Questions and answers on the effects of surgically neutering dogs and cats

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Surgical removal of the ovaries, uteri, testes, and epididymides of dogs and cats has long been the basis of population control and a part of many routine veterinary health maintenance programs for animals not intended for breeding purposes in North America. Nouns used to describe such surgery in females include oophorectomy and ovariohysterectomy (removal of one or both ovaries); ovariohysterectomy, oophorohysterectomy, and spay (removal of the ovaries and uterus of a female animal). Nouns used to describe such surgery in males include orchidectomy and orchietomy (removal of one or both testes). Castration (removal of the gonads) and gonadectomy (removal of one or both ovaries or testes) are the surgical removal of the gonads of either sex. A neuter is an animal that may have been of either sex prior to bilateral gonadectomy. Sterilization refers to procedures by which an animal is made incapable of reproduction, including gonadectomy, vasectomy, or salpingectomy, and does not necessarily imply complete absence of gonadal tissue. Sexually intact animals are those that have both gonads.

As with most surgical procedures, benefits of the surgery on population control and individual animal health should be weighed against surgical/anesthetic risks, and the surgery’s desirable or undesirable sequelae to the procedure. The questions and answers that follow are intended to serve as a review of available literature on these sequelae.

Dogs

What are the effects of bilateral ovariohysterectomy in bitches?

Q: Will reproductive behavior cease?

A: Copulatory behavior in the sexually intact bitch occurs after a period of ovarian estradiol secretion followed by ovarian progesterone secretion; these hormones elicit the vulvar swelling and subsequent softening and acceptance behavior during canine estrus. Complete removal of the ovaries at any

stage of the estrous cycle will prevent subsequent estrous cycles, and will prevent copulatory behavior in nearly all bitches, with only rare exceptions. Ovariectomy performed during proestrus or estrus results in decline in plasma estradiol and/or progesterone to baseline concentrations within 1 day, and, in the estrous bitch, in cessation of copulatory behavior within several days.

False pregnancy in bitches is a syndrome of lactation, protective/mothering behavior, and nesting behavior in nonpregnant bitches. The condition begins with a decline in plasma concentrations of the ovarian hormone, progesterone, which may lead to a surge of the anterior pituitary hormone, prolactin. Such decline in plasma progesterone occurs in sexually intact bitches at the end of diestrus, about 2 months after estrus. Ovariectomy performed during diestrus, or within 2 months after an estrous cycle, causes rapid decline in progesterone, and often results in the onset of false pregnancy signs within 3 to 4 days after surgery. False pregnancy signs subside spontaneously within 4 to 8 weeks of onset and will not recur if ovariectomy was bilateral and complete. Progestogen therapy is contraindicated in most bitches with false pregnancy, because, although it may cause a decrease in clinical signs when used, cessation of therapy and decline in exogenous progesterogen in the blood usually causes relapse of false pregnancy signs.

Q: What signs develop if ovariohysterectomy was incomplete?

A: Incomplete surgical removal of the ovaries and subsequent clinical signs of proestrus, estrus, and/or false pregnancy are called the ovarian remnant syndrome. Depending on the amount of ovarian tissue left in the abdomen, and its blood supply, affected animals may manifest 1 or more of the following signs at 4- to 12-month intervals, starting up to several years after original ovariectomy: vulvar swelling, sanguineous vulvar discharge, attraction of male dogs, receptivity to mating, and false pregnancy. If remnant ovarian tissue becomes a functional cyst or tumor, signs can be continuous. To confirm that these signs are attributable to an ovarian remnant, predominantly cornified epithelial cells in a vaginal smear should be demonstrated.
during time of vulvar swelling, sanguineous vaginal discharge or attraction of males, and plasma progesterone concentration exceeding 2 ng/ml (6.4 nmol/L) should be demonstrated during the 2 months after cessation of these signs or before onset of false pregnancy signs. Neither vaginal cornification nor increased plasma progesterone concentration is found at the time false pregnancy signs are manifested. Signs of false pregnancy may of themselves be adequate to confirm presence of the ovarian remnant syndrome and justify surgical exploration of the ovarian stumps for residual tissue.

