Special Report

The Association of Shelter Veterinarians veterinary medical care guidelines for spay-neuter programs

Association of Shelter Veterinarians' Spay-Neuter Task Force
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As efforts to reduce the overpopulation and euthanasia of unwanted and unowned dogs and cats have increased, greater attention has been focused on spay-neuter programs throughout the United States. Because of the wide range of geographic and demographic needs, a wide variety of programs have been developed to increase delivery of spay-neuter services to targeted populations of animals, including stationary and mobile clinics, MASH-style operations, shelter services, feral cat programs, and services provided through private practitioners. In an effort to ensure a consistent level of care, the Association of Shelter Veterinarians convened a task force of veterinarians to develop veterinary medical care guidelines for spay-neuter programs. The guidelines consist of recommendations for preoperative care (eg, patient transport and housing, patient selection, client communication, record keeping, and medical considerations), anesthetic management (eg, equipment, monitoring, perioperative considerations, anesthetic protocols, and emergency preparedness), surgical care (eg, operating-area environment; surgical-pack preparation; patient preparation; surgeon preparation; surgical procedures for pediatric, juvenile, and adult patients; and identification of neutered animals), and postoperative care (eg, analgesia, recovery, and release). These guidelines are based on current principles of anesthesiology, critical care medicine, microbiology, and surgical practice, as determined from published evidence and expert opinion. They represent acceptable practices that are attainable in spay-neuter programs.

As efforts to reduce the euthanasia of unwanted and unowned dogs and cats, including feral cats, have increased, greater attention has been focused on spay-neuter programs throughout the United States. Spay-neuter programs are designed to facilitate access to spay-neuter services among targeted populations of animals in an effort to prevent reproduction and reduce subsequent overpopulation. Current

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programs include designated spay-neuter practices in stationary and mobile clinics, MASH-style operations, shelter services, feral cat programs, and voucher systems as well as other in-clinic programs provided through private practitioners. In addition, a variety of programs have been established within veterinary colleges. In particular, many spay-neuter programs have been established to provide quality spay-neuter services to high numbers of patients on a regular basis. The proliferation and diversity of these spay-neuter programs have created a need for guidelines for appropriate veterinary medical care in these settings.

In response to this need, the Association of Shelter Veterinarians convened a task force consisting of 22 veterinarians from every region of the United States in December 2006. Task force members were charged with developing veterinary medical care guidelines for spay-neuter programs and included individuals from academia, private practice, and several existing spay-neuter programs. The guidelines they developed consist of recommendations for preoperative care, anesthetic management, surgical care, and postoperative care and are based on current principles of anesthesiology, critical care medicine, microbiology, and surgical practice, as determined by means of reviews of the scientific literature and expert opinion.

In developing these guidelines, the Association of Shelter Veterinarians hoped to establish spay-neuter practice as a recognized practice area within veterinary medicine; instill confidence in the general public regarding the use of spay-neuter programs; promote acceptance of this practice area by the veterinary profession and the public, thereby encouraging increased veterinary participation; provide guidance for veterinarians in this practice area; encourage existing programs to recognize and adhere to these guidelines as a means of ensuring acceptable levels of care; foster confidence among private practitioners regarding local spay-neuter programs and facilitate patient referral; provide a reference for use by state boards of veterinary medicine, other governing agencies, and veterinary professional associations; and provide a set of benchmarks by which funding agencies and donors can determine whether the spay-neuter programs they support provide acceptable levels of care. It is the Association's hope that these guidelines will help to establish the consistency and professionalism necessary for the veterinary profession to promote spay-neuter programs as a means to end the overpopulation of unwanted dogs and cats.

Recognizing that regional differences may exist among spay-neuter programs, guidelines developed by the task force were intentionally broad. Nevertheless, task force members believe that these guidelines represent practical recommendations that are attainable by the vast majority of spay-neuter programs. Importantly, they are meant to enhance, not replace, state practice acts, and where differences exist between these guidelines and state practice acts, veterinarians are encouraged to comply with the more stringent guidelines.

Guidelines for Preoperative Care

Attentive care to preoperative procedures and concerns remains essential to and fosters confidence in spay-neuter programs. Addressing client expectations and concerns, selecting patients appropriately, and ensuring patient safety reduce client, patient, and staff stress. Each of these efforts increases the quality of patient care while reducing legal liability and positively promoting the program.

Patient transport—Spay-neuter programs may include transport of patients by program personnel to and from the clinic for surgery. Safe transport is essential and should include the following:

- Providing proper confinement of animals and securing of enclosures.
- Ensuring safe, comfortable temperatures with appropriate heating, air conditioning, and ventilation.
- Providing a means to verify the identity of patients and to match patients with their medical records.
- Continually monitoring patients during transport.

