is started at least 2 - 3 cm caudal to the umbilicus (resulting in an incision placed nearer the middle third of the distance from the umbilicus to the cranial brim of the pelvis, similar to a feline incision). In kittens, the incision is placed in a similar location as adult cat incisions. Upon entrance into the abdomen, it is common to encounter substantial amounts of serous fluid in both puppies and kittens. It may be necessary to remove some of the fluid using gauze sponges to improve visualization. In contrast to adult dogs and cats, it is recommended that the use of a Snook ovariohysterectomy hook be avoided in pediatric patients due to the delicate nature of the tissues. Because of incision location in both puppies and kittens, the uterus is easy to locate by looking between the urinary bladder and colon. Uterine tissue is extremely friable in young puppies and kittens, therefore care must be taken to avoid excess traction. After the uterus has been located, the suspensory ligament may be carefully broken down to improve visualization, and a window made through the broad ligament adjacent to the ovarian vasculature. A clamp is then placed just proximal (medial) to the ovary across the vessels using a mosquito hemostat on kittens and small puppies and Kelly, Crile, or Carmalt forceps on larger puppies. The ovarian vessels are double ligated using 3-0 to 4-0 absorbable suture material or stainless-steel hemostatic clips. A single ligature may be sufficient to prevent hemorrhaging in very small pedicles. After ligation of the ovarian vessels on both sides, the remaining broad ligament should be broken down and the uterine pedicle ligated at the junction of the uterine body and cervix with two fully encompassing uterine body ligatures or hemostatic clips. After the reproductive tract has been removed, it should be examined to ensure complete removal (of ovaries and uterine body), and the abdomen should be examined for evidence of hemorrhage. When closing, it is important to carefully identify the ventral fascia (external rectus sheath) and differentiate it from the overlying subcutaneous tissue since they can occasionally be difficult to tell apart (particularly in some puppies). The ventral fascia can be closed using either a simple continuous or simple interrupted suture pattern using 3-0 (or possibly 2-0 on large puppies) absorbable (polydioxanone, polyglyconate, or polyglactin 910) or monofilament nonabsorbable (polypropylene, polybutester, or nylon). The subcuticular layer may be closed with an absorbable suture material (3-0 to 4-0) in a continuous intradermal pattern to avoid the use of skin sutures. Alternatively, skin sutures may be loosely placed following closure of the subcutaneous tissues.

Pediatric puppy castration is also performed with modifications to the techniques used in adult dogs [3, 15]. As with adult canine castrations, it is important to ascertain that both testes have descended prior to commencing surgery. Because of the small size and mobility of puppy testes, the entire scrotal area may be clipped and surgically prepped to permit the entire scrotum to be included in the sterile field. This will greatly facilitate testis localization and manipulation, and does not cause scrotal irritation as in adult dogs, since the scrotal sac is not well developed. Puppies may be castrated through a single midline prescrotal or scrotal incision. Alternatively, two scrotal incisions may be used similar to a feline castration. After exposing testicles and spermatic cord in closed fashion (testes remain encased in the parietal vaginal tunic during castration), the spermatic cords should be double ligated with 3 - 0 absorbable suture material or stainless-steel hemostatic clips. Incisions may be closed using 1 - 2 buried interrupted sutures in the subcuticular layer, or incisions may be left open to heal by second intention healing. Closure of incisions prevents postoperative contamination with urine or feces, and prevents fat from extruding from the incision.

Kitten castration is performed using identical techniques as in the adult cat [3, 17]. Care should be used when exteriorizing testes to prevent tearing of the spermatic cord due to its small size. As with adult cats, incisions are left open to heal by second intention.

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ANAESTHESIA AND ANALGESIA FOR KITTENS AND PUPPIES

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Prepubertal gonadectomy (at 6-16 weeks of age) of puppies and kittens is becoming more accepted in the veterinary community. However, some veterinarians are still hesitant to embrace this practice due to lack of experience with neonatal surgery and anaesthesia (1, 2). Overpopulation and resultant euthanasia of healthy animals is a serious welfare issue and an important step towards alleviating this problem is early age neutering.

