Chapter 1

Anesthetic process

Yishai Kushnir and Carolyn M. McKune

Anesthesia is the technical process of causing a temporary loss of consciousness, most commonly in order to facilitate a medical or surgical procedure. Anesthesia aims to achieve loss of consciousness, inhibition of reflexes, muscle relaxation, amnesia, and analgesia. However, it also depresses homeostatic processes, which leads to morbidity and mortality. The role of the anesthetist is to maintain adequate anesthetic depth, in order to perform the intended procedure, while supporting normal physiologic function. However, there is now universal acceptance that "'anesthesia' is not limited to the period when the patient is unconscious but is a continuum of care that begins before the patient leaves home and ends when the patient is returned home with appropriate physiologic function and absent or minimal pain levels" [1]. This more holistic approach to anesthetic care begins with understanding the anesthetic process and the role of the anesthetist in achieving these goals.

I. Preanesthetic workup

"By failing to prepare, you are preparing to fail"

(Benjamin Franklin)

Evaluating, stabilizing and preparing the patient for anesthesia is a vital first step to provide safe anesthesia. This includes a thorough patient workup, with a focus on the patient's history, physical examination, and necessary diagnostic tests, as well as assessing and treating abnormal findings. This is also a suitable time to determine whether sedation alone may be sufficient to meet the needs of the patient. Procedures of a short duration (30–60 min), that are minimally invasive and/or patients with compromised health may benefit from sedation as opposed to general anesthesia. However, it is advisable for the anesthetist to be prepared to convert from sedation to general anesthesia if necessary. It is equally as important in sedated patients that they are monitored and supported (e.g., supplemental oxygenation, fluid therapy, etc.) as well as they would be if general anesthesia were elected.

The veterinary profession as a whole is now recognizing the importance of asking critical questions about whether or not the veterinary team is in a position to safely anesthetize the

Small Animal Anesthesia Techniques, Second Edition. Edited by Amanda M. Shelby and Carolyn M. McKune.

Companion website: www.wiley.com/go/shelby/anesthesia2

patient. For example, the time of day for the procedure or experience level of the staff may alter the safety of the anesthesia. Please see Chapter 3 for more information.

A. Patient workup

1. History

As for any veterinary procedure, a thorough history is taken prior to anesthesia. This consists of identifying the chief complaint and obtaining the signalment, current and chronic medical history, allergies or known sensitivities, and drugs and supplements administered. Information obtained from the history will influence the choice of analgesics, fluid therapy, anesthetic drugs, support, and the monitoring parameters.

Breed-specific sensitivity to anesthesia is rarely reported. Greyhounds demonstrate prolonged and exaggerated responses to several anesthetic drugs, such as barbiturates [2, 3]. However, for most other breeds, sensitivities are associated with comorbidities common for the breed. These may include upper respiratory (brachycephalic or toy breeds), cardiac (Cavalier King Charles spaniels, Dobermans, Maine Coon), coagulopathies (Doberman), A1B1 mutation (Collies), for example. Physiologic function varies from normal in neonatal and geriatric patients, and is further disrupted by anesthesia, and extreme age has been associated with increased perianesthetic morbidity [4, 5]. This is explored further as its own topic (see Chapter 5).

Sex differences in response to pain and analgesia have been demonstrated in humans and laboratory animals [6]. Although the importance of these findings in companion animals has not been studied, sex and neutering status may also affect the perianesthetic period.

A thorough history of drugs and supplements (including nutraceuticals) administered to the patient must be taken, so the anesthetist may advise on drugs to be avoided or included perianesthetically. Drugs for administration prior to anesthesia include medications such as pimobendan, furosemide, maropitant, thyroid supplementation, steroids, and gabapentin. Patients requiring sedation should definitely receive it prior to presentation. Conversely, other medications, such as antihypertensive medication, aspirin or other anticoagulants, and drugs that increase the risk of serotonin syndrome (trazadone or selegiline), may be withheld, at the practitioner's discretion.

A preanesthetic history also includes questions regarding previous anesthesia episodes. Problems observed in previous anesthesia may be avoided or reduced in impact by changing the anesthetic protocol or increasing awareness of complications.

Fasting suggestions have gradually changed over time. The American Animal Hospital Association has created guidelines for appropriate fasting depending on the particular patient. Recommended fasting periods in cats and dogs vary from 4–6 to 6–12 hours prior to elective anesthesia. Fundamentally, most of the concern regarding appropriate fasting is due to the potential for reflux or regurgitation, which may lead to esophagitis, esophageal stricture or aspiration pneumonia. It is advised that whatever fasting standards a practitioner uses are predictable and consistent, so it is easy for staff to ensure that these guidelines are followed. One guideline most anesthesiologists agree on is that shorter fasting times, up to 2 hours, are recommended for cats and dogs under 8 weeks old or weighing less than 2 kg (see Chapter 5 for anesthetic management of neonates, p.185). Drinking water should be available until

premedication [1]. Fasting in diabetic animals should be tailored specifically to the patient, the type and duration of procedure, and clinic practices (such as the time of day, with most anesthesiologists advising taking diabetic patients for anesthesia early in the day, so they may recover by the time of their evening meal). AAHA guidelines suggest one option: a soft food/paté type meal 2–4 hours prior to the procedure, administering half of the dose of insulin and trying to schedule the case for the first thing in the morning [1]. Anesthesia of diabetic patients is further discussed in Chapter 5.

2. Physical examination

A complete physical exam is performed by the primary clinician, prior to anesthesia. The anesthetist must perform a physical exam emphasizing, but not limited to, the aspects of the exam that are important for anesthesia.

The exam begins with general observation. The patient's level of consciousness and temperament are assessed, as these will influence choice of premedication. Abnormal gait, posture, abdominal distention, and skin conditions that may indicate systemic or regional disease may require evaluation prior to anesthesia. The rate and pattern of breathing are assessed to recognize respiratory pathologies. The anesthetist is also aware of behavioral signs of pain as these may influence perioperative pain management.

Obtaining a baseline pain assessment in an animal prior to an anesthetic procedure will help guide the anesthetic plan as well as familiarize the anesthetist with the patient's demeanor, which plays a major role postoperatively in evaluating the results of therapeutic interventions for pain management.

Pain is defined as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" [7]. Thus, a complex variety of experiences can result in pain, and the first step to successful treatment is to effectively assess the animal. Several tools may aid the anesthetist in assessing pain; see Appendix A. Different pain assessment tools are used for acute or chronic pain and vary in their complexity of use and flexibility. Simpler pain scales are often less flexible and may not fit your patient's specific behavior. A list of tools available online for acute pain evaluation is provided in the companion website provided with this book, and pain assessment is further discussed in the appendices.

Parameters monitored during anesthesia are evaluated prior to premedication to provide baseline measurements, for the same reason pain scores are assigned prior to premedication. These anesthesia parameters include eye position and palpebral reflexes; an oral examination to rule out loose teeth or masses which may impede intubation; mucous membranes and capillary refill time; palpation of the neck for abnormalities, and to assess tracheal size; skin tenting; chest auscultation; abdominal palpation; palpation of peripheral pulses for pulse rate, rhythm, and strength; body temperature; body weight and body condition score (BCS). Abnormal findings in the evaluation stage are addressed and treated prior to anesthesia, to the best of our ability. Findings that may indicate a disease process such as a heart murmur, azotemia, or elevated liver enzymes are investigated in order to determine the nature and severity of the disease. Dehydration and hypovolemia should be corrected with adequate fluid therapy. Further diagnosis and treatment may lead to postponing elective procedures, based on the perceived increased risk for the patient, the procedure and other case-specific factors. For

emergency cases, the time necessary for further investigation and therapy with its associated potential benefit is weighed against the harm caused by postponing the procedure.

3. Diagnostics

The minimal blood tests required prior to elective anesthesia include a packed cell volume (PCV), total solids (TS), blood glucose and renal status (i.e., Azo-Stick®, creatinine, or SDMA) taken within 24 hours. Prior to major operations, in patients with ASA ≥III, patients with previous blood work abnormalities, and geriatric patients, a complete blood count (CBC) and chemistry with electrolytes are performed within a relevant time period (approximately 2–4 weeks is usually acceptable if no change occurred in the patient's condition). Further diagnostic tests, e.g., coagulation tests or blood gases, are performed if necessary, based on the patient or the planned procedure. Animals with low albumin (<2 g/dL), acute anemia (PCV <20%) or hyperkalemia (K+ >6.0 mEq/L) that impair physiologic function are corrected prior to anesthesia induction; see Chapter 3. Reference ranges for blood tests and blood gases are available on the companion website provided with this book.