Patient selection—Patient selection will vary depending on clinic staffing, anesthetic capabilities, locale, technical training, and economics. A veterinarian should make the final decision regarding acceptance of any patient for surgery, with acceptance based on historical and physical examination findings and the program's surgical schedule. The surgeon should use discretion regarding minimum and maximum patient age and body weight, taking into account the availability of staff expertise and necessary equipment to care for patients. Owned pets may best be served by scheduling surgery at 4 months of age or older to allow time for the development of immunity through vaccination. Neutering prior to sexual maturity is strongly recommended to prevent the birth of unintended litters, which commonly occurs when surgery is delayed.[1–5] In situations involving animals that will be placed for adoption, neutering is best performed prior to adoption (as early as 6 weeks of age) to ensure compliance.[4–6] Neutering prior to adoption is likely to improve the odds that adopted animals will be retained in their new homes because being sexually intact has been identified as the leading risk factor for owner relinquishment of cats and dogs.[7–11]

Veterinarians must weigh the risks and benefits of neutering patients with mild infectious or noninfectious medical conditions, such as upper respiratory tract infection, parasite infestation, or subclinical heartworm disease. Although some conditions may theoretically increase the risk of anesthetic complications or the risk of transmitting infectious diseases to other animals, the benefits of neutering likely outweigh these risks in the setting of a spay-neuter program. In the task force's experience, the opportunity to neuter any individual animal may not present itself again in the future. Thus, the benefits of neutering such animals when the opportunity arises generally outweigh the risks posed by such medical conditions. For animals that are pregnant, in estrus, or have pyometra, the task force's experience has been that neutering can be performed safely despite these conditions. Steps to mitigate the risk of compli-

cations in such animals are discussed elsewhere in the guidelines.

Client communication—Clients must be asked about patient history, including whether the animal is currently receiving any medications or has any pertinent medical conditions, such as allergies. In addition, clients should be instructed on withholding food from their animals prior to surgery. An individual patient risk assessment should be thoroughly discussed with the client before securing the client's consent for surgery. In the case of shelter, rescue, and feral animals, general consent inclusive of all patients should be obtained on the basis of established guidelines of the participating shelter, program, or humane organization.

Consent forms should be reviewed with and signed by the client or appropriate agent prior to induction of anesthesia. Although the specific topics contained in the consent form will vary from one program to the next, recommended subjects for inclusion on the consent form consist of the following:

- Client confirmation of the patient's health, whenever possible.
- Acknowledgment of the risk of infectious disease exposure, including increased risk if the animal has not previously received vaccinations.
- Acknowledgment of the risks of anesthesia and surgery, including death.
- Authorization for surgery.
- A recommendation that ongoing health care be provided by a full-service veterinary clinic.
- Client contact information, including emergency telephone contact numbers.
- A description of fees, if any.

Record keeping—Record keeping procedures should comply with state and local practice acts and with guidelines provided by state and national veterinary medical associations. A medical record should be prepared for each animal and should include physical examination findings, body weight, dosages of all drugs administered or prescribed and routes of administration, the surgical procedure performed, any abnormalities that are identified, and any other pertinent information regarding the animal's condition. Standardized operative reports may be used but should allow for additions when necessary.

Vaccination—Vaccination is always recommended prior to surgery, but perioperative vaccination is acceptable when necessary. Rabies vaccination should be required, and rabies vaccines should be administered as mandated by state regulations. Vaccination procedures should follow current guidelines established by the American Association of Feline Practitioners and the American Animal Hospital Association.[12,13]

Withholding of food—Food should be withheld from all animals for an appropriate period prior to surgery; however, withholding water is neither necessary nor recommended. For pediatric animals (ie, animals between 6 and 16 weeks old), a small meal should be fed 2 to 4 hours before surgery, and food should not be withheld for > 4 hours before surgery.[14–17] For juvenile (ie, animals > 16 weeks old) and adult animals, food should be withheld for a minimum of 4 hours[18–21,a] but withholding food for > 6 hours is not warranted. Exceptions should be made for feral cats in traps because of the safety risks associated with removing uneaten bait.

Physical examination—For all patients, a physical examination should be performed by a veterinarian or a supervised veterinary student to qualify the animal as a surgical candidate. Measurement of body temperature may or may not be performed at the discretion of the attending veterinarian. Ideally, the physical examination should always be performed before the animal is anesthetized, but it is recognized that anxiety, aggression, or feral behavior may prevent a thorough examination from being performed. Whether the physical examination is performed before or after the animal is premedicated or anesthesia is induced should be at the discretion of the attending veterinarian. Preanesthetic diagnostic testing may also be performed at the attending veterinarian's discretion.

When possible, sex and reproductive status (sexually intact vs neutered) should be verified prior to anesthesia and surgery. Body weight should be determined as close to the time of surgery as possible to guide selection of drugs and dosages. When weighing an individual animal is not feasible (eg, intractable or feral animals), body weight should be estimated as accurately as possible.

Patient housing—For patients to be safe and comfortable, appropriate housing should be provided for each animal. The following are recommendations for housing:

- A system should be in place for identification of animals.
- Housing should allow for adequate temperature and ventilation and stress reduction.
- Housing should be properly cleaned and disinfected between patients.
- Tractable adult animals should be housed in individual cages or runs that allow for good visibility and adequate space to turn around as well as for safety at various stages of sedation and anesthesia.
- At the discretion of the attending veterinarian, pediatric littermates or housemates may be housed together.[14–17]
- Intractable or feral animals should be housed in traps or other enclosures that allow for administration of anesthetics without extensive handling to minimize stress on the animals.
- Intractable or feral animals should only be removed from their trap or enclosure after sedated and should be returned to the holding enclosure when considered adequately recovered.