The most common age for neutering pets is between 5 and 12 months of age but does not appear to be based on scientific evidence but rather when most veterinarians feel the risks of anaesthesia and surgery are minimal. Previously held concerns related to early age neutering included the following: retarded growth, growth plate fractures, obesity, diabetes mellitus, urinary incontinence, feline urologic syndrome and obstruction, vaginitis, perivulvar dermatitis and behavioural changes. Several studies indicate that these fears are no longer warranted (3-8).

Spain and others (8) have recently published long term data on 1,660 cats and concluded there was no association with this practice and increased rates of relinquishment, medical or behavioural problems. In a survey of New York veterinarians, over 90% stated there were benefits to early spaying and neutering but almost 60% believed that this would be associated with an increased risk of anaesthetic complications (2). Contrary to these beliefs there are several reports of suitable anaesthetic regimens for young animals with good outcomes (5,7,9-11).

Neonates and Anaesthesia

Neonates are more prone to hypothermia because of their large surface area to body weight ratio and lack of body fat. (This topic is discussed fully in another lecture). Neonates have limited glycogen reserves and should not be fasted for more than a few (2-3) hours. They should be offered small amounts of soft food within an hour following the procedure.

It is tempting to assume that inhalant anaesthesia alone would be ideal in neonates because agents like isoflurane are minimally metabolized. However, when inhalant agents are relied upon as the sole anaesthetic, high concentrations (a large "dose") are needed and this causes significant cardiovascular and respiratory depression. Although there is no published data for dogs and cats, in neonatal foals, the use of inhalant

agents alone is associated with a higher mortality rate compared to injectable techniques.

It is better to practice "balanced anaesthesia" where several different drugs are combined to achieve specific goals. Injectable agents may be combined to provide a complete anaesthetic or may be used with an inhalant agent to reduce the amount of inhalant required.

Kittens

Fagella and Aronsohn (9) evaluated different combinations of tiletamine/zolazepam, ketamine, midazolam, butorphanol and oxymorphone in 6-14 week old kittens. Tiletamine/zolazepam was most reliable for male kittens, but for females they recommended midazolam and ketamine followed by intubation and isoflurane, although they reported excitement in some females following the injectable protocol. In male kittens the time from injection to induction was approximately 5 minutes and mean time to sternal recumbency and standing were 77 and 103 minutes respectively. In the females, induction times using midazolam and ketamine was approximately 5 minutes and time to extubation, sternal and standing were 2.8, 20 and 36 minutes respectively. The disadvantage of these findings is that different protocols were needed based on sex. It may be inconvenient to have more than one drug combination and in some cases (e.g. feral cats) the sex is not always known prior to injection.

In another study (5), acepromazine, butorphanol and glycopyrrolate given by IM injection followed by inhalant agents was found to be suitable for male and female kittens.

Robertson and others (11) evaluated medetomidine (40µg/kg), ketamine (20 mg/kg) and buprenorphine (20µg/kg) [MKB] combined and given subcutaneously for castration or ovariohysterectomy of 7-12 week old kittens (average weight 0.9 kg). At the end of surgery, 0.5 mg/kitten of atipamezole was injected IM. This technique was compared to a mask induction with isoflurane followed by intramuscular butorphanol. Kittens in the isoflurane group were sternal approximately 4 minutes after the inhalant was discontinued and in the MKB group this took 9 minutes after atipamezole injection. Oxygen saturation was lower in the MKB group who were breathing room air. There was no difference between groups in intra-operative heart rate or blood pressure.

Puppies

The most practical technique for puppies is pre-medication with midazolam or acetylpromazine and an opioid followed by mask induction with isoflurane or sevoflurane.