II. Factors involved in creating an anesthetic plan

When creating an anesthesia plan, the anesthetist anticipates the *potential* problems associated with the event of general anesthesia. These may stem from the patient's species, the specific patient itself, the use of inhalant, and the planned procedure; see Table 1.2. Predicting these problems guides the anesthetist in choosing anesthetic drugs and monitoring devices, and preparing for potential complications. This is also a good time to communicate with the patient's owners about the animal's level of anesthetic risk and additional necessary steps (including working up or treating a newly identified disease process) to improve the safety of anesthesia for the patient.

The protocol itself includes emergency drug calculations, premedication, induction and maintenance drugs, monitoring, medication and techniques for support (fluid therapy, antinausea medication, warming, etc.), and perioperative pain management. It is generally advantageous for anesthesia drugs to be given intravenously when possible, as this assures optimal bioavailability of the drug.

All the elements for anesthesia are prepared prior to induction, when possible. This includes an anesthetic record sheet (and if this record is electronic, a hard copy of this sheet in case the computer system fails) to record all events during anesthesia. Various designs of anesthesia records are available, and they may be electronic or recorded on paper; see this chapter's online supplementary material for hyperlinks to anesthesia record templates, and Table 1.1 for hard text. The anesthesia machine and equipment should undergo a routine check prior to use (see Chapter 2), in order to detect malfunctions. Using a documented standard operating procedure, or a shortened anesthesia machine checklist with only the necessary points, ensures that all the necessary elements are checked. An example of an anesthesia machine checklist is available in the companion website provided with this book. Missing or malfunctioning elements are repaired or replaced; inability to resolve equipment issues may result in cancelation of the procedure.

Table 1.1 Resources for anesthesia record templates.

Anesthesia record provider	Website
American Animal Hospital Association (fee payable)	https://ams.aaha.org/eweb/DynamicPage.aspx?site=store&Action=Add&ObjectKeyFrom=1A83491A-9853-4C87-86A4-F7D95601C2E2&WebCode=ProdDetailAdd&DoNotSave=yes&ParentObject=CentralizedOrderEntry&ParentDataObject=Invoice%20Detail&ivd_formkey=69202792-63d7-4ba2-bf4e-a0da41270555&ivd_cst_key=&ivd_cst_ship_key=&ivd_prc_prd_key=0f20d049-90cc-44af-87dc-39a77417c7c9
Association of Veterinary Anaesthetists (High ASA score)	https://ava.eu.com/wp-content/uploads/2015/11/AVA-ASA-Hi-Electronic.pdf
Association of Veterinary Anaesthetists (Low ASA score)	https://ava.eu.com/wp-content/uploads/2017/10/AVA-ASA-Low-Electronic-UK.pdf
Jurox	http://thinkanesthesia.education/sites/default/files/2019-05/US%20-%20Multidose-MonitoringChart%20V2.05%20-%20WEB_0.pdf

A. Patient species problem list

Different species have different anesthetic risks (Table 1.2). For example, cats are more sensitive to errors in fluid therapy, tracheal trauma, and laryngospasm [8]. Rabbits are difficult to intubate and gain intravenous access to, and are prone to laryngospasm and gastrointestinal complications. Understandably, rabbits are also at high risk of anesthetic death compared to dogs and cats [9].

B. Specific patient problem list

Signalment, chronic and acute conditions, abnormal diagnostic findings, and concurrent medications influence the response to anesthesia, and anesthesia may adversely affect underlying conditions.

C. Inhaled anesthesia and drug-induced problem list

Inhalants will result in hypotension, hypothermia, and hypoventilation for every patient anesthetized; bradycardia in most species is often secondary to the essential administration of opioids.

D. Procedure-driven problem list

Breaking down the procedure into its basic steps will help to assess the adverse events associated with the procedure itself, positioning, or ancillary procedures, and allow adequate preparation.

Table 1.2 Theoretical anesthesia problem list examples.

Problem list group	Example 1: A geriatric cat for a dental prophylaxis	Example 2: A 6-month-old bulldog for an ovariohysterectomy
Species	Hyperthyroidism, cardiac disease, renal failure, laryngospasm, tracheal tear from intubation, fluid sensitivity, relative increase in mortality secondary to anesthesia as compared to canine patients	Brachycephalic airway concerns (hypoplastic trachea, elongated soft palate, prolong extubation, pre-oxygenate, regurtitation)
Specific patient	Geriatric	Brachycephalic airway syndrome (stenotic nares, elongated soft palate, everted laryngeal saccules, hypoplastic trachea), high resting vagal tone (author's experience), prolonged recovery
Inhaled anesthesia and drug induced	Hypotension, hypoventilation, hypothermia, bradycardia	Hypotension, hypoventilation, hypothermia, bradycardia
Procedure	Prolonged if extensive dental disease is present, patient will cool rapidly, aspiration of exogenous fluids used to lavage mouth, may require airway packing, pain/noxious stimuli if dental extractions. Gag associated post anesthetic blindness	Noxious stimuli/pain, hemorrhage fluid and heat loss
Total problems anesthetist prepares for	17	9

Protocols for invasive procedures are always multimodal in nature; that is, there should be a diverse range of methods for addressing pain and noxious stimuli (see Chapter 3 for additional information on differentiation of the two). Adequate pain prevention and management is not only ethically important for animals in both the short and long term, but will also facilitate a decrease in drugs required to maintain the patient under anesthesia, and therefore reduce negative side-effects associated with these drugs (such as hypotension and hypoventilation) or the negative side-effects associated with noxious stimuli under anesthesia (such as the patient becoming abruptly light, hypertensive, and tachypnea). The drug formulary (Section II) provides a dedicated review of a multimodal analgesic plan.

E. Anesthetic morbidity and mortality

The anesthetist incorporates information from the comprehensive anesthesia problem list to assess the patient's anesthetic risk. The American Society of Anesthesiologists (ASA) physical status is a risk score based on the patient's perceived health (Table 1.3). This methodology allows anesthetic risk to be stratified, with patients in ASA 1–2 being considered at less anesthetic risk than patients who are assigned an ASA 3–5. Higher ASA scores are

Table 1.3 American Society of Anesthesiologists (ASA) Physical Status Classification.

ASA physical status	Description
1	A normal healthy patient
2	A patient with mild systemic disease which is not a threat to life
3	A patient with severe systemic disease which is not a threat to life
4	A patient with severe systemic disease that is a constant threat to life
5	A moribund patient who is not expected to survive without the operation
E (added to score)	Emergency surgery: defined as existing when delay in treatment of the patient would lead to a significant increase in the threat to life or body part

associated with longer intensive care hospitalization and increased risk for hypothermia, acute kidney injury (AKI), and mortality [10, 11]. Indeed, stabilization to reduce the assigned ASA category in ASA 3–5 patients demonstrated a reduction in anesthetic-related morbidity and mortality [12]. Please see Anesthetic morbidity and mortality in Chapter 3 for more information.

One of the most remarkable differences between human and domestic animal anesthesia is the perianesthetic mortality rate, with human anesthesia being up to 100-fold less risky than that of our veterinary patients [13]. When evaluating a morbidity and mortality study, it is imperative to ensure that the study has significant case enrollment, as subtle details are often difficult to discern, even when several thousand patients are enrolled. To date, the largest study involved almost 98 000 dogs and approximately 78 000 cats [4, 8, 9, 14, 15]. This study, performed by Brodbelt and colleagues, is arguably the largest study performed in veterinary medicine and strongly powered. The overall risk of mortality under anesthesia is 0.17% in canine patients and when stratified for ASA 1–2 (healthy) canines is about 0.05%. For those who prefer these numbers in a user-friendly fashion, 1 in 2000 dogs (classified as healthy) have an anesthetic-related mortality. In cats, overall sedation- and general anesthetic-related mortality is 0.24%; again, when one includes only healthy ASA 1–2 cats, the mortality rate is 0.11%, which translates into 1 in 900 "healthy" cats dying as a result of anesthesia. Mortality in other pet species including rabbits (1.4–4.8%) [16], guinea pigs (3.8%) and avian species (up to 16%) [17] is even higher [9].