Ovariohysterectomy in bitches generally results in a small, ligated, and sometimes oversewn uterine pedicle (cervical to the cervix) being left in the animal. Incomplete surgical removal of the uterus does not result in signs of reproductive behavior, such as vulvar swelling, willingness to copulate, or false pregnancy. However, if retained tissue becomes infected and inflamed (uterine stump granuloma), a purulent or sanguinopurulent vulvar discharge may develop and attract males. In such cases, the cytologic nature of the discharge should be defined, to rule out cornification, which would be found with an ovarian remnant. Site of origin of a purulent vulvar discharge in a spayed bitch should be determined by use of vaginoscopy, vaginography, and/or ultrasonography of the uterine stump; uterine stump granulomas should be removed surgically. Uterine neoplasia, a potential sequel to incomplete hysterectomy, comprises only 1 to 2% of all tumors of the female reproductive organs and is usually benign. Pyometra secondary to residual ovarian tissue may also develop.

Q: What complications may develop with ovariohysterectomy?

A: Ovariohysterectomy in healthy bitches is a common and routine abdominal surgery, with low incidence of morbidity and mortality. Incidence of complications varies with the experience of the surgeon and preoperative patient risk factors such as age, concurrent reproductive diseases such as pyometra, and nonreproductive diseases such as diabetes mellitus, congestive heart failure, and coagulation defects. Complications of abdominal surgery include anesthetic complications, wound dehiscence, and infection along the suture line. Surgical complications of ovariohysterectomy include hemorrhage of incompletely ligated or ruptured ovarian or uterine vessels; accidental ligation of a ureter, with resulting hydronephrosis; accidental ligation of a ureter with the vaginal remnant leading to ureterovaginal fistula and immediate urinary incontinence; and granulomas of the uterine and/or ovarian stumps, which may be associated with paralumbar fistulous tracts.

Q: Will ovariohysterectomized bitches gain weight and become lethargic?

A: Weight gain of up to 38% has been reported in ovariohysterectomized bitches fed ad libitum. Food intake in bitches fed ad libitum was significantly greater in ovariohysterectomized Beagle bitches (1,708 kcal/d), compared with that in sham-operated controls (1,423 kcal/d); mean daily caloric intake was lowest in estrus and highest in anestrus in sexually intact Beagle bitches. Fifteen bitches (Doberman Pinscher, Bouvier des Flandres, German Shepherd Dog) fed a fixed amount of commercial dog food and exercised regularly had no increase in weight 55 weeks after bilateral ovariohysterectomy, when compared with 15 sexually intact bitches and 15 bitches in which ovarian tissue was autotransplanted to the serosal wall of the stomach. These data suggest that ovariohysterectomized bitches may eat more and gain more weight than sexually intact bitches if allowed free access to food, but do not necessarily gain weight postoperatively if food intake is regulated.

Inactivity and lethargy have been described anecdotally as sequelae to ovariohysterectomy, but may be difficult to distinguish from changes in activity with increasing age. Ovariohysterectomized male dogs have been reported to show unsatisfactory work performance when compared with sexually intact females. Four bitches ovariohysterectomized 60 weeks prior to placement in an intensive 6-week training period failed work performance tests measuring boldness and aggressiveness when compared with 4 sexually intact females of similar age and training. The 2 groups had similar results when judged on obedience. There is no evidence to our knowledge that a litter of pups promotes good behavior in companion bitches.

Q: What are the beneficial effects of ovariohysterectomy on incidence of reproductive diseases in bitches?

A: Mammary neoplasia—Mammary neoplasia is the most common tumor of the sexually intact bitch, comprising 42% of tumors from all sites and 82% of reproductive tumors in the bitch. Sexually intact bitches have been reported to have 3 to 7 times greater risk of developing mammary cancer, compared with neutered females, and risk is lowest for bitches spayed at a young age. Bitches spayed prior to the first estrus were reported to have 0.5% risk for this tumor, when compared with sexually intact bitches, and those neutered after 1 or 2 seasons had 8% and 26% risk, respectively; there is slight or no sparing effect with ovariohysterectomy performed later. Once mammary neoplasia has been diagnosed (usually in bitches >6 years old), and if the tumor is an adenocarcinoma (about 24% of all canine mammary tumors) rich in estrogen and progesterone receptors (about 40% of adenocarcinomas), ovariohysterectomy may be beneficial in preventing progression of the mammary disease.