Analgesia

There is little information on analgesic drugs in neonatal animals. Sensitivity to opioid-induced analgesia decreased between 1 and 34 days of age in dogs⁽¹²⁾. Puppies are prone to the respiratory depressant effects of opioids, but fentanyl was found to have less effect on respiration than morphine⁽¹²⁾. Carprofen is the NSAID with the lowest recommended age limit (6 weeks for puppies). Local anaesthetics can be used at the incision site.

Monitoring should include physical assessment of anaesthetic depth and colour of the mucus membranes. The heart rate or pulse rate can be measured with a Doppler and if used on a limb, blood pressure can easily be monitored with a paediatric cuff and sphygmomanometer. Pulse oximetry is easy to perform and probes can be attached to the paw.

Delayed recovery is usually a result of hypothermia, residual drug effects, hypoglycaemia, or a combination of these. This can be remedied by further warming, administration of a reversal agent (if indicated) or providing an easily assimilated glucose source such as 50% dextrose or "karo" syrup.

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Pros and Cons of Neutering

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Spaying (ovariectomy or ovariectomy) has been shown to reduce unwanted pregnancies, prevent pyometra and decrease the risk of mammary gland tumors in female dogs and cats. However, increased tendency to develop obesity may occur in either species. In dogs, an increased incidence of certain cancers, aggressiveness, sedentary behavior, and urinary incontinence may develop after spaying. The ideal spay would result in positive effects from spaying with the least risk of developing negative effects. It would also result in minimal pain and immediate postoperative complications. Controversy thus continues to surround the best time and method of spaying.

A major controversy is whether ovariectomy or ovariectomy is the preferable surgery. The rationale for removing the uterus is that stump pyometra may develop if the uterus is not removed. The rationale for ovariectomy is that the surgery is less invasive and the risk of pyometra is minimal once the animal is no longer cycling. In several long term studies of dogs and cats under going ovariectomy, stump pyometra did not occur in any animal after surgery. Studies have also shown that there is no difference in the incidence of urinary incontinence after ovariectomy or ovariectomy in the dog.

A second controversy surrounds whether or not a midline approach or a flank approach is preferable. The advantages of the midline approach are that it is technically easier to perform an ovariectomy from this approach, the incision can be quickly opened if needed, and both sides of the reproductive tract are easily accessible from one approach. The advantage of the flank approach is that, in experienced hands, it allows ovariectomy or ovariectomy to be performed through a very small lateral incision. The flank approach can be closed with a few buried sutures and has a minimal risk of dehiscence. The flank approach is used in many feral cat neutering programs to avoid the risk of dehiscence. More recently, techniques for laparoscopic ovariectomy and ovariectomy have been described for the dog. Although the surgery is technically challenging, the advantage of performing a spay using minimally invasive surgery is that the dog experiences less postoperative pain and distress.

A third controversy surrounds the best time to perform a spay. This controversy has been widely discussed in the United States literature in regard to the issue of neutering at a very young age compared to the traditional age of 6 - 8 months. Initial studies of 200 - 300 dogs and cats followed for up to 4 years did not indicate physical or behavioral differences between early age spaying or traditional age spaying. A larger study of 983 dogs found that 12.9% of dogs spayed at < 3 months developed urinary incontinence, while only 5% dogs spayed at >3 months became incontinent. Other differences documented in early age neutered dogs compared to traditional age neutered dogs were an increased incidence of cystitis, hip dysplasia, noise phobias and sexual behaviors, and a decreased incidence of obesity, separation anxiety, escaping behaviors, and inappropriate elimination when frightened. In 859 cats, an increased incidence of shyness was found in early age neuters compared with traditional age neuters, whereas a decreased incidence of asthma, gingivitis and hyperactivity were found.