Infectious disease control—As is typical for any surgery, standard procedures for controlling potential infectious diseases should be practiced. In particular, spay-neuter programs should include the following when possible:

- All equipment that has direct patient contact (eg, examination tables, endotracheal tubes, laryngoscope blades, pulse oximeter clips, esophageal

stethoscopes, and thermometers) should be thoroughly cleaned and disinfected between patients with agents known to destroy common veterinary pathogens.[22,23]
- Anesthetic breathing circuits should be periodically cleaned, thoroughly disinfected, and dried. If used daily, they should be cleaned and disinfected once or twice a week at a minimum.
- Dome and 1-way valves as well as absorbent canisters should be disassembled, cleaned, and left open to airdry once a week at a minimum.[24]
- Staff should wash or sanitize their hands between patients and litters.
- Infected animals should be scheduled to undergo surgery after healthy animals each day.

Equipment—An equipment safety checklist should be completed prior to anesthesia on a regularly scheduled basis. Several references are available for checklists.[24–26] Inspection procedures should include a general machine audit, confirmation of oxygen supply, a check of the breathing circuit, and if a ventilator is used, a ventilator safety and function check.[26–28] A waste gas scavenging system should be used; both active and passive systems are acceptable. Use of charcoal canisters for scavenging waste anesthetic gases is acceptable only for short periods, typically < 8 hours or as determined by the weight of the canister.[23,29–32]

Guidelines for Anesthetic Procedures

Balanced anesthesia remains essential and involves proper analgesia, loss of consciousness, muscle relaxation, and immobility without patient compromise. Because of their very nature, spay-neuter programs provide unique opportunities to develop the safest general protocols for anesthesia (ie, drug selection, perioperative care, monitoring, and overall technique) of large numbers of animals being neutered in a short time frame.

Perioperative and intraoperative thermoregulation—As with any surgical procedure, thermoregulation is critically important,[33,34] and for most patients undergoing neutering through a spay-neuter program, there is a considerable potential for hypothermia. Efforts to preserve body temperature therefore should be consistent and continual. Contact with cold surfaces after premedications have been administered reduces body temperature, which subsequently is not easily increased during surgery. Warmth is best preserved by reducing contact with cold surfaces, limiting body cavity exposure, and providing carefully protected contact with circulating warm water or heated containers, such as carefully monitored water bottles or rice bags. Forced hot air or convective warming can also be an effective means of maintaining body temperature perioperatively.[35] In contrast, direct or close, unprotected contact with electric heating pads, blow dryers, heat lamps, drying cages, and hot water containers must be avoided to prevent thermal injury. This is especially important for pediatric, debilitated, frail, and geriatric patients for which low total protein concentration or low body fat stores may increase susceptibility to thermal injury and burns.[36]

During patient preparation for surgery, care should be taken to minimize conductive heat loss in heavily sedated or anesthetized animals by placing paper or cloth between the patient and any cold surfaces, especially stainless steel. Excessive removal or moistening of the hair coat around the surgical site as well as use of isopropyl alcohol or aggressive scrubbing should be avoided to minimize heat loss and aid in preserving the patient's body temperature.[37] Heat can also be conserved by using low oxygen flow rates with rebreathing anesthetics circuits. In contrast, most nonrebreathing anesthetic circuits are inappropriate for use with low oxygen flow rates because patients may experience clinically important hypercarbia and mild hypoxia.[38]

Oxygen supplementation and ventilation—Oxygen supplementation is especially helpful for patients that are debilitated, traumatized, dehydrated, or nutritionally compromised. Appropriate flow rates when oxygen supplementation is delivered by mask range from 2 to 5 L/min depending on the patient's size, the breathing system used, and the degree of mask closure.[39] Caution should be exercised when using oxygen in an environment where electrocautery is used because of the potential for explosion or fire.

Ventilation may be accomplished in anesthetized patients by connecting the anesthesia machine to a rebreathing circuit with a functional carbon dioxide absorbent or to a nonrebreathing circuit with appropriate oxygen flow rates. Ventilation is compromised when carbon dioxide absorbents are saturated or when inappropriately low oxygen flow rates are used with nonrebreathing circuits.[40]

Fluid therapy—When hydration is needed, fluids are best administered SC or IV during or immediately after surgery. The goals are to avoid stress and pain associated with administration when patients are awake and to ensure that fluid administration does not contribute to hypothermia. Fluids should be warmed prior to administration, particularly for patients predisposed to hypothermia (eg, pediatric, small, frail, or ill patients).[41,42]

Monitoring—To ensure maintenance of an adequate plane of anesthesia, individual patients must be carefully monitored.[43] Indeed, the most reliable means to ensure ongoing patient assessment and safety during anesthesia is vigilant monitoring by trained observers. In general, monitoring of several variables is required to accurately assess anesthetic plane and identification of changes in vital parameters is critical to an accurate assessment.[44] Reliance on any single variable can lead to an inadequate plane of anesthesia or, conversely, to an excessive depth of anesthesia, increasing the risk of complications, including death. The use of monitoring equipment must never replace vigilant, hands-on monitoring by educated observers.