Pyometra—Pyometra is a common disorder of the canine uterus, and is most common in bitches.
>6 years old or in those given estrogen injections for mismating. The underlying pathologic change in the uterus, which provides a medium for ascending bacterial infection, is that of cystic endometrial hyperplasia, which can be induced with exogenous progestogen injections or with estrogen injections just prior to the luteal phase, or which may develop spontaneously with aging and the repeated, 2-month luteal phases of the bitch. In a lifetime colony study of the reproductive organs of Beagle bitches that started with 80 females and to which female offspring were added, approximately half of the 4- to 8-year-old bitches had uterine abnormalities that could have impaired reproduction, and approximately two thirds of the bitches had such lesions at ages 9 to 17 years. These data suggest that ovariohysterectomy at any age may confer a health benefit to bitches by preventing development or progression of the pyometra complex.

Vaginal prolapse—Vaginal prolapse is an estrogen-mediated disorder of the young, sexually intact large-breed bitches at the time of proestrus or estrus, or at the end of diestrus. Edematous mucosal tissue from the floor or the entire circumference of the cranial portion of the vagina may prolapse into the vaginal vault or through the vulvar cleft. Prolapsed tissue will regress at the end of estrogen stimulation, but may, before then, become traumatized or mutilated by the bitch, and may prevent normal copulation or parturition. Vaginal prolapse is prevented by ovariohysterectomy or by treatment to prevent reproductive cycle

Disorders associated with pregnancy and parturition—In bitches, reproductive disorders of pregnancy and parturition that are preventable by ovariohysterectomy include spontaneous abortion and fetal death, pregnancy toxemia, uterine torsion, uterine rupture, dystocia, uterine prolapse, retained fetal membranes, postpartum hemorrhage, pre- and postpartum hypocalcemia, metritis, mastitis, and subinvolution of placental sites.

Q: What are the potentially undesirable effects of ovariohysterectomy in bitches?

A: Estrogen-responsive urinary incontinence—Estrogen-responsive urinary incontinence is a nonneurogenic incontinence in ovariecotomized bitches that appear to urinate normally. Some affected bitches are continent during wakefulness, but awake from sleep in a small puddle of urine. Others dribble urine during wakefulness or at times of excitement. In some dogs, these signs develop within days of ovariohysterectomy, and in others, not until years later. Hormonal incontinence was reported in 34 of 791 (4%) of spayed bitches and 7 of 2,434 (0.3%) of sexually intact bitches. Diagnosis is based on history and on response to oral treatment with diethylstilbestrol (0.5 to 2 mg/d for 5 to 7 days, followed by decreasing dose and increasing interval [weekly] until the minimal amount needed to control signs is reached).

Perivulvar dermatitis—Perivulvar dermatitis may develop in obese females that are sexually intact or spayed if folds of skin provide a warm, moist environment for bacterial and fungal growth. Treatment is weight reduction, if indicated, and surgical excision of the perivulvar folds.

Atrophic vaginitis—The vaginal epithelium of the anestrous bitch is 2 cell layers thick; after the prooestrous influence of estrogen, its thickness increases, in estrus, to about 20 to 30 cell layers. There is disagreement in the veterinary literature about the need for a bitch to undergo 1 estrus cycle to have good vaginal tone and health throughout life. Some bitches with "puppy vaginitis" that are spayed prepubertally may have recurrence of vaginitis throughout their lives. Chronic vaginitis in spayed bitches, in which other causes of vaginitis (such as anatomic abnormality, foreign body) have been ruled out, may respond to oral diethylstilbestrol therapy at the same dose as that used for estrogen-responsive urinary incontinence. Such treatment will thicken the vaginal mucosa.

Endocrine alopecia—Endocrine alopecias that respond to additive or ablative endocrine therapy have been reported in spayed and sexually intact bitches. To date, plasma concentrations of progesterone and estradiol have not provided diagnostic or prognostic information on these disorders. Because progestogens have many glucocorticoid-like properties, their effectiveness in affected bitches may or may not reflect sex-steroid deficiencies.

What are the effects of bilateral orchidectomy in dogs?

Q: Will reproductive behavior cease?

