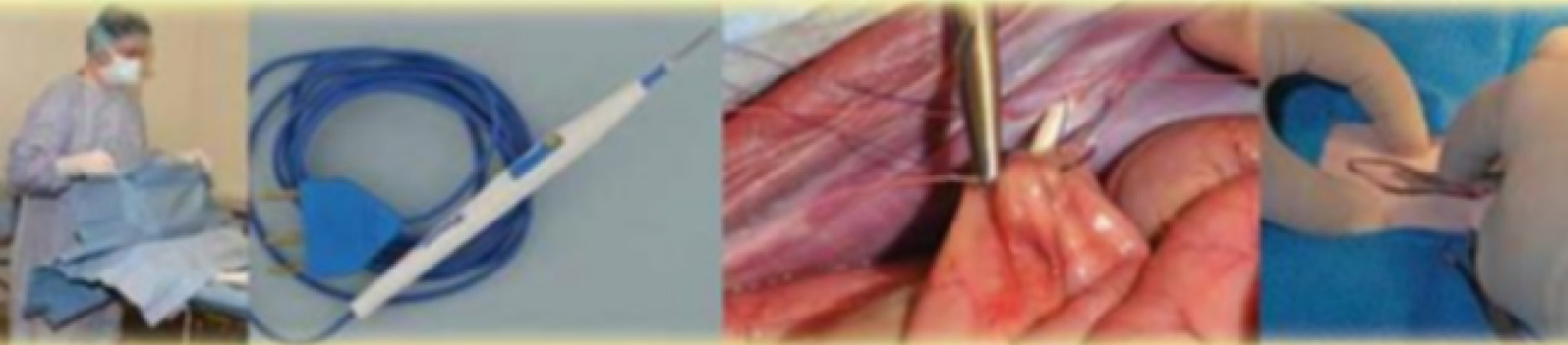



# Fundamentals of Small Animal Surgery



Fred Anthony Mann,  
Gheorghe M. Constantinescu  
and Hun-Young Yoon

 WILEY-BLACKWELL



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# **Fundamentals of SMALL ANIMAL SURGERY**



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**SMALL ANIMAL  
SURGERY**

**Fred Anthony Mann**

**Gheorghe M. Constantinescu**

**Hun-Young Yoon**

 **WILEY-BLACKWELL**

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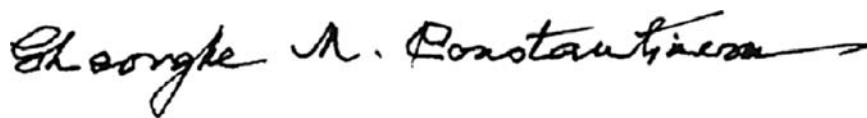
# DEDICATIONS

We, the authors, dedicate this textbook to all of the students who we have had the pleasure of training in the art and science of small animal surgery and to all of those companion animals who have benefitted from their surgical skills. The authors also state the following individual dedications.

I dedicate this textbook to my loving wife, Dr. Colette Wagner-Mann, my son, Lucas Mann, and my daughter, Danielle Mann. I thank them for their love, understanding, and patience as I have dedicated enormous amounts of time to veterinary student education, including the production of this textbook.



My contribution to this book as an anatomist and medical illustrator started long ago and was encouraged by my wife, Dr. Ileana Constantinescu, whom I thank warmly for her unlimited support, understanding, and sacrifice. I dedicate this book to her, to my son Dr. Răzvan Constantinescu and daughter Adina Klima, and their families.



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# PREFACE

Today, owners of dogs and cats typically consider their pets to be members of the family. As such, the pet-owning public expects access to the same level of medical and surgical care that is available to human beings. Further, the general public expects veterinarians to have a certain level of surgical competence immediately upon graduation from veterinary school. To that end, veterinary educators are charged with preparing veterinary students to be competent surgeons. Competent surgery begins with a thorough knowledge of surgical principles and proficiency in basic sur-

gical techniques. This textbook is intended to facilitate the initial stages of surgical training and to serve as a refresher to those in the profession who may have had little surgical experience since veterinary or veterinary technician schooling. It is the authors' hope that those studying to be veterinarians and veterinary technicians will find this textbook to be a helpful complement to their instruction and that graduate veterinarians and veterinary technicians will find this textbook to be valuable in postgraduate in-service training for veterinary staff.