Depending on individual circumstances, monitoring should involve assessment of various combinations of the following parameters.

Pulse quality, rate, and rhythm

The pulse can be assessed by manual palpation of the radial, dorsal metatarsal, femoral, lingual, facial,

and carotid arteries. Unlike electrocardiography, pulse oximetry allows accurate measurement of oxygenation and heart rate[45] and is preferred because electrocardiography may not accurately assess heart rate or mechanical output and does not allow oxygenation to be determined.

Respiratory rate and pattern

Monitoring respiratory rate and pattern is particularly useful in the early identification of anesthetic problems. Respiratory rate should be assessed by observing chest excursions or by ausculting the lungs with a stethoscope. Direct monitoring is preferred over the use of respiratory or apnea monitors, which may sense false flow impedance changes more indicative of surgical abdominal intervention (false diaphragmatic motions) than effective respiration.[46] Similarly, monitoring of respiration solely on the basis of rebreathing bag movement may result in an inaccurate assessment because of manipulation of the abdominal contents or diaphragmatic stimulation and is not recommended.

Jaw tone

A moderately relaxed jaw tone is indicative of a surgical plane of anesthesia. Lax jaw tone may indicate excessive anesthetic depth, whereas tense jaw tone may be associated with an inadequate plane of anesthesia.

Eye position and pupil size

In general, a central eye position with dilatation of the pupils indicates a potentially life-threatening depth of anesthesia. However, central eye position and pupillary dilatation can occur in cats and dogs anesthetized with high doses of ketamine and may not be associated with complications.[47,48] Moderate ventral strabismus of both eyes often indicates an adequate surgical plane of anesthesia in most species but is dependent on the drug combinations used for anesthesia.[25]

Palpebral reflex

A mildly sluggish or slow palpebral reflex indicates an adequate surgical plane of anesthesia. However, the palpebral reflex may be absent in animals anesthetized with some injectable protocols, especially those that include ketamine.[25,48]

Capillary refill time and mucous membrane color have been promoted as reliable means of assessing perfusion. However, many factors, including age, sex, body temperature, and Hct, affect these parameters, making them potentially unreliable. Notably, a normal capillary refill time and mucous membrane color may be observed following cardiopulmonary arrest.[49,50] For these reasons, reliance on capillary refill time and mucous membrane color for assessment of anesthetic depth and quality must be avoided.

Anesthetic protocol—Selecting anesthetic protocols for spay-neuter programs depends on many factors, including the number and type of patients, the skill and efficiency of available technical assistance, the timing of and competence in various surgical and anesthetic techniques, and the financial constraints for each individual program. Four criteria remain critical to identifying the safest, most humane, and most time- and cost-efficient anesthetic protocols. These include the provision of analgesia or a lack of pain; stress reduction or anxiolysis; immobility or muscle relaxation; and safe, controlled, reversible depression of the CNS resulting in unconsciousness. Numerous protocols combining multiple anesthetic agents, including injectable and inhalant agents, exist for pediatric and adult patients.[16,17,51–58]

Administration of analgesics—Analgesic agents are required for all patients undergoing neutering.[59,60] Acceptable choices include opioids (eg, butorphanol, buprenorphine, morphine, hydromorphone, and pentazocine), α_2-adrenoceptor agonists (eg, medetomidine, dexmedetomidine, and xylazine), NSAIDs (eg, carprofen, meloxicam, tepoxalin, deracoxib, firocoxib, aspirin, flunixin, ketoprofen, and etodolac), and local anesthetics (eg, lidocaine and bupivacaine).[61–77] Combining multiple analgesic agents in a single protocol is known as multimodal analgesia[78–80] and greatly improves pain and stress control in animals undergoing neutering through a spay-neuter program. Use of reversible agents and preemptive administration of analgesics prior to the initial surgical incision are common methods for providing safe and effective analgesia in high-volume settings. Surgical technique also influences severity of postoperative pain.[81]

Anxiolytic agents for stress reduction include minor and major tranquilizers (eg, acepromazine, midazolam, and diazepam) and α_2-adrenoceptor agonists. These can be delivered in combination with other analgesics.[53,64,82–85,b,c] Administering a single injection that includes anxiolytic, analgesic, and anesthetic induction agents substantially reduces patient pain and stress, compared with administering multiple injections. Thus, combining premedications and anesthetic induction agents in a single injection is advised for spay-neuter programs. Recommended combinations for such single injections include α_2-adrenoceptor agonists, opioids, and dissociative drugs.[86–94,d]

Anticholinergic agents—Although historically recommended as a component of many premedication regimens, the routine use of anticholinergics such as atropine has decreased owing to an improved understanding of the many adverse effects associated with their administration. Potential adverse effects include ileus, increased myocardial workload and oxygen consumption, hypertension, increased tenacity of many body fluids (including urine and salivary, gastric, and pancreatic secretions), mydriasis, and delirium or anxiety.[95–99] Even in pediatric patients (ie, animals between 6 and 16 weeks old), the routine use of anticholinergics is not recommended because clinical studies and experience to support their use are lacking. Only in neonatal patients (ie, animals < 3 weeks old) should anticholinergics such as glycopyrrolate be routinely administered because cardiac output is more dependent on heart rate in these patients.[100,e]