A: Castration of prepubertal and virgin male dogs usually prevents mounting and copulatory behavior throughout the rest of their lives. Copulatory behavior decreases considerably in experienced adult male dogs following castration, but may not end completely for months to years, suggesting that copulation may be a learned, neurologic behavior in the dog as it is in some other mammals. Among 42 dogs castrated as adults, about 40% had a rapid decline, and about 70% had gradual or rapid declines, in mounting behavior. Ejaculates of bilaterally vasectomized male Beagles contained spermatozoa for as long as 21 days after vasectomy, suggesting that spermatozoa may persist in the ductus deferens and be capable of causing pregnancy from copulations taking place after castration.

Q: What signs develop if orchidectomy was incomplete?

A: Incomplete orchidectomy of an abdominal testis is a differential diagnosis in dogs with strong mounting and copulatory behavior, lack of scrotal
testes, variable prostatomegaly, and an insufficient history that bilateral orchidectomy was performed. Although abdominal location of the testis prevents normal spermatogenesis in the seminiferous tubules, it does not prevent the normal, pulsatile secretion of testosterone by the interstitial cells of the testis. Diagnosis of retained testicular tissue can be made by measuring serum testosterone concentration before and 1 hour after administration of 2.2 μg of gonadotropin-releasing hormone/kg of body weight; the hormone stimulates maximal testosterone secretion by any testicular tissue remaining. Resting concentrations of serum testosterone in the sexually intact male are about 0.5 to 5.0 ng/ml (1.7 to 17.3 nmol/L), and concentrations 1 hour after administration of gonadotropin-releasing hormone are about 3.7 to 6.2 ng/ml (12.8 to 21.5 nmol/L).

Q: What complications may occur with orchidectomy in dogs?

A: Major postoperative complications of castration in male dogs include hemorrhage, scrotal bruising and swelling, and infection at the incision site; lower incidence of scrotal swelling is reported by use of the closed technique of canine orchidectomy, which involves incision to, but not through, the parietal vaginal tunic. Surgical excision of retained abdominal testes requires abdominal exploration, and may convey some of the same risks of complications as are described for canine ovariohysterectomy. Hemiprosthetic urethral avulsion has been described following use of a stay hook to probe a retained testicle through a preputial incision.

Q: Will castrated males gain weight and become lethargic?

A: There are no data in the veterinary literature to support or disprove the hypothesis that ad libitum food intake and exercise change after bilateral orchidectomy. There are, however, data reporting that intermale aggression declines following castration in more than 60% of male dogs; other types of aggression may not be affected. Urine marking was reported to decrease in about half, and roaming behavior was reported to decrease in more than 90% of 42 male dogs castrated for problem behavior.

Q: What are the beneficial effects of bilateral orchidectomy on incidence of reproductive disease in dogs?

A: Testicular neoplasia—Testicular neoplasia is the second most common tumor in the male dog (following skin), constituting 4 to 7% of all canine tumors, and 99% of male reproductive tumors. Risk of neoplasia increases in cryptorchid testes. Testicular tumors may develop in dogs as young as 2 years; mean age of incidence varies with tumor type from about 10 to 11 years, and drops to 7 to 8 years for cryptorchid testes. Rate of metastasis varies with tumor type, from 0.6 to 9%. Blood dyscrasias similar to those caused by estrogen toxicity may develop in 11 to 23% of dogs with Sertoli cell tumors, and are associated with a grave prognosis.

Other testicular diseases—Testicular torsion is an uncommon, but potentially life-threatening disorder in dogs, which can occur in the normal or neoplastic, scrotal, or abdominal testis. It occurs most often in abdominal testes with Sertoli cell tumors, and may cause acute anorexia, painful abdomen, vomiting and shock. Infection of the testes and/or epididymides is more common and less serious than torsion, but is painful and eventually may require castration. Scrotal testes may be subject to trauma, penetrating wounds, grass awn migration, or frostbite.