Mortality rates are decreasing over the years in healthy patients, and newer studies demonstrate lower rates. This may be due to advances in knowledge, training, equipment safety, and monitoring [9,18,19]. In a recent study investigating healthy animals undergoing anesthesia for neutering, fewer than 1/10 000 dogs and 1/2000 cats died [18].

New work on the horizon by Redondo and colleagues is not as reassuring. Initial abstracts released at the World Congress of Veterinary Anesthesia in 2018 incorporated data from multiple countries all over the world, enrolling just over 10 000 dogs. Overall mortality rate in the canine was a shocking 0.76%, with the bulk of mortality occurring in patients with an ASA score of 3 or greater (ASA 1 0.18%, ASA 2 0.30%, ASA 3 1.11%, ASA 4–5 13.05%) [20]. Likewise, Redondo presented data on feline mortality rate of 0.74%, again with the bulk of

mortality in patients with an ASA score of 3 or greater (ASA 1 0.14%, ASA 2 0.00%, ASA 3 3.32%, ASA 4–5 7.05%) [21]. In summary, things have improved for young and healthy animals consistently over the years, but clearly, veterinary medicine has a significant way to go to rival our human colleagues for all animals.

Increasing ASA status is associated with risk of death in every species examined. In dogs, cats, and rabbits, an ASA score ≥3 is associated with a 3.3-fold, 4.8-fold, and 11.3-fold increase in risk of death compared to ASA score <3 [10]. Mortality is higher in emergency procedures and in procedures performed after hours [4, 10]. Mortality is also affected by procedure type, and may be as high as 5–7% for thoracic or cervical spinal surgery [22, 23].

Death is not the only possible negative outcome; many other complications that occur perioperatively may lead to increased morbidity, prolonged hospitalization, and suffering. These include hypothermia, nausea, pain, hypotension, AKI, pneumonia, and others. A common misconception is that the improved morbidity and mortality rates in human anesthesia reflect a greater infusion of financial dollars into the personnel, drugs, and equipment used for human anesthesia. However, evidence-based literature reinforces that simple things, such as the use of checklists, documenting that these checklists were performed, and performing surgeries within normal hours of operation (when possible) [24], will reduce anesthetic mortality [9, 25]. Morbidity and mortality may also be decreased by continuous monitoring of heart rate and oxygen saturation (SpO_2), and by the presence of a dedicated veterinary technician during anesthesia [8, 19]. These are simple strategies that every veterinarian can use.

F. Anesthesia checklist

Modern anesthesia is a complex process, involving numerous drugs, equipment, and personnel. Errors may arise from any of these parts or their interactions. Using a checklist is a simple way for the anesthetist to assure that all parts in this complex endeavor are in place. A checklist is a tool that aids the anesthetist to simplify work in a complex environment and improves patient safety. Using a checklist leads to a 60% or higher decrease in peri- and postoperative complications, and wound infections [25, 26].

The checklist is simple to use and minimally time consuming but must incorporate the potential failure points (Figure 1.1); this differentiates the checklist from its close relative, the standard operating procedure (SOP). An SOP is intended to be thorough so no detail is overlooked, whereas a checklist is meant to be quick and cover only the commonly overlooked points. An excellent baseline for an initial checklist is the World Health Organization's Surgical Safety Checklist (www.who.int/patientsafety/safesurgery/checklist/en/). This checklist is then modified and tailored, after use, to each hospital's specific needs.

A separate checklist, or SOP if preferred, can be designed for preanesthetic testing of anesthesia equipment and monitors, which should be turned on, evaluated and determined to be functional prior to induction. Please see Chapter 2 on essential equipment and necessary safety checks, as well as the critical role trained staff play in anesthesia safety. Other useful visual aids in the clinic are a table of emergency drug doses and volumes (see Appendix B) and a table of constant rate infusion doses and rates. Please refer to the companion website for printable tables with this information.

Surgical safety checklist

Sign in (before induction of anesthesia)

- ☐ Confirm identity of the animal and presence of the correct medical file
- ☐ Confirm procedure, brief plan and surgery site Confirm that required pre-operative imaging has been performed and is available in the OR
- ☐ Check completeness of anesthesia machine, monitoring equipment, and drugs
- ☐ Any special anesthetic concerns yes/no
- ☐ Preoperative blood work has been viewed and abnormalities have been addressed
- ☐ Preoperative analgesia, antimicrobial
- ☐ Risk of bleeding yes/no blood or blood donor available yes/no
- ☐ Confirm that required equipment in the surgery room is working (suction, cautery, battery for drill) Confirm that if required diagnostic imaging is set up in the surgery suite
- ☐ Confirm that informed owner consent to the procedure, post-op therapy and cost has been received

Time out (before surgery is initiated)

- ☐ All team members, name and role
- ☐ Confirm procedure and place and side (R/L, fore/rear) of incision, name all the procedures to be performed under this anesthesia
- ☐ The surgeon: Critical part of the procedure and estimated time
- ☐ Confirm sterility of the equipment and sterile scrub in the correct location
- ☐ Confirm that all required instruments are available
- ☐ OR tech state any equipment concerns / missing equipment in sets
- ☐ Confirm appropriate anesthetic depth, and state if there are any anesthetic concerns

Sign out (before recovery, at the end of the surgical procedure)

- ☐ Is the correct procedure performed and are all planned events performed
- ☐ Are all samples labelled and has one responsible person for submission
- ☐ Any issues regarding the anesthesia/monitoring or surgical instruments
- ☐ Any abnormalities that should be addressed for the recovery.
- ☐ Read out blood gas prior to moving to recovery.
- ☐ State the recovery sedation and analgesia plan.
- ☐ Confirm that the recovery room is prepared.
- ☐ Confirm that bladder has been voided, that bandages are placed where necessary, and that unnecessary catheters / tubes/ tourniquets have been removed.

Figure 1.1 Surgical safety checklist example.

III. Patient preparation

Common-sense preparation begins at home, with appropriate fasting for the patient prior to anesthesia, as well as ensuring any necessary drugs such as pimobendan or thyroxine (drugs which do not have an injectable equivalent) are administered; please see the section entitled

"History" in this chapter for more details (p.4). Other important drugs may include anxiolytic drugs, such as trazadone and gabapentin, which help with reduced stress for the patient and easier handling for the staff. The administration (or withholding) of these drugs is shared with the anesthetist, and can be conveyed either verbally by the owner or via completion of a patient dropoff form with short, pertinent questions such as this. At the time of dropoff, an accurate weight is obtained on the day of surgical procedure, and drug dosages are based on the animal's lean body weight [1].

IV. Premedication

The aims of premedication are to decrease stress, provide preemptive analgesia, decrease the dose of anesthetic drugs, and improve the quality of anesthesia and recovery. Traditionally, premedication drugs are administered by the hospital staff in close proximity to anesthesia. However, at least some of these drugs may be administered orally at home by the owner before arrival to the hospital. Premedication is usually administered intramuscularly (IM) or intravenously (IV) if a catheter is present. The epaxial muscles near the lumbar spine are commonly used for IM injection but other extensor muscles (such as the quadriceps, the dorsal muscles of the neck or supraspinatus muscle above the shoulder) are alternative sites. A list of drugs commonly used for premedication is provided in Table 1.4 and further discussed in the drug formulary (Section II). When selecting premedications, one must take into account the goals for both the patient (such as additional analgesia) and the veterinary staff (such as reversibility or desired level of patient hand ability).

During the premedication phase, an IV catheter is placed (if not already in place), ideally after peak sedation is achieved. The IV catheter is located where it will be easily accessible during the procedure. For example, for procedures involving the head, the catheter is ideally placed in a hindlimb and for abdominal procedures, in the forelimb. Other patient monitoring and support is initiated during this phase as well. In order to decrease hypoxemia and desaturation during induction and intubation, the patient is preoxygenated (Figure 1.2) for 3–5 minutes with a mask connected to a source of 100% oxygen prior to induction [27]. Thermal support is often warranted in the premedicated patient, as many drugs used for premedication also result in central thermal dysregulation.