---

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[Assistance in assuring accuracy in the first section of Chapter 16]

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[Assistance with portions of Chapters 3, 7, and 17 while employed as a Small Animal Soft Tissue Research/Teaching Intern at the University of Missouri, Columbia, Missouri]

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# **Fundamentals of SMALL ANIMAL SURGERY**





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# Chapter 1

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## PREOPERATIVE PATIENT ASSESSMENT

*Elizabeth A. Swanson and Fred Anthony Mann*

In general practice, the veterinarian often already knows the patient being presented for surgery. Even so, the veterinarian should take this opportunity to instill a sense of confidence and firmly establish a solid veterinarian–client–patient relationship. To that end, a complete history and physical examination are paramount in the surgeon’s toolbox of information about the patient. The history and physical examination will determine whether a patient is a good candidate for surgery, will determine what further tests are necessary prior to anesthesia, and will allow the veterinarian to give the owner an accurate assessment of what to expect. The information gained also helps to guide decision-making regarding anesthetic protocol, type of procedure to be performed, pain management, and postoperative care. In short, nothing can replace a thorough history and physical examination in establishing a base of information about the patient that can be used for perioperative decision making.

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### HISTORY

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Even when the patient is known to the surgeon, a current and detailed patient history should be obtained from the owner at the time of presentation. The presenting complaint is ascertained and details recorded on the duration of the problem, what clinical signs have been observed, and whether the owner feels the problem is better, worse, or the same as when it was first noticed. Such historical information may not be pertinent for a healthy dog or cat being presented for elective ovariohysterectomy or orchietomy; however, it is necessary to make certain that there have been no changes in the patient’s health status prior to surgery. In addition, for dogs and cats presenting for ovariohysterectomy, it is important to always ask about when the animal was last in heat and if there is a possibility that the animal is pregnant.

Other information gathered when taking the history includes environment, diet, patient lifestyle, any current or previous medical conditions, previous surgeries, current medications (including over-the-counter medications, supplements, and heartworm and flea/tick preventatives), and adverse reactions to medication. Appetite, drinking, urination, defecation, and

occurrences of coughing, sneezing, vomiting and/or diarrhea are also noted.

Medical information may lead the veterinarian to identify previously undiagnosed disorders, such as hyperthyroidism in a geriatric cat presented for dental prophylaxis with increased appetite and concurrent weight loss. Patient lifestyle can play a huge role in determining which procedure should be performed. For example, external fixation of a tibial fracture in a free-roaming farm dog may not be the best option for healing and management of that fracture.

In the case of an emergency, basic information should include signalment, the presenting complaint, major concurrent medical conditions, current medications, and drug sensitivities. The remainder of the history may be obtained at the first available opportunity.

## PHYSICAL EXAMINATION

The physical examination may commence once the history has been taken. A more experienced practitioner will be able to begin the physical examination while still taking the history, a practice that can be most beneficial for triaging emergency cases. The importance of a good physical examination cannot be overly stressed. A thorough physical examination can identify both major and subtle changes in a patient's condition that may affect what is done for that patient. The finding of a swollen vulva in an intact female dog presented for ovariohysterectomy may lead the veterinarian to discuss with the owner the increased risk of hemorrhage and, potentially, the recommendation to postpone the surgery.

A consistent, systematic approach is recommended for physical examination. Important developments may be missed when the examiner makes the mistake of focusing only on the presenting problem. A full examination consists of close inspection of the head and neck (eyes, ears, nose, oral cavity), lymph nodes, cardiovas-

cular system, respiratory system, digestive tract, urogenital system, integument, musculoskeletal system, and neural system. The precise order of the examination is not dictated, but to ensure that no system is missed, the examiner should establish an order and remain consistent from one patient to the next.

## LABORATORY DATA

Findings during the history and physical examination will help determine which laboratory data are necessary. For a young, healthy animal less than five years of age that is presented for elective surgery, a laboratory baseline of packed cell volume (PCV), total protein (TP), blood urea nitrogen (BUN) or creatinine, blood glucose, and urine specific gravity will typically suffice. Full laboratory work-up, including complete blood cell count (CBC), serum chemistries, electrolytes, and urinalysis, are in order for patients older than five years and any sick or debilitated patient. A recent heartworm test should be required for patients who have lived or traveled in endemic areas. All cats should be tested for feline leukemia and feline immunodeficiency virus if they have not previously been tested. Cats that have access to the outside or that come in regular contact with an outdoor cat should be tested annually. Additional tests may be run in patients with specific medical conditions.