Prostatic disease—Benign prostatic hypertrophy or hyperplasia of the canine prostate is an androgen-dependent disorder in more than 60% of sexually intact male dogs over 5 years old. Benign prostatic hypertrophy may be a consequence of aging in this species; it predisposes to bleeding into the prostatic fluid and to ascending bacterial infection of the prostate with normal urethral flora. Such infection may lead to acute or chronic supplicative prostatitis. Surgical correction of prostatic cysts and abscesses is associated with serious postoperative complications in dogs. In 13 dogs treated for nonneoplastic prostatic disease by prostatectomy, 12 became incontinent and developed decreased urethral pressures or detrusor instability.

Ninety-two dogs with prostatic abscessation treated surgically with a multiple Penrose drain technique had postoperative complications that included hypoproteinemia, edema of the scrotum, prepuce, or hind limbs, sepsis, shock, urine leakage and urinary incontinence; long-term complications included urinary incontinence, urinary tract infection, reabsorption, and fistula formation. Three dogs in that study died during surgery, and 19 died or were euthanized in the immediate postoperative period because of sepsis or peritonitis. Benign prostatic hypertrophy is both effectively prevented and treated by castration, as the hypertrophied gland will undergo involution following that surgical procedure.

In human patients with prostatic carcinoma, an androgen-responsive tumor in that species, survival time increased following castration. In dogs, however, the tumor develops in sexually intact and castrated males, with no known sparing or therapeutic effect of orchidectomy.

Q: What are the potential undesirable effects of bilateral orchidectomy in dogs?

A: Testosterone-responsive urinary incontinence—Nonneurogenic urinary incontinence, similar to

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4CEVA Cystorelin (gonadorelin), Abbot Laboratories, North Chicago, Ill.
that observed in spayed bitches, has been observed in a small number of males. In one, a 36 kg Afghan Hound, incontinence that started 5 months after castration responded to subcutaneous implants of 200 mg of depotestosterone administered every 3 to 4 months.

Endocrine alopecia—Endocrine alopecia in neutered males is reported to be very rare and is sometimes attributable to thyroid insufficiency or a normal shedding cycle.

Cats

Q: What are the effects of bilateral ovariectomy in queens? Will reproductive behavior cease?

A: Copulatory behavior in the queen occurs during the time of peak ovarian estradiol secretion. Complete removal of the ovaries causes rapid decline in plasma estradiol concentration in the follicular-phase (estrus) queen, and prevents future cycling activity in queens spayed at any time of the cycle. Ovariectomy performed within 45 days after induction of ovulation by a fertile or sterile mating may be associated with the false pregnancy sign of lactation 3 to 4 days following surgery. Although the cat is described as an induced ovulator, requiring repeated stimulation of the cervix to induce the neuroendocrine reflex leading to ovulation, some queens may ovulate spontaneously, and may develop false pregnancy signs when spayed within 45 days of estrus, even without prior breeding.

Q: What signs develop if ovariohysterectomy was incomplete?

A: The ovarian remnant syndrome may develop in cats as well as dogs, and consists of cyclic episodes of estrus or false pregnancy starting months to years after ovariohysterectomy. The cause is failure to remove all of a normal ovary at ovariohysterectomy, or partial or complete separation of a small portion of normal ovary during development. Experimentally, excision of the ovarian cortex from its blood supply and subsequent suturing of the cortex to the lateral abdominal wall resulted in signs of estrus 4 months after the surgery, suggesting that ovarian tissue may be active even after ligation of the ovarian artery. Signs of estrus in the cat, which may be subtle in those with ovarian remnants, include lordosis, calling, head rubbing behavior, and receptivity to mating. False pregnancy signs of lactation and nesting behavior are uncommon in queens, compared with those in bitches, but may develop. To confirm an ovarian remnant, a cornified vaginal cytology smear should be demonstrated during time of estrous behavior. Ovulation should be induced by the administration of 25 μg of gonadotropin-releasing hormone IM, and plasma progesterone concentration should exceed 2 ng/ml (6.4 nmol/L) 2 to 3 weeks after induction of ovulation.

Incomplete removal of the uterus at ovariohysterectomy does not result in signs of reproductive behavior, but may, if the uterus becomes infected, be associated with purulent vulvar discharge. In such cases, cytologic nature of the discharge should be defined, to rule out cornification, which would be present with an ovarian remnant. Uterine neoplasia is a potential sequel to incomplete hysterectomy. Although uterine neoplasia is rare in queens, it may develop and may be malignant. Endometrial adenocarcinoma, for example, may metastasize to the abdominal cavity and beyond.