To achieve the most benefit out of a premedication, certain nonpharmacologic options are considered. This includes things like separate areas for dogs and cats post premedication, the use of a quiet, dark room with minimal stimulation for patients receiving dexmedetomidine, and pheromones in holding areas. These interventions often reduce patient stress, allowing for a greater premedication effect.

V. Induction

During induction, the patient transitions from a state of consciousness to unconsciousness. General anesthesia is composed of several stages that appear in sequence (Tables 1.5 and 1.6). During the initial stages, the patient may exhibit increased motion, muscle rigidity, and

Table 1.4 Commonly used premedication drugs in cats and dogs; see the drug formulary for details of dosage, route, and effects.

Drug	Benefits	Disadvantages
Acepromazine	Antiemetic Antihistamine High margin of safety	Vasodilation Hypotension No reversal Not antianxiety [30]
Alfaxalone	Useful for fractious animals Minimal cardiovascular effects Off-label use: IM administration	Large volume Shivering/twitching and muscle rigidity on recovery
Buprenorphine	Minimal cardiovascular effects Analgesia Reversible Available in a variety of concentrations for varying durations of effect	Mild reduction in inhalant requirements in dogs (minimal in cats) Outcompetes other opioids for the same receptor
Butorphanol	Minimal cardiovascular effects Analgesia Reversible	Antagonizes mu agonist opioids Short-acting in canines
Dexmedetomidine	Reversible Synergistic with opioids Can be used as an oral gel at home 1 h prior to visit as an anxiolytic	Decreased cardiac output due to bradycardia Emesis
Diazepam	Muscle relaxation Minimal cardiopulmonary effects Reversible	Unreliable in healthy patients as it may cause excitement Although labeled for IM, this is discouraged
Gabapentin	Analgesia Can be given orally at home as an anxiolytic 1–2 h prior to visit Often used in combination with melatonin and trazadone for patients who are difficult to handle due to fear or anxiety	Too much drug can result in profound sedation and obtundation, with hypothermia and possible state of shock Not reversible
Hydromorphone	Minimal cardiovascular effects Analgesia Reversible	High incidence (almost 40%) of postoperative hyperthermia in cats May cause vomiting
Ketamine	Useful for fractious animals Increases sympathetic tone	Muscle rigidity Pain on injection Dysphoric recoveries especially in cats
Melatonin	Promotes sleep Can be given orally at home as an anxiolytic 1–2 h prior to visit Often used in combination with gabapentin and trazadone for patients who are difficult to handle due to fear or anxiety	May not provide appreciable sedation when used alone

(Continued)

Table 1.4 (*Continued*)

Drug	Benefits	Disadvantages
Meperidine	No vomiting Minimal cardiovascular effects Analgesia Reversible	Unreliable in cats Short-acting Histamine release
Methadone	No vomiting Minimal cardiovascular effects Analgesia Reversible	Bradycardia
Midazolam	Muscle relaxation Minimal cardiopulmonary effects Reversible	Unreliable in healthy patients as it may cause excitement
Morphine	Minimal cardiovascular effects Analgesia Reversible	Vomiting Histamine release
Trazadone	Used to promote sleep in people, and for cage rest in animals Can be given orally at home as an anxiolytic 1–2 h prior to visit Often used in combination with gabapentin and melatonin for patients who are difficult to handle due to fear or anxiety	No analgesia Not reversible

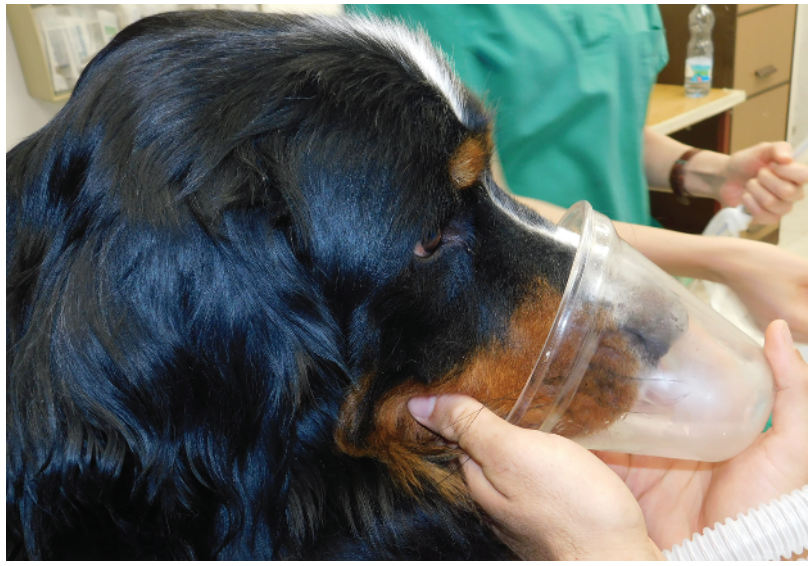

Figure 1.2 Preoxygenation (canine).

Table 1.5 Guedel's stages of anesthesia.

Stage	Name	Description
I	Analgesia or disorientation	Amnesia and decreased sensitivity to pain, still conscious
II	Excitement or delirium	Loss of consciousness, irregular breathing, may struggle or vomit
III	Surgical anesthesia[a]	Loss of motion, decreased response to stimulus and reflex activity
IV	Medullary paralysis or coma	Respiratory arrest, vasomotor collapse, lack of reflexes

[a]Divided into planes (see Table 1.6).

Table 1.6 Planes within stage III of anesthesia (surgical anesthesia).

Plane	Name	Eye position	Palpebral reflex	Jaw muscle tone	Cough and swallow
I	Light	Central to rotated	Present	Strong	May be present
II	Moderate	Rotated ventromedial	Relaxed to absent	Relaxed	Absent
III	Deep	Rotated to central	Reduced to absent	Relaxed	Absent
IV	Very deep	Central	Absent	Flaccid	Absent

delirium. Modern anesthetics induce rapid anesthesia that shortens these stages and decreases excitement.

Preoxygenation is standard of care. Effectively preoxygenating a patient for 3–5 minutes prior to induction allows the anesthetist 3–5 minutes of increased oxygen in the blood (PaO_2) [27], which is critical for patients with any type of respiratory compromise, including but not limited to brachycephalic airway syndrome, pregnancy, lower airway disease or thoracic trauma. In the case of pregnant animals, the fetus as well as the mother benefits from this increased oxygenation. The authors emphasize *effective* oxygen delivery; oxygen delivered by a well-fitting mask provides more effective oxygenation than attempting flow-by oxygen delivery via the end of the anesthetic circuit (i.e., circle or nonrebreathing hose), which does not provide a high concentration of oxygen. Sedating a patient either during the premedication phase or with an initial quarter dose of induction drug increases an animal's tolerance to an oxygen facemask.

Induction is typically achieved with injectable drugs administered IV (Table 1.7). The drug formulary reviews induction drugs in greater depth. Although anesthesia may be induced with an inhalant, this is a longer process (during which the patient has an unsecure airway), often involves a state of excitement and disinhibition, and is associated with a six-fold increase in mortality [4]. Furthermore, inhalant inductions increase the exposure of staff to inhalant anesthetics that are considered a work hazard by the United States Department of Labor, which has strict regulations on work practices surrounding waste anesthetic gases. An IM induction with

Table 1.7 Commonly used induction drugs in cats and dogs; see the drug formulary for details such as route and dosage.