Induction and maintenance of anesthesia with inhalant anesthetics—Although there may be times when mask administration of inhalant anesthetics is required for patients in spay-neuter programs, mask administration of inhalant anesthetics for induction or mainte-

nance of anesthesia should be minimized. In the context of these guidelines, mask induction refers to effecting general anesthesia from consciousness through the delivery of inhalant anesthetics via a face mask. Mask maintenance or supplementation refers to continuation of general anesthesia for a period of time through the delivery of inhalant anesthetics via face mask. Finally, chamber induction refers to effecting general anesthesia from consciousness through the delivery of inhalant anesthetics via a chamber (ie, an enclosure surrounding the animal or the animal's head and face).

For the following reasons, mask induction should not be performed routinely and should be avoided whenever possible. Patients experience a relatively higher degree of stress during mask induction than they do during other methods of anesthetic induction. Furthermore, loss of consciousness is poorly controlled. Mask induction with isoflurane is associated with severe sympathomimetic effects and bronchial irritation. Mask induction is also associated with increased risk of aspiration of gastric contents because the patient's airway is not protected. In addition, high concentrations of the inhalant anesthetic that might harm the patient can potentially develop. Finally, proper mask induction requires high oxygen flow rates, which are expensive and produce substantial environmental contamination with waste anesthetic gases.[101–108,f]

Chamber induction is more likely than mask induction to result in prolonged and excessive patient stress and excitement as well as potentially high inhalant anesthetic concentrations that may harm the patient. Furthermore, chamber induction produces the highest amounts of waste anesthetic gas environmental contamination known in the veterinary profession.[102,f] Thus, this method of induction is not recommended.

Mask maintenance or supplementation during the surgical procedure should be minimized to avoid aspiration of gastric contents, environmental contamination, and bronchial irritation.[103–108,f] In a busy environment such as that encountered in spay-neuter programs, mask supplementation may be required and is appropriate for a few animals for short periods of time. However, if mask supplementation becomes frequent or regular, other options should be considered for patient and staff safety. Options that should be considered include the following:

- Using an anesthesia protocol that requires intubation, which is safer for the patient and avoids environmental contamination.
- Considering alternative anesthesia protocols that employ better analgesics and sedatives, thereby circumventing the need for mask supplementation.
- Considering the administration of additional analgesics via sublingual or IV routes to maintain adequate surgical planes of anesthesia (eg, low doses of opioids, ketamine, or α_2-adrenoceptor agonists).
- Eliminating issues that contribute to unsteady states of anesthesia, including hypothermia, hypoxia, hypotension, hypercarbia, and hypoglycemia.

Preparation for emergencies—Emergency readiness protocols are essential. Several important practices must be considered to prepare for any emergency that might occur during spay-neuter surgeries. Standard emergency equipment, including a source of oxygen and means of ventilation (eg, an Ambu bag or anesthesia machine), drugs, and reversal agents, must be readily available in ample supply in all situations. In addition, emergency drug charts containing volumes of drugs to be administered by body weight should be readily accessible to facilitate rapid preparation of doses. Emergency drug charts can be found in several references.[109,110] Clinic staff should be fully prepared for emergencies at all times. Staff training should include regular drills or rounds to review identification of respiratory or cardiovascular arrest versus depression and the fundamentals of CPR (eg, airway, breathing, and circulation). Rounds may also include equipment inspections, record keeping for emergencies, reviews of difficult cases, and morbidity-mortality rounds.[110–112]

Accurate drug calculation and administration—Given the high-volume nature of many spay-neuter programs, veterinarians may be tempted to use predetermined or standardized drug doses (ie, a 1-size-fits-all approach). These approaches do not take into account individual patient weight or health status and consequently can result in inappropriate dosing, including overdosing of smaller patients and inadequate dosing of larger ones. For example, use of a standard dose of medetomidine (eg, 0.25 mL of a 1 mg/mL solution) for all cats regardless of size is not recommended in place of use of a standard dose rate (eg, 60 µg/kg [27 µg/lb]). Similarly, administration of drug volumes that only fill the needle hub should be avoided. On the other hand, use of drug doses for animals categorized on the basis of body weight (eg, X µg of drug for patients weighing 1 to 2 kg [0.45 to 0.9 lb] and Y µg for patients weighing 2 to 4 kg [0.9 to 1.8 lb]) may be an acceptable means to facilitate dose preparation. Furthermore, use of a chart that expresses drug doses as a function of body weight may help prevent calculation errors.

For spay-neuter programs in which an accurate weight cannot be obtained prior to drug administration, such as programs to neuter feral cats, safety is increased by using readily and safely reversible agents and by infrequent use of drugs that result in marked cardiorespiratory depression. Obtaining estimates of body weight to facilitate a compensatory increase or decrease in anesthetic dose further increases safety.