Advanced laboratory tests may be indicated in certain conditions. Breeds that have a high incidence of von Willebrand's Disease, such as Doberman pinschers, should have a buccal mucosal bleeding time (BMBT) performed as part of the preoperative work-up before any surgery, elective or otherwise, is performed, even if there is no history of abnormal bleeding tendencies. A prolonged BMBT (>5 minutes) indicates further testing, such as for von Willebrand's factor (vWF). An elective procedure may be postponed pending further information. If surgery is required and the patient is suspected to

have Type I (low concentration of vWF) von Willebrand's disease, the animal may be pretreated with desmopressin acetate (1-deamino-8-D-arginine vasopressin, also called DDAVP) or administered cryoprecipitate. Fresh whole blood, fresh frozen plasma, or cryoprecipitate may be necessary if significant hemorrhage occurs or in dogs with Type II (low concentration of large multimers of vWF) or Type III (complete absence or only trace amounts of vWF) von Willebrand's disease. If time allows, desmopressin can also be administered to a blood donor 30–120 minutes prior to blood collection. The BMBT is also indicated to assess the bleeding tendency of patients with suspected thrombocytopathia, such as dogs that have been treated with aspirin.

Platelet counts and coagulation panels are necessary for any patient showing signs of easy bruising, ecchymoses, or petechia pre- or postoperatively. Platelet counts and coagulation panels should also be run for patients undergoing procedures where significant hemorrhage is possible and adequate hemostasis may not be directly achieved, such as for liver biopsies obtained via laparoscopy or ultrasound-guided needle biopsy. If a coagulopathy is diagnosed, fresh frozen plasma should be administered to provide coagulation factors. Also, transfusion of fresh whole blood may be necessary to stabilize a patient with thrombocytopenia. It is important to realize that whole blood, platelet-rich plasma, and platelets do not significantly raise the platelet count.

Arterial blood gas analysis and acid–base status should be evaluated in patients with suspected hypoxia or hypoventilation, such as patients with pulmonary disease (i.e., aspiration pneumonia, pulmonary edema, thromboembolism), pneumothorax, pleural effusion, and in critical patients that are in shock, are septic, or are showing signs of systemic inflammatory response syndrome. The arterial partial pressure of oxygen ( $\text{PaO}_2$ ), the arterial partial pressure of carbon dioxide ( $\text{PaCO}_2$ ), pH, bicarbonate concentration ( $[\text{HCO}_3^-]$ ), base excess

(BE), anion gap, and electrolyte concentrations can be interpreted together to evaluate respiratory function and to determine the cause of acid–base imbalance. Blood gas analysis is used to help determine what, if any, supplemental therapy is necessary and to help monitor the response to treatment.

Critical patients, especially those with effusive disease processes, such as peritonitis, protein-losing enteropathy, generalized lymphangiectasia, and burns, may lose a large amount of protein into the effusion through leaky blood vessels. Loss of protein, especially albumin, causes movement of intravascular fluid into the interstitium (edema) or body cavities via osmosis. The pressure exerted within the blood vessels by albumin and other colloids is called colloid oncotic pressure (COP), which can be measured from a patient's whole blood sample. The measurement of COP is used to help direct fluid therapy, particularly the use of colloids, such as hetastarch, dextran, whole blood, and plasma.

## DIAGNOSTIC IMAGING

Diagnostic imaging is not routinely performed prior to elective procedures in healthy animals. Other conditions, however, benefit from data obtained through radiography, ultrasonography, and more advanced imaging modalities, including computed tomography and magnetic resonance imaging (MRI). Patients undergoing surgery as therapy for neoplasia should be staged according to the suspected tumor type, and diagnostic imaging is part of the staging process. Minimal data obtained for oncological surgery patients should include CBC, serum chemistries, urinalysis, thoracic radiographs (right and left lateral views and ventrodorsal view), right lateral and ventrodorsal abdominal radiographs, and abdominal ultrasound. Computed tomography or MRI, whichever is more appropriate for the given situation, is used to map tumors and help plan surgical margins.

The minimal database for trauma patients should include PCV/TP, BUN, blood glucose, urine specific gravity, right lateral and ventrodorsal thoracic and abdominal radiographs, and sometimes abdominal ultrasound. Diaphragmatic continuity, body wall continuity, and the presence of a urinary bladder should be assessed, in addition to looking for pneumothorax, pleural and peritoneal effusion, and pulmonary contusions.