Drug	Advantages	Disadvantages
Alfaxalone	Minimal cardiovascular depression, smooth induction, can be given IM (off-label)	Apnea and oxygen desaturation; preoxygenate, myoclonus and poor recoveries for short procedures
Etomidate	Minimal cardiovascular and respiratory depression	If not well premedicated may display vomiting, salivation, and strong laryngeal tone; adrenocortical suppression
Fentanyl + midazolam/diazepam	Minimal cardiovascular effects, large therapeutic index	May cause dysphoria in healthy patients. Not a reliable induction technique in cats
Ketamine	Short-acting, minimal respiratory depression, increases HR and BP, antihyperalgesia, analgesic properties, high therapeutic index, can be given IM	Muscle rigidity when used alone (tip: administer with benzodiazepine or an alpha-2-agonist), does not depress cough and swallow reflex, poor recoveries in cats
Propofol	Fast onset, short-acting, excellent recoveries, smooth induction	Apnea, oxygen desaturation (tip: preoxygenate), vasodilation, relatively narrow therapeutic index
Thiopental[a]	Decreases intracranial and intraocular pressure, minimal effect on laryngeal motion, smooth induction	May cause sloughing if injected subcutaneously, vasodilation and arrhythmias, respiratory depression
Tiletamine/zolazepam (Zoletil®, Virbac; Telazol®, Zoetis)	Fast onset, increases HR and BP, antihyperalgesia, longer lasting than ketamine, small volume, can be given IM, effective immobilization in fractious patients	Burns on injection when administered IM, poor recoveries, seizures at high doses, requires reconstitution, has limited shelf-life after reconstitution
Isoflurane	No IV access required, minimal contact with fractious animals with chamber induction	Dose-dependent cardiovascular and respiratory depression, prolonged excitement phase, may irritate respiratory tract, increases environmental and personnel exposure, increases risk of morbidity and mortality for patients when used alone (i.e., without premedicating)
Sevoflurane	No IV access required, minimal contact with fractious animals with chamber induction, faster and less irritation than isoflurane	Dose-dependent cardiovascular and respiratory depression, prolonged excitement phase, increases environmental and personnel exposure, expensive, increases morbidity and mortality for patients when used alone (i.e., without premedication)

[a]Currently unavailable in USA.

BP, blood pressure; HR, heart rate; IM, intramuscular; IV, intravenous.

combinations that include ketamine or alfaxalone, in addition to opioids and sedatives, is a useful tool in small patients undergoing a short procedure (such as a cat neuter) or in aggressive or fearful animals. As with an inhalant induction, there is no secure airway using this methodology, although a well-fitting facemask can provide oxygen supplementation once the patient is induced. Careful monitoring and observation are necessary for any patient who is induced without a secure airway.

The total induction dose is calculated based on the patient's clinical state, ideal body weight, and response to premedication administered. Geriatric, neonatal, deeply sedated, and sick patients require lower induction doses. Induction agents are titrated to effect, with one-quarter to one-third of the calculated dose administered every 30–60 seconds until patient depth is sufficient for intubation.

The transition from wakefulness to an anesthetized state is not without risk. Of deaths occurring within 48 hours of anesthesia, 1% occur during induction; this number is quite high considering induction lasts less than 0.2% of this period [9].

A. Intubation

Placing an endotracheal tube (ETT) or supraglottic device such as the v-gel® enables administration of oxygen, inhalant anesthetics, emergency and aerosolized drugs, and positive pressure ventilation, and protects the lungs and airways from aspiration.

The largest ETT which comfortably fits the patient's trachea is used, to decrease resistance to respiration and therefore work of breathing. Palpating the trachea allows for an estimate of the ETT, which the anesthetist uses to select two or three tubes which might be suitable. Visualizing the space between the arytenoids after induction allows selection of the most appropriate of those tubes. Other described methods (based on weight, the distance between the nares, etc.) are less reliable. Compared to dogs of a similar size, brachycephalic dogs need smaller ETTs, and sight hounds and dachshunds need larger ETTs. A 3.5–4.5 mm internal diameter (ID) ETT tube fits most cats. The length required is measured externally from the tip of the nose to the thoracic inlet. Longer tubes are shortened (i.e., cut) to decrease airway resistance, dead space, and risk of endobronchial intubation. Ideally, the distal tip of the ETT sits just outside the thoracic inlet, and the connection to the Y-piece is within a couple of centimeters of the mouth. Measuring and cutting the ET tube prior to intubation will save stress for the anesthetist. The steps for endotracheal intubation are described in Table 1.8.

1. Difficult intubation

Patients with upper airway pathology (such as masticatory muscle disease, trauma, or anatomic abnormalities) may be difficult to intubate, due to an obstructed view or path to the larynx. For these cases, the anesthetist prepares the necessary equipment (Figure 1.7) and a plan of action in order to secure the airway (Figure 1.8). The patient should be preoxygenated (under sedation if necessary to tolerate the mask), and SpO_2 monitored. A retrograde intubation may prove useful in these cases; see Table 1.9 for steps and materials for a retrograde intubation. If at any stage there is a threat to the patient's life, a tracheostomy tube is placed, and the discontinuation of anesthesia is considered.

Table 1.8 Intubation.

Materials: Laryngoscope, 3 ETTs, lubricant, tie to secure ETT, 4 × 4 gauze square to hold the tongue, stylet and lidocaine (cats)

Techniques:

1. Induction agent is appropriately administered until jaw and tongue are lax.
2. The patient is placed in sternal recumbency, although large dogs can be placed in lateral recumbency. The assistant opens the mouth of the patient by placing one hand over the snout, holding behind the maxillary canine teeth and extending the tongue between the mandibular canine teeth with the other hand. Extension of the head and neck helps the anesthetist visualize the larynx (see Figures 1.3, 1.4).
3. The anesthetist places the laryngoscope blade on the base of the tongue under the epiglottis. Placing the tip of the blade on the epiglottis may damage this sensitive tissue, and may contribute to airway obstruction at extubation. Applying pressure on the base of the tongue will help displace the epiglottis and allow visualization and brief examination of the larynx (see Figure 1.5).
4. Lubricate the ETT at the distal end with lubricant. In cats, a drop of lidocaine is placed on each arytenoid to minimize laryngeal spasm. Wait 60 seconds for this to take effect.
5. Once the anesthetist visualizes the larynx, the ETT is advanced between the arytenoids.
   (a) In dogs, when resistance is encountered, a slight twist of the ETT helps facilitate advancement. In brachycephalic patients, an elongated soft palate often obstructs visualization of the arytenoids. The tip of the ETT is used to displace the soft palate.
   (b) For cats, position the end of the ETT over the arytenoids, *be patient*, and wait for the patient to take a breath. At inspiration, the arytenoids will open slightly. With a gentle, determined motion, insert the ETT between the arytenoids. Slight rotation may help facilitate intubation if resistance is encountered. However, feline laryngeal tissue is easily damaged and therefore, applying any force during intubation is highly discouraged.
6. Once the patient is intubated, the anesthetist visually confirms proper intubation and the ETT is tied over the muzzle or behind the ears.
7. The ETT is then attached to the breathing circuit with an appropriate flow rate of 100% oxygen. The ETT cuff is inflated to 20–25 cmH_2O, or by performing a leak test: while the anesthetist attempts to "hold" a 20–25 cmH_2O breath, the cuff is inflated until there is no leak. Higher pressures may lead to tracheal necrosis and rupture, especially in cats. A cuff inflation syringe (see Figure 1.6) helps with objectively knowing how much air was used to inflate the cuff.
8. Once the cuff is sealed, inhalant anesthetics are initiated.

VI. Anesthetic maintenance

Once intubation is complete, anesthetic monitoring equipment is appropriately placed (see Chapter 2), eyes are lubricated, and the patient is supported with intermittent manual ventilation. A common misconception in veterinary anesthesia is that the patient is allowed to initiate breathing on their own after induction, and so it is best not to breathe for the patient. This scenario often leads to a patient getting acutely light, in that the inhalant is not being effectively taken up (due to the hypoventilation brought on by the injectable induction agent), and yet the effects of the injectable agent are fading as the drug is redistributed or metabolized. Thus, it is the recommendation of the authors to supplement ventilation immediately post induction, until the patient begins ventilating on their own. Oxygen support is provided to the patient at all times, regardless of maintenance anesthesia choice.