Drugs that are used should be of appropriate concentration and volume for patients in the program. If commercially available drug concentrations do not accommodate accurate dosing, stock concentrations should be diluted on a daily basis to improve accuracy of dosing. For example, an anesthetic agent that is commercially available as a 10 mg/mL solution could be diluted to a 1 mg/mL concentration to aid in preparation of small doses.

High-risk patients—Attending veterinarians may deem particular patients as being at a high risk for anesthetic or surgical complications on the basis of history and physical examination findings. This would include, for example, brachycephalic and geriatric patients and patients with severe preexisting medical conditions. In these instances, an alternative anesthetic protocol may

be used to minimize risks and ensure safe and humane care. Anesthetic protocols for high-risk patients should rely less on anesthetic agents that cause marked cardiorespiratory depression and might include reversible agents, supplementation with oxygen and fluids, and intubation if airway patency is questionable.[113,114,g]

Intubation—Intubation provides patients with a usable, patent, artificial airway but does not necessarily imply the use of oxygen or inhalant anesthetics. Historically, intubation with a cuffed endotracheal tube has represented the gold standard for maintaining a protected airway in surgical patients. However, intubation requires training, practice, time, patience, and the proper depth of anesthesia. In the context of spay-neuter programs, intubation may complicate the surgical routine and even compromise patient care if it is not performed with skill, care, and efficiency.[115,116] Hence, the pros and cons of intubation must be weighed against the historical safety benefit. If intubation is performed as a standard part of an anesthetic protocol, having an anesthesia team that possesses the required skills for this maneuver is critical to success.[110,h] In particular, patients that may benefit from intubation include most adult overweight dogs, most brachycephalic animals, and most animals with preexisting respiratory tract compromise, especially if it involves the upper airway.[117] Whereas intubation does not necessarily need to be a part of all spay-neuter anesthetic regimens, it should be a possibility for all patients if required in an emergency situation.

Guidelines for Surgical Care

Guidelines concerning the aseptic and technical aspects of performing spay-neuter surgeries are based on accepted principles of microbiology, surgical asepsis, and surgical technique; reviews of the scientific literature; and the opinions of experts knowledgeable in the subject. These surgical practices represent acceptable standards that are attainable in spay-neuter programs.

Operating-area environment—The operating area should be a room or an area dedicated to surgery. The area should contain and have readily available the necessary equipment for performing anesthesia and patient monitoring. Scheduled disinfection policies and procedures should be in place. Traffic within the operating area should be limited to essential personnel.[118,119]

Surgical-pack preparation—Separate sterile instruments are required for each patient.[120–123] Instruments must be cleaned prior to sterilization. Surgical packs may be sterilized by steam, gas, or plasma. A sterility indicator strip should be located inside and outside the pack. Although sterility indicator strips do not ensure sterility of the pack, they help in the detection of procedural errors and equipment malfunctions and allow quick differentiation between processed and nonprocessed packs.[120] A number of materials, including reusable and disposable materials, are acceptable for the outer wrap of the surgical pack. The outer wrap material must provide a minimum microbial barrier equivalent to dry 270–thread count pima cotton. Additionally, the wrap material and pack storage conditions must ensure sterility for the longest anticipated pack turnover interval.[121]

Patient preparation—The following issues should be considered during patient preparation.

Bladder

Caution should be exercised during bladder expression. If excessive pressure is necessary to express the bladder preoperatively and bladder expression is deemed necessary, urethral patency should be evaluated, and expression should be delayed until deeper planes of anesthesia are attained or intraoperative examination and surgical expression are possible.

Skin

Preparation of the skin should be performed in a manner that preserves skin integrity. Hair removal should be adequate to prevent inadvertent contamination of the sterile surgical field. The prepared area should be large enough to accommodate extension of the incision if necessary. After hair removal, the entire skin area should be disinfected with an appropriate surgical scrub agent used according to accepted patient preparation practices.[121,124]

Draping

Patient draping is required for all abdominal procedures and for the castration of dogs, with the exception of castration of pediatric puppies. The surgical drape should be of adequate size to prevent contamination of the sterile field. Drape material must resist penetration by fluids and microorganisms under normal operating conditions.[124,125] The barrier function of reusable drapes is lost after repeated launderings; therefore, processing of packs should adhere to published guidelines for sterilization practices regarding laundering, autoclaving, and useful service life.[126] In the case of cats and pediatric puppies undergoing castration, use of a clean or sterile drape as a barrier to prevent hair or fecal contamination is left to the surgeon's discretion. If a barrier is not used, extra care must be taken to prevent contamination during the procedure.

Surgeon preparation—Various issues related to surgeon preparation should be considered.

Surgical attire

The surgeon should wear appropriate surgical attire intended for use within the operating area.[127]

Surgical caps and masks

Surgical caps and masks are required, except for routine castration of cats and pediatric puppies.

Surgical hand and arm scrub

A properly performed hand and arm scrub with an appropriate surgical scrub agent used in accordance with published guidelines is required prior to performing surgical procedures, except for routine castration of cats.[127] Approved waterless surgical prep agents have been shown to be effective and acceptable alternatives to traditional scrub techniques when used according to published guidelines.[128,129]

Surgical gowns

Sterile surgical gowns, either cloth or disposable, are recommended when performing abdominal procedures.[127] However, their use is left to the discretion of the surgeon provided that aseptic technique is maintained.