Q: What complications may develop with ovariohysterectomy in queens?

A: Complications of abdominal surgery include anesthetic complication, wound dehiscence, and infection along the suture line. In a retrospective study of 66 cats undergoing routine ovariohysterectomy, adverse reactions to suture material were seen in 22, and included swelling and inflammation, abscesses or seromas, scar tissue, edema, and dehiscence; there was no consistent association between reaction and type of suture (chromic gut, polydioxanone, nylon) used. In a prospective study of 99 cats in the same report, closure with polyglactin 910 without subcutaneous sutures was associated with considerably fewer adverse reactions than was surgical gut or polydioxanone with subcutaneous sutures. Surgical complications of ovariohysterectomy may include hemorrhage of incompletely ligated or ruptured ovarian or uterine vessels, accidental ligation of a ureter with resulting hydronephrosis, and granulomas of the uterine and/or ovarian stumps.

Q: Will ovariohysterectomized queens gain weight and become lethargic?

A: Anecdotal observations and comparison with spayed bitches suggest that queens may eat more and gain weight following ovariohysterectomy if food is available ad libitum. Scientific documentation of these findings is not available.

Q: What are the beneficial effects of ovariohysterectomy on incidence of reproductive disease in the queen?

A: Mammary neoplasia—Mammary tumors are the third most common neoplasm in cats, and, as in dogs, early ovarioectomy has a sparing effect on later development of these tumors. Age incidence increases after 6 years, peaking at 10 to 11 years in sexually intact queens. Sexually intact females have 7 times greater risk of mammary cancer than neutered females of this species. Nearly 90% of mammary tumors in cats are malignant, and most have metastasized by the time of diagnosis, so early ovarioectomy provides substantial health benefit in this species.
Pyometra—Feline pyometra is a diestral disorder of queens, which develops under the influence of progesterone and ascending vaginal bacteria, and which ovariohysterectomy prevents. Although queens are induced ovulators, there is evidence, from histologic detection of corpora lutea in feline reproductive tracts with pyometra, that female cats not exposed to males may sometimes ovulate spontaneously and be at risk for this disease.47

Diseases associated with pregnancy and parturition—Although cats are generally perceived to have less difficulty during pregnancy and parturition than dogs, spontaneous abortion, uterine torsion, dystocia, retention of fetuses and placentas at parturition, uterine prolapse, postpartum metritis, mastitis, and postpartum hypocalcemia have been described in this species, and are all preventable by ovariohysterectomy.

Urine marking—Urine marking is a normal behavior in cats that may begin at or just after the onset of puberty. It includes urinating in a standing (spraying) or squatting posture, and can be influenced by endocrine and environmental variables.46 Frequency of urine marking in queens reportedly increases during estrus in multiple cat households, and with crowding, and decreases following ovariohysterectomy or reduction in the number of cats in a household.48 A 5% frequency of urine spraying was reported in 152 prepuberally gonadectomized female cats evaluated at least 1.5 years after surgery; this behavior was not influenced by age at gonadectomy, which ranged from 6 to 10 months.49

Q: What are the potentially undesirable effects of ovariohysterectomy in queens?
A: Undesirable side effects of ovariohysterectomy have not been identified in queens. Estrogen-responsive urinary incontinence has not been confirmed in this species, and urethral closure pressures, proximal urethral sphincter pressures, and distal urethral pressures have been reported as the same in sexually intact and spayed female cats.50

What are the effects of bilateral orchidectomy in toms?
Q: Will reproductive behavior cease?
A: Although most male cats cease sexual behavior soon after castration, some males that had copulated with females before castration continued copulatory activity for as long as 3.5 years after surgery, and in others mounting behavior persisted indefinitely.51 Male kittens castrated at 4 months old showed little sexual behavior as adults unless treated with injections of testosterone propionate, in which case 4 of 6 males began mounting and achieving intromissions.52

Live spermatozoa were reported in ejaculates from vasectomized cats for up to 49 days after pre-scratal vasectomy, and for up to 120 hours after intra-abdominal electrocoagulation of the ductus deferens, suggesting that castrated males may continue to be fertile for at least those lengths of time.53,54