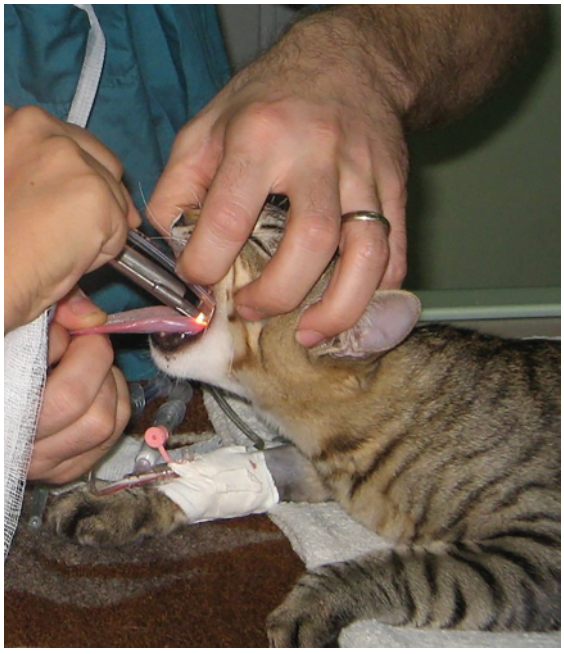

Figure 1.3 Sternal positioning for intubation (feline).

Figure 1.4 Lateral positioning for intubation (canine).

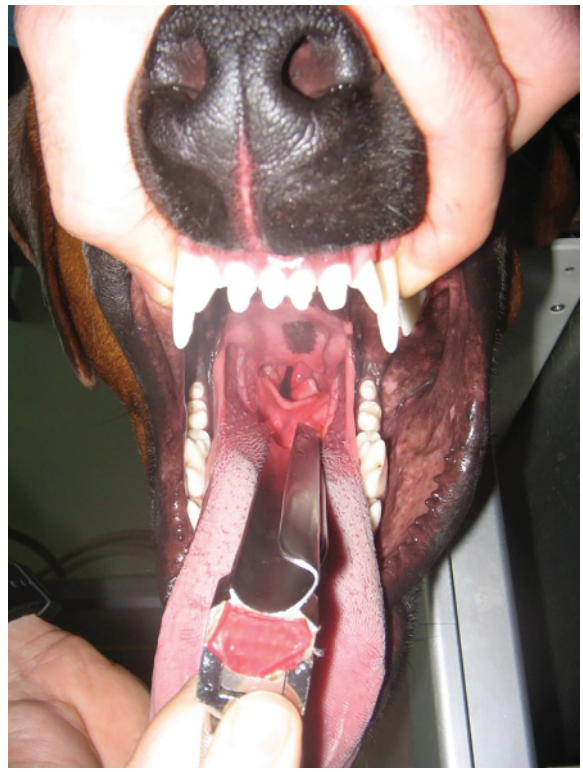

Figure 1.5 Visualizing the larynx (canine).

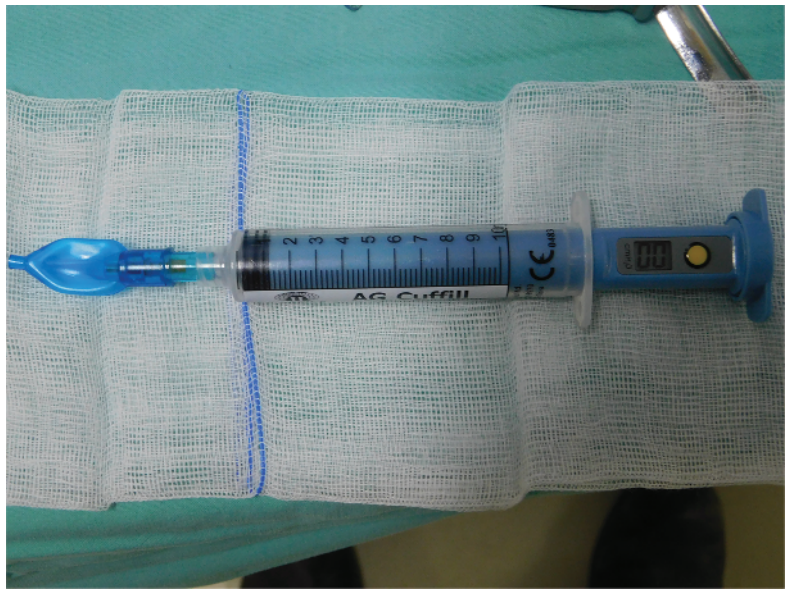

Figure 1.6 Cuff intubation syringe. *Source:* Hospitech Respiration Ltd.

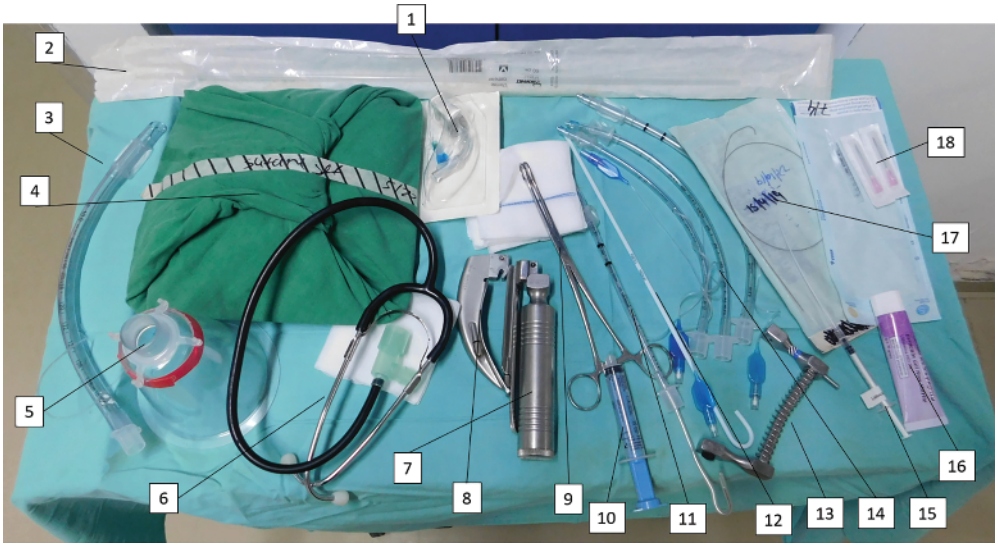

Figure 1.7 Difficult intubation tray. When difficult intubation is anticipated, the necessary equipment is arranged in advance. These are some items which may aid in this situation. 1. Tracheostomy tube of appropriate size, 2. Insemination tubes (potential guide for endotracheal [ET] tubes), 3. Large ET tube to block esophagus, 4. Surgical set for tracheostomy placement, 5. Facemask for preoxygenation, 6. Stethoscope connected to an airway adaptor, 7. Laryngoscope with a straight (Miller) blade, 8. Alternative curved blade (MacIntosh), 9. Gauze forceps and gauze pads to swab secretions, 10. Cuff inflation syringe, 11. ET tube of appropriate size with a stylet in place, 12. Stylet for ET tube, 13. Spring-loaded mouth gag, 14. ET tubes of various smaller sizes, 15. Local anesthetic connected to a tom cat catheter for local anesthesia atomization on the larynx, 16. Local anesthesia gel for cuff lubrication, 17. Guidewire for retrograde intubation, 18. 18 G needles for transcutaneous retrograde intubation or emergency oxygen insufflation.

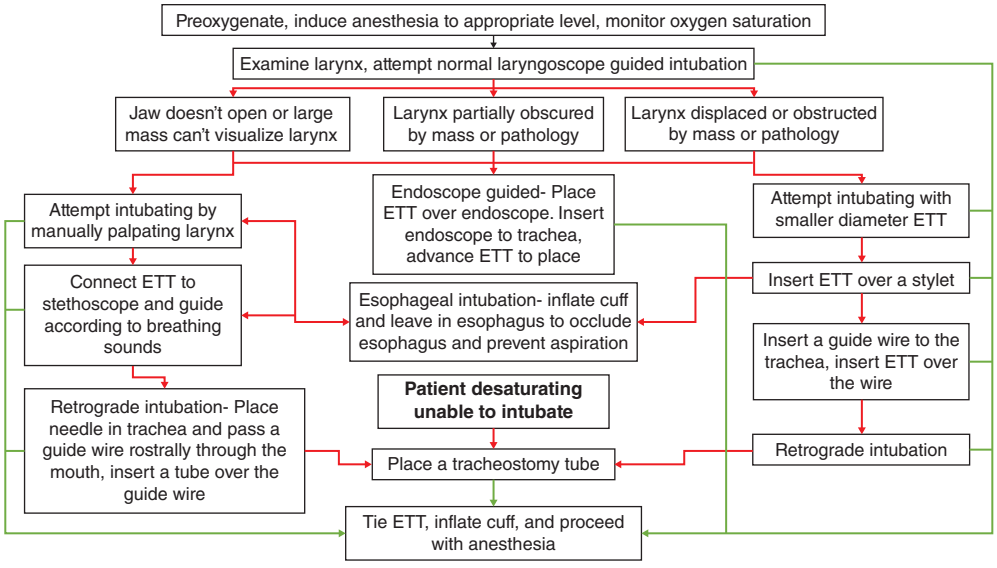

Figure 1.8 Difficult intubation algorithm.