Surgical gloves

Single-use sterile surgical gloves are required for all surgeries, except for routine castration of cats.[127] For routine cat castrations, sterile gloves are ideal; however, single-use examination gloves are permissible for this procedure when incisions are left open to heal by second intention.

Surgical procedures—Veterinarians or veterinary students under the direct supervision of a veterinarian must perform all surgical procedures. For female patients, ventral midline, flank, and laparoscopic approaches are acceptable and use of these approaches for ovariohysterectomy and ovariectomy has been described.[17,130–143] For male patients, prescrotal and scrotal approaches are acceptable and use of these approaches for castration of puppies and adult dogs has been described.[17,130,133,135–137,142,144–146] General principles of gentle tissue handling, meticulous hemostasis, and aseptic technique should be followed.[121,147] Hemostasis must be ensured and verified prior to completion of the procedure. Either an interrupted or continuous suture pattern is acceptable for abdominal closure.[148]

Ovariohysterectomy and ovariectomy

Many variations of the spay procedure are accepted for cats and dogs.[17,130–143] The particular surgical procedure and its details, including the length and location of the surgical incision, are chosen on the basis of the attending surgeon's preferences. In all cases, complete removal of both ovaries is required. When ventral abdominal incisions are used, closure must incorporate the external rectus fascia.[149,150] When flank incisions are used, closure must incorporate the transversus abdominus and internal and external abdominal oblique muscles.[133,149]

Orchidectomy

Various accepted techniques for castration of cats and dogs exist.[17,130,133,135–137,142,144–146] The specific procedure performed should be chosen on the basis of the attending surgeon's preference. In all cases, complete removal of both testes is required. For male cats, incisions are commonly left open to heal by second intention. For cryptorchid dogs and cats, both testes must be removed or the patient should be referred elsewhere for complete removal. The length and location of the surgical incisions are chosen on the basis of the attending surgeon's preferences. Closure of ventral abdominal incisions must incorporate the external rectus fascia.[149,150]

Procedures in pediatric (6- to 16-week-old) patients

Neutering of pediatric animals has been endorsed by the AVMA as a means of reducing the numbers of unwanted cats and dogs.[151] Various accepted techniques for neutering of pediatric cats and dogs have been described.[17,130,132,135–137,145] The particular procedure used should be chosen on the basis of the attending surgeon's preferences. Scrotal incisions may be used for castration of pediatric puppies and kittens, with incisions sutured, glued, or left open to heal by second intention at the surgeon's discretion.

Suture materials—Sutures or surgical clips must be of biomedical grade, approved for medical use, and dated for current use. Materials placed beneath the skin surface must be absorbable or inert nonabsorbable materials, such as stainless steel, nylon, or polypropylene.[149]

Identification of neutered animals—Each spay-neuter program should choose a consistent means of identifying animals that have been neutered. Tattooing of the ventral abdominal skin is recommended for females. Sterile instrumentation should be used to apply the tattoo regardless of the method chosen. Several acceptable tattoo methods exist and include the following:

- Applying tattoo ink directly to the surgical incision after subcuticular closure.
- Applying tattoo ink to a cutaneous incision other than the surgical incision.
- Intradermal injection of tattoo ink.
- Use of a tattoo gun with a sterile needle for each patient.

For free-roaming and feral cats, unilateral ear tipping (ie, surgical removal of the distal tip of one of the pinna) is the recommended method for identifying cats that have been neutered.[4] Removal of an ear tip represents the universally accepted international standard for identifying a neutered free-roaming or feral cat. Hemostasis of the pinna should be ensured prior to the conclusion of recovery observation.

Use of antimicrobials—Routine perioperative use of antimicrobials is not recommended. Rather, antimicrobial use should be reserved for specific indications, such as a preexisting infection (eg, pyometra) or a break in surgical asepsis. If antimicrobials are used, they should be administered prior to surgery whenever possible or as soon as a break in surgical asepsis is recognized.[152–154]

Guidelines for Postoperative Care

Providing patients a smooth transition from an anesthetized state to wakeful comfort for return to their home environments requires vigilance and diligent attention to detail. Successful recovery protocols are associated with a minimal number of adverse patient events, a rapid return to normal behaviors, staff contentment, and owner or caregiver satisfaction. Prompt attention to problems and concerns combined with open client communication serves to minimize negative consequences.[i]

Patient transport within the clinic—Safe delivery to the recovery area is essential and must include ensuring that the patient airway remains patent, pain and stress are continually minimized, and thermoreg-

ulation is continuously addressed. In addition, protecting patients against infectious disease is essential. Patients should be triaged prior to transport and segregated if there are potential signs of contagious disease. Comprehensive infectious disease control practices, including procedures for proper cleaning and disinfection between patients, should be in place.