While orthogonal views are always preferred when interpreting radiographs, obtaining a right lateral radiograph of a critical, bloating dog will usually suffice in diagnosing gastric dilatation-volvulus (GDV). Right and left lateral and ventrodorsal thoracic radiographs should also be taken in geriatric dogs with GDV to evaluate for evidence of neoplasia, because the presence of neoplasia may influence owner decisions. Of course, the GDV patient must be stable enough to take additional radiographs prior to surgery.

Patients with a heart murmur or known cardiac disease should have right lateral and either ventrodorsal or dorsoventral thoracic radiographs taken and, if indicated, an echocardiogram performed prior to anesthesia. Right lateral and ventrodorsal thoracic radiographs are indicated for any vomiting or regurgitating patient to assess for aspiration pneumonia and for patients that develop an increased respiratory effort or respiratory distress during treatment.

Various forms of contrast radiography are used in the diagnosis of medical problems. Videofluoroscopy can be used to evaluate esophageal function and gastric emptying times. Oral administration of barium with sequential right lateral and ventrodorsal abdominal radiographs is used to evaluate gastrointestinal motility and to identify gastrointestinal obstruction, such as from a foreign object or tumor. Excretory urography is useful in evaluating renal function of the opposite kidney prior to nephrectomy if renal function is questionable. Evaluation of the urinary bladder and urethra for tumors, tears, and luminal filling

defects is performed, using positive-contrast cystourethrography.

Postoperative radiographs are indicated for any orthopedic procedure where metal implants are used or removed. Radiographs are also taken after cystotomy to document removal of uroliths from the urinary bladder. Proper nasogastric and esophageal feeding tube position and percutaneous chest tube placement should be checked radiographically with orthogonal thoracic views.

## ASSESSMENT OF ANESTHETIC AND SURGICAL RISK

Once the full picture has been obtained, as appropriate for the patient and situation, the patient's anesthetic and surgical risk is assessed. In 1963, the American Society of Anesthesiologists developed a simple classification system by which to determine a patient's physical status and potential risk for complications. These same criteria have been adapted for use in veterinary medicine (Table 1.1).<sup>1,2</sup> In general, no adjustment to the anesthetic protocol is considered unless a patient is classified as Physical Status 3 or higher. In human medicine, a sixth level has been added to include brain-dead patients whose organs are being removed for donation. The letter *E* is used to denote an emergent case. For example, most cases of gastric dilatation-volvulus would be designated as physical status 4-E.

Clients should be alerted to the possible complications of the procedure to be performed and the relative likelihood of adverse events. Even routine, elective procedures carry risk, and it is wrong not to inform the client. For all patients, general anesthesia poses risk of death, albeit minor in healthy animals. Common risks, such as hemorrhage, incisional dehiscence, and postoperative infection of the surgical wound, should always be discussed, in addition to any complications specific to the procedure

**Table 1.1 Physical status classification system<sup>a</sup>**

Physical status	Patient condition	Examples
1	Normal, healthy patient	Elective ovariohysterectomy; elective orchiectomy
2	Patient with localized disease or mild systemic disease	Fractures; cranial cruciate ligament rupture; skin laceration; skin mass removal ( <i>E: Open fracture</i> )
3	Patient with severe systemic disease	Renal failure; fever; hyperadrenocorticism; dehydration; anemia ( <i>E: Gastrointestinal perforation</i> )
4	Patient with severe systemic disease that is a constant threat to life	Any condition prone to developing systemic inflammatory response; heart failure ( <i>E: Gastric dilatation-volvulus</i> )
5	Moribund patient not expected to live with or without the operation	Systemic inflammatory response that is progressing toward multiple organ dysfunction; trauma with decompensatory shock ( <i>E: Intestinal volvulus</i> )
6	Brain-dead patient whose organs may be removed for donation purposes	Currently no veterinary examples

Use “E” after the appropriate classification to denote an emergency operation

<sup>a</sup>Based on Classification of Physical Status. *ASA Relative Value Guide*. 2009. ([www.asahq.org/clinical/physicalstatus.htm](http://www.asahq.org/clinical/physicalstatus.htm)) of the American Society of Anesthesiologists. A copy of the full text can be obtained from ASA, 520 N. Northwest Highway, Park Ridge, Illinois 60068-2573.

performed. A well-informed client is in a better position to recognize and handle complications than one who is not.