Intermale aggression and roaming behavior are reported to decline rapidly in more than half of all male cats after castration, and to decline gradually in most of the rest.33,55

Q: What signs develop if orchidectomy was incomplete?
A: Signs of incomplete orchidectomy, or of intra-abdominal testicular tissue, include continued reproductive behaviors of mounting and intromission, spraying with strongly scented urine, presence of the androgen-dependent penile spines, and presence of the male phenotype with a thick, cervical dermis. Complete castration causes an immediate decrease in plasma testosterone to baseline concentrations (<0.5 ng/ml, or <1.8 nmol/L), but, because these baseline values are also often present in intact cats, provocative testing is necessary to make certain no testicular tissue remains.56 Diagnosis of retained testicular tissue in toms can be made by measuring serum testosterone before and 1 hour after IM administration of 25 µg of gonadotropin-releasing hormone, which stimulates endogenous luteinizing hormone release and maximum testosterone secretion. Resting concentrations of serum testosterone in the sexually intact male cats range from undetectable to 3.0 ng/ml (undetectable to 10.4 nmol/L), and concentrations 1 hour after administration of gonadotropin-releasing hormone are 5.0 to 12.0 ng/ml (17.3 to 41.6 nmol/L).

Q: What complications may develop with castration of toms?
A: Postoperative complications of castration in male cats, as in male dogs, include hemorrhage, scrotal bruising and swelling, and infection at the incision site. Priapism, pollakiuria, and strangury developed in a young male cat within 3 days of routine castration and was found to be caused by an inflamed, thrombolic remnant at the base of the right spermatic cord of the penis that was removed at perineal urethrostomy.57 Surgical excision of retained abdominal testes requires abdominal exploration, and may convey some of the same risks of complication as any abdominal surgery. Clotting factor deficiency has been reported following prolonged hemorrhage associated with castration in cats.58

Q: Will castrated toms gain weight and become lethargic?
A: In a study of 16 toms castrated from 3 months to 3 years old, fed an experimental calculi-inducing diet ad libitum, and compared with age- and size-matched sexually intact controls fed the same
diet, food intake and body weight did not change.\textsuperscript{59} These data should be interpreted with caution when recommending castration of pet cats, however, because roaming and intermale aggression activity in uncaged pet cats may change after castration, and because the experimental groups may have eaten more if the diet had been more palatable.\textsuperscript{55}

Q: What are the beneficial effects of castration on incidence of reproductive disease in the tom?

A: Testicular disease—Testicular disease is rare in cats, and castration affords more benefits in areas of behavior and population control than in health maintenance. Several cases of orchitis have been reported in cats, with etiologic agents as diverse as tuberculosis, \textit{Brucella} sp bacteria, and feline infectious peritonitis virus.\textsuperscript{50-52} Case reports have documented testicular Sertoli cell tumors and undifferentiated carcinoma and teratoma in cats, but these are rare.\textsuperscript{63,64}

\textit{Disease of the accessory sex organs}—The accessory sex organs of male cats, the prostate and the bulbourethral glands, are androgen dependent, and atrophy following castration.\textsuperscript{65} Lesions of these organs are rare, consisting primarily of a few cases of prostatic adenocarcinoma, and are not known to be prevented by castration.

\textit{Urine marking}—Prepuberal castration usually prevents urine marking in male cats.\textsuperscript{49,55} Approximately 10\% of 134 prepuberally gonadectomized male cats were reported to spray as adults, and were more likely to spray if housed with females.\textsuperscript{49} Most males castrated in adulthood have postoperative declines in urine spraying. Rapid decline occurred in 78\% of 42 toms castrated as adults, and another 9\% had gradual declines.\textsuperscript{35} Age at castration was not related to the rate of decline.

Q: Are there potentially undesirable effects of castration in the tom?

A: Adhesions of the prepuce to the penis—The prepuce is adhered to the surface of the penis during pre- and early postnatal development, in most mammals. Separation of these tissues is an androgen-dependent event that may take place before birth, as in human beings, or after birth (at about 46 days) as in mice.\textsuperscript{66} Adhesions of the prepuce to the penis were found in 4 of 10 cats castrated at 5 months old, and were not evident in a similar group of castrates that had been given testosterone therapy.\textsuperscript{66} Because such adhesions can result in pockets of inflammation and irritation, these data suggest that early castration of cats should be performed only on animals in which the penis can be protruded and is separate from preputial adhesion.