Table 1.9 Retrograde intubation.

Materials: Laryngoscope, 3 ETTs, lubricant, tie to secure ETT, 4 × 4 gauze square to hold the tongue, guidewire tested to fit through an 18 G needle, 18 G needle and local anesthetic

Techniques:

1. Induction agent is appropriately administered until jaw and tongue are lax.
2. The patient is placed in sternal or dorsal recumbency, after the skin over the trachea is clipped and aseptically prepped from the caudal edge of the mandible to thoracic inlet. The assistant elevates the head and is prepared to hold the mouth as if for intubation (see Table 1.8).
3. The trachea is palpated and at the midpoint, an 18 G needle is rostrally passed through the trachealis muscle, between the hyaline cartilage rings.
4. A guidewire is passed through the needle, and rostrally, while the assistant holds the mouth appropriately for intubation. The guidewire should be visualized as it passes between the arytenoids and exits the mouth. Enough guidewire should be present to accommodate the whole length of the tube, and an additional 3–4 cm for the anesthetist to grasp. The guidewire must fully exit the tube or it will not be possible to pass the tube effectively.
5. Lubricate the ETT at the distal end with lubricant. In cats, a drop of lidocaine is placed on each arytenoid if possible to minimize laryngeal spasm.
6. The tube is fed over the guidewire and blindly but gently between the arytenoids. Several small sizes of tubes should be available as it may not be possible to fit an appropriate sized ETT past the obstruction.
7. Once the anesthetist has felt the tube pass between the arytenoids, the guidewire and needle are removed from the trachea, and the tube is seated just rostral to the thoracic inlet.
8. Once intubated, the anesthetist only has $EtCO_2$ as confirmation that the tube is appropriately placed. This monitoring device should be connected and several hand breaths given to confirm the ETT is appropriately placed. .
9. The ETT is then attached to the breathing circuit with an appropriate flow rate of 100% oxygen. The ETT cuff is inflated to 20–25 cmH_2O, or by performing a leak test: while the anesthetist attempts to "hold" a 20–25 cmH_2O breath, the cuff is inflated until there is no leak. Higher pressures may lead to tracheal necrosis and rupture, especially in cats.
10. Once the cuff is sealed, inhalant anesthetics are initiated.

A. Options for anesthetic maintenance

Anesthesia is typically maintained with inhalant anesthetics. However, other options for maintenance include total IV anesthesia (TIVA), a combination of inhalants and injectable drugs (balanced anesthesia; partial IV anesthesia [PIVA]), or, in the case of short procedures, injectable drugs administered IM [PIMA]) (Table 1.10). During this period, the patient's vital signs and depth of anesthesia are monitored and adjusted continuously. Planes I or II of anesthesia are appropriate for diagnostic procedures, and planes II or III are appropriate for surgical procedures (see Table 1.6). The anesthetist must support all homeostatic requirements for the patient at this stage, such as maintaining normal blood pressure, pulse, ventilation, and temperature. Continuous monitoring of vital signs during maintenance is a simple tool to decrease mortality 8, 19]. Any interventions or treatments are based on the anesthetist's observations of the patient as well as information supplied by multiparameter monitoring. Monitoring for the anesthetized patient is the subject of Chapter 2.

Table 1.10 Commonly used maintenance drugs; see the drug formulary for details such as route and dosage.

Drug	Advantages	Disadvantages
Isoflurane	Easily titratable, no IV access required (although it is recommended), inexpensive	Dose-dependent cardiovascular and respiratory depression, noxious smell
Sevoflurane	Easily titratable, no IV access required (although it is recommended), less noxious smell, statistically faster recovery times	Dose-dependent cardiovascular and respiratory depression, expensive, recovery times (while statistically faster) are not clinically different from isoflurane
Alfaxalone	No ETT is required but recommended, not dependent on pulmonary function, IM administration option if no IV access is present, cardiovascular friendly	Apnea, muscle rigidity, shivering, opisthotonos and hypermetria on recovery
Ketamine	No ETT is required but recommended, not dependent on pulmonary function, has analgesic properties, quarter doses can be given IV as a top up as opposed to a CRI, wide margin of safety, IM option if IV access is not present	Muscle rigidity, increased heart rate [31], poor recovery in cats
Propofol	No ETT is required but recommended, not dependent on pulmonary function	Apnea, vasodilation, prolonged recovery after long anesthesia

ETT, endotracheal tube; CRI, constant-rate infusion; IM, intramuscular; IV, intravenous.

B. Fluid therapy

Fluid therapy is an essential part of perianesthetic support. Hydration status is evaluated prior to anesthesia and corrected if necessary. Fluid requirements are dynamic during anesthesia. Anesthetic agents and changes in hormone excretion may affect renal fluid excretion. Losses may be increased due to evaporation from the respiratory tract or surgical site. Fluid requirement may increase due to vasodilation and decreased cardiac stroke volume. Crystalloid solutions are administered at a rate of 5 mL/kg/h for anesthetized dogs and 3 mL/kg/h for cats. Fluid rates may be higher for dehydrated, neonatal, and hypovolemic patients, or for patients undergoing laparotomy or thoracotomy. Rates are decreased in geriatric patients and those susceptible to volume overload, such as patients with cardiac disease. Extreme care is required to maintain fluid balance in anesthetized patients with renal or cardiac disease.

In certain patients, necessary fluids for the procedure may not be crystalloids; for example, patients with severe hemorrhage may require a blood transfusion or patients with a protein-losing enteropathy may require colloidal support. Please see Chapter 5 for more information.

VII. Recovery from anesthesia in the clinical setting

Recovery begins when the maintenance anesthetic is discontinued and continues until all effects of the anesthetics wear off and homeostasis returns. Before the anesthetic is discontinued, confirm that all planned procedures have been performed and examine the oral cavity for regurgitation or other foreign material. Additional analgesia and sedation are administered if necessary, and a plan for further pain management is formed. Use of a checklist at this stage decreases the risk of omission. The recovery location, while often predetermined, should be evaluated for its level of noise, lighting, and general demeanor before a patient is located there. Recovering a patient who may be physiologically challenging in the OR or in another minimally trafficked area, such as a relatively unused radiology suite, may facilitate a smoother recovery. All necessary monitoring must be on hand, however.

The patient is extubated when a strong swallow or cough reflex is observed, at which point the ETT cuff is deflated. In cases where there may be risk of fluid in the trachea (e.g., a patient who underwent a dental procedure or was known to have regurgitated), the ETT cuff may be left partially inflated to help draw out some of that material. Brachycephalic dogs and patients with upper airway disease are extubated only when they are able to maintain a patent airway (see Chapter 4). Normal airflow through the nares is confirmed after extubation in order to rule out laryngospasm.

Recovery is the most dangerous period of anesthesia. In large-scale work, approximately 47–60% of perioperative deaths occur in this period, most of which occur in the first 3 hours [9]. Newer research is even more disturbing, with up to 90% of canine mortality and approximately 74% of feline mortality occurring postoperatively [20, 21]. It is wise to leave an IV catheter in place throughout the entire recovery period in case of adverse events requiring injectable medication, and to lubricate the eyes during the recovery as necessary. Patient monitoring by vigilant staff as well as support of the patient continues until the patient's protective reflexes have fully recovered, vital signs are within normal limits and stable, and the patient is fully awake and ambulatory. Often times, recovery includes monitoring equipment that is easy to remove (such as a capnograph or pulse oximeter) to ensure a normal return of respiratory function. For young animals, periodic blood glucose monitoring is important during recovery. Prolonged recoveries may be observed in obese and hypothermic animals; however, these lengthy recoveries may have other rule-outs, including hypoglycemia or decreased drug metabolism due to hepatic, renal, cardiopulmonary or hormonal dysfunction [1]. Patients with delayed recovery are adequately supported and these causes are ruled out.