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2. Muir WW, Hubbell JAE, Bednarski RM, Skarda RT. Patient evaluation and preparation. In: Muir WW, Hubbell JAE, Bednarski RM, Skarda RT, eds. *Handbook of Veterinary Anesthesia*, 4th ed. St. Louis, Missouri: Mosby Elsevier, 2007:22.

## ADDITIONAL RESOURCES

Additional information about preoperative patient assessment in small animal surgery can be found in the following textbook chapters:

1. Fossum TW. Preoperative and intraoperative care of the surgical patient. In: Fossum TW, ed. *Small Animal Surgery*, 3rd ed. St. Louis, Missouri: Mosby Elsevier, 2007:22–31.
2. Shmon C. Assessment and preparation of the surgical patient and operating team. In: Slatter D, ed. *Textbook of Small Animal Surgery*, 3rd ed. Philadelphia, Pennsylvania: Saunders, 2003:162–168.
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## Chapter 2

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# BASIC SMALL ANIMAL ANESTHESIA

*John R. Dodam and Fred Anthony Mann*

A single chapter cannot provide a comprehensive review of small animal anesthesia. Instead, this chapter will attempt to provide a procedural framework that can be expanded and modified to fit the needs and goals of the surgeon and anesthetist. The procedural framework will be based upon an anesthetic protocol that includes preoperative assessment of the patient; premedication with sedative, analgesic, and/or anticholinergic agents; induction of unconsciousness by intravenous injection of a hypnotic, sedative, or dissociative agent; maintenance of anesthesia with an inhalant anesthetic; and recovery of the patient.

### DRUGS USED IN SMALL ANIMAL ANESTHESIA

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The following is a summary of the classes of drugs used for premedication, induction, or maintenance of anesthesia. Please consult an appropriate resource for more detailed information concerning any of the listed agents, spe-

cific drug combinations, or for appropriate dosing recommendations.

Drugs used in anesthesia premedication are usually given by intramuscular or subcutaneous injection 20–40 minutes prior to the induction of general anesthesia. Premedication of the patient is important from a logistical standpoint because the drugs may sedate or calm the patient, decrease the level of physical restraint required, and facilitate catheter placement. Importantly, anesthesia premedication drugs may improve the quality of anesthetic induction and/or recovery and decrease the requirement for induction or maintenance anesthetics. Premedication drugs may also be used to provide preemptive analgesia. Indeed, the administration of analgesic drugs prior to a surgical insult may improve the effectiveness of postoperative interventions aimed at treating a patient's postoperative pain. Premedication drugs may also be used to modify autonomic tone, stabilize or increase heart rate, or decrease salivary secretions.

### Anticholinergics

Anticholinergic agents like atropine or glycopyrrolate interfere with the action of

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acetylcholine at muscarinic receptors of the autonomic nervous system. Thus, these agents are used to increase heart rate (or prevent bradycardia) and decrease salivary and respiratory secretions. They also increase gastric pH, decrease gastrointestinal motility, and evoke bronchodilation. Although many veterinarians use these agents routinely as part of premedication protocols, others prefer to use them only as needed to treat bradycardia. Both atropine and glycopyrrolate can cause tachycardia and/or ventricular dysrhythmias, but the risk is higher after intravenous injection than intramuscular or subcutaneous administration. Glycopyrrolate has a longer duration of action than atropine and does not cause central nervous system effects. Atropine has a shorter onset time than glycopyrrolate. For these reasons, glycopyrrolate is often preferred as part of an anesthesia premedication protocol, while atropine is preferred for emergency treatment of life-threatening bradycardia.

### Phenothiazines

Acepromazine is a phenothiazine tranquilizer that produces mental calming without providing analgesia. It decreases histamine release, has antidysrhythmic properties, and has been reported to decrease mortality associated with anesthesia. However, acepromazine causes vasodilatation, hypotension, hypothermia, and decreased platelet function, and may decrease seizure threshold. Acepromazine is commonly used with opioids as part of premedication protocols, and because of its long duration of action, premedication with acepromazine may help to smooth postoperative recoveries.

### Benzodiazepines

Benzodiazepine drugs (e.g., diazepam, midazolam, and zolazepam) are tranquilizers frequently paired with dissociative agents (e.g.,

ketamine and tiletamine) to induce anesthesia. Benzodiazepines are not typically given alone for preoperative sedation because they are relatively ineffective unless an animal is depressed, very young, or very old. Paradoxically, benzodiazepines can cause excitement in some animals when given alone. Moreover, diazepam is not absorbed predictably after intramuscular injection. When combined with induction agents, benzodiazepines decrease the required doses of those agents, provide for muscle relaxation, and have minor effects on the cardiovascular system. Benzodiazepines are also frequently used for their anticonvulsant properties. The actions of benzodiazepine drugs are reversible with administration of flumazenil, a specific antagonist.