In Europe, the debate has centered on whether or not to spay before or after the first heat. The mammary carcinoma data would suggest that performing a spay before the first heat would result in the lowest chance of mammary cancer. The pyometra data would suggest that as long as a spay was performed in the first 4 years of life, pyometra is not likely. One study of 809 bitches showed no difference in urinary incontinence in animals spayed before or after the first heat at the 5% significance level, but a difference at the 10% level. Other studies have documented urinary incontinence in 9.7% of bitches spayed before the first heat compared to a 20% incidence in bitches spayed after the first heat. Even though the incidence of incontinence was lower in bitches spayed before the first heat, severity of the incontinence in these dogs was much worse than in dogs spayed after the first heat.

The effect of spaying on behavior is controversial. Some studies have shown few effects, while others have demonstrated more reactivity and aggressive barking in spayed compared to intact bitches. In a study of 227 dogs that had bitten humans, neutered female dogs and male dogs were overrepresented. In a study of cats that had bitten humans, owned female Siamese cats were over-represented. The neuter status of the cats was not recorded, but most owned female cats are spayed.

In male dogs, neutering (castration) has been shown to reduce the incidence of prostatic hyperplasia and infection, but not prostatic cancer. Castration reduces the incidence of perineal hernia and the chance that perineal hernia will recur, if fixed. Castration will prevent perianal adenomas from occurring and cause regression of many perianal adenomas, once present. The incidence of urinary incontinence associated with castration in male dogs is much lower than the incidence of urinary

incontinence associated with spaying in female dogs, but it does occur. Castration has been shown to reduce urine marking, mounting and roaming, but is effective in reducing aggression in only about one third of dogs. Castration appears to increase the speed with which age-related cognitive impairment progresses in the male dog.

In male cats, neutering (castration) reduces urine spraying, fighting and roaming. In one study, cats that were castrated before 5.5 months of age had fewer abscesses, aggression towards veterinarians, sexual behaviors and urine spraying compared to cats that were castrated at an older age.

Orthopedic conditions associated with neutering (spaying or castration) include hip dysplasia, cruciate injury and slipped capital femoral epiphysis. Dogs that are spayed or castrated before bone growth is complete are taller than intact dogs or dogs that are spayed or castrated at a later age. Orthopedic diseases in neutered animals are thus likely to be conditions associated with late or incomplete closure of growth plates or altered joint anatomy due to changes in skeletal growth.

The risk of obesity associated with neutering appears to be higher in sexually mature animals compared to immature animals. Animals that undergo early spay or castration can often self-limit their feed and maintain a healthy weight with free choice feeding. Animals that undergo spay or castration as adults are very likely to be unable to self-limit their feed and become obese with free choice feeding. Obesity can be controlled by limiting access to feed, but the owner must be warned that controlled feeding will be necessary.


Neuter status obviously affects tumor development and growth, if the tumor tissue is hormonally responsive. Less obviously, it may affect the development and growth of cancer in other tissues. Studies in Rottweilers have shown that the risk of osteosarcoma is increased in spayed and castrated animals compared to intact animals. For each month that an animal remained intact, there was a 1.4% decrease in osteosarcoma risk. The overall incidence of osteosarcoma in the study population of 683 Rottweilers was 12.6% during the study period. Spayed female dogs have been shown to have an increased risk of developing cardiac hemangiosarcoma.

The question must be asked: Is there a group of animals, particularly dogs, in which the risks of spaying may outweigh the benefits? The most likely candidates would be large breed dogs at increased risk for cruciate rupture, osteosarcoma, urinary incontinence and/or aggression. Osteosarcoma may result in early death, while urinary incontinence and/or dominance aggression can result in a pet becoming unacceptable and at risk of euthanasia. Weighing the risks of these conditions may shift the balance of "spay to prevent mammary cancer and pyometra" to "do not spay or delay spay to prevent severe urinary incontinence or biting". Regarding castration, the benefits of reduced aggression in some dogs, decreased prostatic disease and decreased perineal hernia and perianal adenoma development must be weighed against the risks of developing orthopedic disease or bone cancer.


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