Recovery—The recovery environment should minimize the risk of complications, including airway obstruction, emergence delirium, and staff injury. Caution is advised when holding animals during recovery to avoid airway restriction, which can result from malpositioning of the head and neck, and excitement, which could contribute to emergence delirium and subsequent caretaker injury. For these reasons, patients should be allowed to recover on a secure, level surface, such as a floor or cage bottom whenever possible. Designated recovery areas that allow for continuous, direct observation of each patient and separation of species should be used whenever possible. These areas should be clean, dry, and warm; loud noises should be minimized. For pediatric patients, recovery with littermates is recommended when possible to provide warmth and reduce anxiety associated with separation.[14–17]

Patients recovering from anesthesia should be continuously observed for any signs of hemorrhage, respiratory compromise, pain, stress, discomfort, and other complications and for urination and defecation. Identified problems should be triaged and addressed accordingly.[155] Complications that may occur in the postoperative period include but are not limited to cardiorespiratory depression or compromise, a continual decrease or increase in body temperature, prolonged distress or anxiety, and vomiting or regurgitation with the risk of aspiration.[134,i-k] At a minimum, the following parameters should be continually assessed during recovery:

- Heart rate and pulse quality (except for feral animals).
- Airway patency.
- Respiratory rate and character.
- Signs of pain and anxiety.
- Body temperature in all patients at risk for developing hypothermia or hyperthermia.
- Neurologic status, including degree of arousal or sedation.
- Movement and ability to ambulate.

Analgesia—If NSAIDs were not administered before or during surgery, they may be administered parenterally or, once adequate swallowing reflexes have returned, orally, so long as animals are adequately hydrated. Other analgesics such as opioids and α_2-adrenoceptor agonists may be administered after surgery alone or in combination with NSAIDS as needed to ensure appropriate analgesia.

Anesthetic reversal—At the veterinarians' discretion, reversal of sedative, analgesic, and anesthetic agents may be performed if necessary because of emergency situations and in programs in which patients are promptly returned to the environment, owner, or caregiver. However, it must be remembered that reversal of analgesic and sedative agents may cause pain and anxiety. In particular, IV administration of reversal agents is commonly associated with sudden catecholamine release. Hence, rapid IV administration should be avoided if at all possible, except in emergency situations when rapid reversal is required.[156,157]

Thermoregulation—As previously described, thermoregulation is critical. Body temperature can be preserved through the use of various materials, such as papers, towels, and blankets, to cover the animal and the surface on which it is lying. If needed, supplemental heat sources should be used, but care must be taken to prevent hyperthermia and burns.

Kennel environment—Certain details particular to the kennel environment deserve careful attention. When transporting a patient to an assigned cage or other enclosure, verification of the patient's identification is critical. Patient identification must match the appropriate paperwork and cage assignment. Patients should be continually evaluated for changes in their mental status and overall condition that could signal potential complications, stress, or pain. Cleanliness should also be carefully monitored. Under supervision, small amounts of water should be offered as soon as patients are ambulatory[38,134] and patients can be offered food as needed. To protect against hypoglycemia, pediatric, geriatric, frail, and at-risk patients should be offered small amounts of food and water under supervision as soon as appropriate, as determined on the basis of adequate neurologic status, including mentation and swallowing reflexes.

Dogs that are ambulatory should be walked to encourage urination and defecation, if they do not pose a safety risk for staff. If cats are to be held > 12 hours, a litter box should be provided after the patient is ambulatory. Traps housing feral cats should be elevated to allow urine and feces to fall through the wire bottoms away from the patient. Feral cats should be returned to their environments as soon as they are fully recovered from anesthesia.

Release—Patients must be evaluated immediately prior to release. Postoperative evaluations should include assessments for normal mentation, ambulation, and respiratory rate and character and for adequate analgesia. If possible, surgical incisions should be examined to ensure that the skin edges are clean, dry, and well apposed.[134,158] Cats and dogs that are not ambulatory should not be discharged until they are recovered.

Animal owners, caregivers, or their agents should be provided with clear instructions for postoperative care. Written instructions are required in addition to oral instructions. Discharge instructions should include resources for handling questions or concerns about postoperative complications and emergencies.

Spay-neuter programs must establish regular policies for managing complications and emergencies that occur within the 48-hour period after surgery. If possible, the program should perform its own reexaminations. For MASH-style and mobile unit programs, contingencies for emergency veterinary care must be arranged in advance. In the event of patient death, the program should be notified, and if possible, a necropsy

should be performed to establish the cause of death. The necropsy may be completed by a neutral source such as a diagnostic laboratory or by the clinic veterinarian with appropriate documentation.

Conclusion

Spay-neuter programs are an integral and imperative part of veterinary medicine and the community. By following these guidelines, including paying careful attention to perioperative care and intraoperative monitoring, recognition of potential complications, and thorough record keeping, these programs succeed in their mission to provide humane methods for neutering large numbers of cats and dogs. At this time, these programs are the best antidote to mass euthanasia of cats and dogs resulting from overpopulation. Furthermore, they represent the most financially responsible and humane way for communities to increase the numbers of cats and dogs that are neutered. By engaging in this new and rapidly developing practice area, veterinarians can play vital roles in alleviating overpopulation and decreasing untimely euthanasia of cats and dogs.

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