\textit{Urethral obstruction}—At one time, urethral obstruction was proposed as a potential adverse effect of early castration, because of the hypothesis that urethral diameter could be smaller in castrates than in sexually intact males. However, comparison of urethral circumference in cats left sexually intact, castrated prepubertally (at 5 months old), or castrated prepubertally and subsequently treated with testosterone revealed no differences in urethral circumference among the 3 groups.\textsuperscript{67} In addition, when 2 groups of 16 cats, (castrated and sexually intact) were fed a calculi-inducing diet, no effect of castration on the development or severity of urethral obstruction or lower urinary tract disorder signs was found.\textsuperscript{99}

Onset of pubertal estrus has been reported to occur between 6.3 and 23.2 months in the bitch, and between 4 and 21 months in the queen, with queens influenced to cycle at a younger age if exposed to a long photoperiod.\textsuperscript{68-74} In the testicles of male Beagles, a few spermatids can be histologically identified as early as 29 weeks.\textsuperscript{73} Some dogs can be trained to ejaculate into an artificial vagina as early as 33 weeks, but their semen contains high percentages of dead and abnormal spermatozoa; semen collected after 41 weeks of age have normal sperm numbers, progressive sperm motility, and normal sperm morphology for young adult dogs.\textsuperscript{75} Earliest histologic evidence of spermatogenesis in cats appears at approximately 20 weeks; spermatozoa may be ejaculated in semen of male kittens as young as 7 months of age, but the average age of onset of intromission and ejaculation is 8 to 10 months.\textsuperscript{76,77}

The optimal age at which to neuter a dog or cat and minimize surgical complications and undesirable effects is not known. Many veterinarians suggest surgery when the animal is between 6 and 12 months of age, which decreases risk of mammary neoplasia in females of both species, often precedes behavioral signs and inconvenience of puberty, decreases risk of an undesired litter, and assures adequate size for venous catheter placement and familiar anesthetic techniques. Dr. K. Salmeri has presented some data to suggest that much earlier neutering of dogs may be not only as safe as, but perhaps even safer than the standard guidelines currently in use.\textsuperscript{78} It appears that neutering of older animals confers many, if not all, of the benefits described above, and should be recommended to clients interested in optimal pet health, if their pet is an acceptable surgical risk. There is no present support for the contention that a bitch or queen will be a better companion animal if she has delivered offspring. Although clients sometimes request sterilization without gonadectomy (hysterectomy, vasectomy) so that their animals may continue to experience normal reproductive behavior, the high incidence of mammary neoplasia, pyometra, testicular neoplasia, and prostatic disease in members of these species suggest that bilateral gonadectomy is preferred.
76. Scott MN, Scott PP. Postnatal development of the testis and epididymis in the cat. J Physiol 1957;136:40P–41P.

Current and proposed methods for contraception and termination of pregnancy in dogs and cats

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The options available for preventing estrus or pregnancy in dogs and cats remain limited, particularly to practitioners in the United States. Ovariohysterectomy is the most obvious approach if permanent sterility is desired. In dogs, administration of available synthetic progestogens or androgens, if properly timed in relation to the estrous cycle, can be used for short-term or long-term prevention of estrus and ovulation. Experimental, nonsteroidal methods of long-term or permanent contraception also have been investigated (Table 1). Treatment of mismating with estrogen presents the problem of serious side effects and low margin of safety. Other methods of nonsurgically termi-

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nating pregnancy are limited to experimental protocols involving prostaglandins, gonadotropin-releasing hormone antagonists, antiprogestins, inhibitors of progesterone synthesis, corticosteroids, or dopamine agonists, many of which have yielded promising results. In many cases, methods developed for use in dogs have been untested or might pose problems in cats.

Surgical Sterilization

Canine ovariohysterectomy—Ovariohysterectomy is the recommended approach to surgical sterilization in the bitch and has advantages over tubal ligation, ovarioectomy alone, salpingectomy, or subtotal hysterectomy. Removal of the uterus, cervix, when feasible, and the ovaries precludes any subsequent development of uterine or cervical