Please see Chapter 3 for more information on problems that may occur during recovery.

A. Timeline and signs of recovery at home

Animals recovering from anesthesia may display a variety of abnormal behaviors, including drowsiness, sedation, decreased appetite, pain-associated behaviors or clinical manifestations of anesthesia-associated complications (e.g. coughing from tracheitis, or signs of nausea due to esophagitis) [1]. Signs of drowsiness and sedation should show a trend of improvement over

the 24–48 hours following anesthesia, and pain should decrease over time depending on the procedure performed and the efficacy of the postoperative pain management plan.

B. Communications about returning home

Owners are informed as to what they should expect during the first days of recovery and what signs necessitate contacting the clinic or an emergency center. Since oral communication during stressful situations is less effective, these points are stated on the patient's discharge form; separate anesthesia-focused discharge instructions may assist with this. Such forms are available online, at no cost [28]. Abnormal behaviors presented by their beloved pets may distress owners, and this may be exacerbated by concerns regarding the medical procedure or economic issues. Availability and good communication skills are important at this stage to improve outcome of the interactions, and owner satisfaction [29].

www.wiley.com/go/shelby/anesthesia2

Please go to the companion website for access to videos relating to the book

References

1. Grubb T, Sager J, Gaynor JS et al. 2020 AAHA Anesthesia and Monitoring Guidelines for Dogs and Cats. J Am Anim Hosp Assoc. 2020;56(2):59–82.
2. Robinson EP, Sams RA, Muir WW. Barbiturate anesthesia in greyhound and mixed-breed dogs: comparative cardiopulmonary effects, anesthetic effects, and recovery rates. Am J Vet Res. 1986;47(10):2105–12.
3. Sams RA, Muir WW, Detra RL, Robinson EP. Comparative pharmacokinetics and anesthetic effects of methohexital, pentobarbital, thiamylal, and thiopental in Greyhound dogs and non-Greyhound, mixed-breed dogs. Am J Vet Res. 1985;46(8):1677–83.
4. Brodbelt D, Pfeiffer D, Young L, Wood J. Results of the confidential enquiry into perioperative small animal fatalities regarding risk factors for anesthetic-related death in dogs. J Am Vet Med Assoc. 2008;233(7):1096–104.
5. Matthews NS, Mohn TJ, Yang M et al. Factors associated with anesthetic-related death in dogs and cats in primary care veterinary hospitals. J Am Vet Med Assoc. 2017;250(6):655–65.
6. Mogil JS. Qualitative sex differences in pain processing: emerging evidence of a biased literature. Nat Rev Neurosci. 2020;21(7):353–65.

7. IASP. Part III: Pain Terms, A Current List with Definitions and Notes on Usage. www.iasp-pain.org/resources/terminology/
8. Brodbelt D, Pfeiffer D, Young L, Wood J. Risk factors for anaesthetic-related death in cats: results from the confidential enquiry into perioperative small animal fatalities (CEPSAF). Br J Anaesth. 2007;99(5):617–23.
9. Brodbelt D, Blissitt K, Hammond R et al. The risk of death: the confidential enquiry into perioperative small animal fatalities. Vet Anaesth Analg. 2008;35(5):365–73.
10. Portier K, Ida KK. The ASA Physical Status Classification: what is the evidence for recommending its use in veterinary anesthesia? A systematic review. Front Vet Sci. 2018;5:204.
11. Kavkovsky A, Avital Y, Aroch I, Segev G, Shipov A. Perioperative urinary heat shock protein 72 as an early marker of acute kidney injury in dogs. Vet Anaesth Analg. 2020;47(1):53–60.
12. Bille C, Auvigne V, Bomassi E, Durieux P, Libermann S, Rattez E. An evidence-based medicine approach to small animal anaesthetic mortality in a referral practice: the influence of initiating three recommendations on subsequent anaesthetic deaths. Vet Anaesth Analg. 2014;41(3):249–58.
13. Carter J, Story DA. Veterinary and human anaesthesia: an overview of some parallels and contrasts. Anaesth Intensive Care. 2013;41(6):710–18.
14. Brodbelt D. Perioperative mortality in small animal anaesthesia. Vet J. 2009;182(2):152–61.
15. Brodbelt D, Hammond R, Tuminaro D, Pfeiffer D, Wood J. Risk factors for anaesthetic-related death in referred dogs. Vet Rec. 2006;158(16):563–4.
16. Lee HW, Machin H, Adami C. Peri-anaesthetic mortality and nonfatal gastrointestinal complications in pet rabbits: a retrospective study on 210 cases. Vet Anaesth Analg. 2018;45(4):520–8.
17. Seamon AB, Hofmeister EH, Divers SJ. Outcome following inhalation anesthesia in birds at a veterinary referral hospital: 352 cases (2004–2014). J Am Vet Med Assoc. 2017;251(7):814–17.
18. Levy JK, Bard KM, Tucker SJ, Diskant PD, Dingman PA. Perioperative mortality in cats and dogs undergoing spay or castration at a high-volume clinic. Vet J. 2017;224:11–15.
19. Dyson DH, Maxie MG, Schnurr D. Morbidity and mortality associated with anesthetic management in small animal veterinary practice in Ontario. J Am Anim Hosp Assoc. 1998;34(4):325–35.
20. Redondo JI. Perianaesthetic mortality in dogs: preliminary data of a worldwide multicentric study. [Abstract]. Presented at the 13th World Congress of Veterinary Anaesthesiology, Venice, Italy 2018.
21. Redondo JI. Perianaesthetic mortality in cats:preliminary data of a worldwide multicentric study. [Abstract]. Presented at the 13th World Congress of Veterinary Anaesthesiology, Venice, Italy 2018.
22. Posner LP, Mariani CL, Swanson C, Asakawa M, Campbell N, King AS. Perianesthetic morbidity and mortality in dogs undergoing cervical and thoracolumbar spinal surgery. Vet Anaesth Analg. 2014;41(2):137–44.
23. Robinson R, Chang YM, Seymour CJ, Pelligand L. Predictors of outcome in dogs undergoing thoracic surgery (2002–2011). Vet Anaesth Analg. 2014;41(3):259–68.
24. Stefani LC, Gamermann PW, Backof A et al. Perioperative mortality related to anesthesia within 48h and up to 30 days following surgery: a retrospective cohort study of 11,562 anesthetic procedures. J Clin Anesth. 2018;49:79–86.
25. Hofmeister EH, Quandt J, Braun C, Shepard M. Development, implementation and impact of simple patient safety interventions in a university teaching hospital. Vet Anaesth Analg. 2014;41(3):243–8.
26. Bergstrom A, Dimopoulou M, Eldh M. Reduction of surgical complications in dogs and cats by the use of a surgical safety checklist. Vet Surg. 2016;45(5):571–6.
27. McNally E, Robertson S, Pablo L. Comparison of time to desaturation between preoxygenated and nonpreoxygenated dogs following sedation with acepromazine maleate and morphine and induction of anesthesia with propofol. Am J Vet Res. 2009;70(11):1333–8.

28. American Animal Hospital Association. Anesthesia Discharge Template. www.aaha.org/aaha-guidelines/2020-aaha-anesthesia-and-monitoring-guidelines-for-dogs-and-cats/anesthesia-discharge-template/
29. Bonvicini KA, Cornell K. Are clients truly informed? Communiation tools and risk reduction. Compend Contin Educ Vet. 2008;30(11):572–6.
30. Bergeron R, Scott SL, Emond JP, Mercier F, Cook NJ, Schaefer AL. Physiology and behavior of dogs during air transport. Can J Vet Res. 2002;66(3):211–16.
31. Sumikura H, Andersen OK, Drewes AM, Arendt-Nielsen L. Spatial and temporal profiles of flare and hyperalgesia after intradermal capsaicin. Pain. 2003;105(1-2):285–91.