### Alpha-Two Agonists

Alpha-two agonists (e.g., xylazine and dexmedetomidine) decrease the release of norepinephrine in the central nervous system. This effect causes reliable sedation, analgesia, and muscle relaxation, and greatly decreases the requirements for other anesthetic agents. Alpha-two agonists cause cardiovascular changes that are characterized by bradycardia, biphasic blood pressure changes (hypertension followed by hypotension), and a significant decrease in cardiac output. These drugs also cause hyperglycemia, diuresis, and decreased gastrointestinal motility. Emesis is common when low doses of these drugs are given by the intramuscular or subcutaneous route. Xylazine is shorter-acting than dexmedetomidine and is more likely to be associated with cardiac dysrhythmias. The effects of alpha-two agonists can be reversed by specific antagonists. The effects of xylazine are typically reversed in small animal patients with yohimbine, while dexmedetomidine effects are reversed with atipamezole. Alpha-two agonists are frequently given in combination with opioid drugs to decrease the dose administered and to limit the cardiopulmonary effects of the alpha-two agonists.

Anticholinergic drugs may be given to limit alpha-two agonist-induced bradycardia, although the routine use of glycopyrrolate with dexmedetomidine is somewhat controversial.

## Opioids

Opioids are commonly used for their analgesic activity and anesthetic sparing effects. In general, they cause mild to moderate sedation, but may be associated with excitation in some animals (especially in cats). Excitatory opioid effects are effectively eliminated when the agents are administered concurrently with tranquilizers or sedatives like acepromazine or xylazine. In general, full agonists (e.g., morphine, oxymorphone, hydromorphone, and fentanyl) are considered to be more efficacious than partial agonists or agonist/antagonists (butorphanol, buprenorphine, and nalbuphine). Side effects may also be more likely with the full agonist opioids. Respiratory depression, bradycardia, vomiting, decreased gastrointestinal propulsive motility, and urine retention are all potential side effects. Morphine may also evoke histamine release. Morphine, oxymorphone, and hydromorphone are commonly used as part of premedication protocols. Fentanyl may be given intramuscularly as part of a premedication protocol. However, fentanyl has a very short duration of action (less than an hour) and is frequently administered as a constant rate infusion when more prolonged analgesia is required. Partial agonists and agonist/antagonist drugs are generally used to treat mild to moderate pain. Butorphanol is frequently used to premedicate small animal patients. However, butorphanol's duration of action is short in the dog. Buprenorphine, because of its relatively long duration of action, is frequently used to provide postoperative pain relief in dogs and cats.

The effects of opioids are reversible. Naloxone is the most commonly used full antagonist used in small animal anesthesia today. Nal-

buphine and butorphanol can also be used to reverse the effects of mu agonists (e.g., morphine and hydromorphone). The advantage of using nalbuphine and butorphanol is that, unlike naloxone, they will provide mild to moderate analgesia through their agonistic effects at the opioid kappa receptor.

Tramadol is an atypical opioid that is currently available in an oral formulation. Tramadol has effects on the opioid mu receptor and also works through other pathways in the central nervous system. Because an injectable formulation is not currently available in the United States, tramadol's use in the preoperative period is limited.

## Nonsteroidal Anti-inflammatory Drugs (NSAIDs)

Nonsteroidal anti-inflammatory drugs decrease pain and inflammation by interfering with the production of prostaglandins and, in a few cases, leukotrienes. Newer agents like carprofen, deracoxib, meloxicam, and tepoxalin are markedly less toxic than older NSAIDs like aspirin, indomethacin, and phenylbutazone. Renal failure and gastrointestinal ulceration are the most significant toxic effects of NSAIDs, and anesthesia-induced hypotension can contribute to NSAID toxicity. Some NSAIDs also inhibit platelet function. Because of these potential side effects, and because NSAIDs do not alter anesthetic requirements, many veterinarians confine the use of NSAIDs to the postoperative period.

## Dissociative Agents

Dissociative drugs like ketamine and tiletamine are N-methyl-D-aspartate receptor antagonists that may be administered intravenously or intramuscularly as part of premedication protocols or for the induction of anesthesia. Dissociative agents are not well suited to be given



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