ANESTHESIA and ANALGESIA for the Veterinary Practitioner: Canine and Feline
CLINICAL ESSENTIALS

**Clinical essentials** are standards of practice that constitute the minimum acceptable level of care. Practice below this level of care is below expectations. Failure to provide at least this level of care, or clearly document sound reasons for not providing this care, can result in disciplinary consequences.

### GENERAL

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Details</th>
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<tbody>
<tr>
<td>All associates must comply with their state practice acts</td>
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<tr>
<td>Veterinarians or trained associates under the direct supervision of a veterinarian perform anesthetic procedures</td>
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<tr>
<td>Sedate or anesthetize brachycephalic pets with brachycephalic-specific protocols and monitoring</td>
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<tr>
<td>Offer referral of critical or unstable pets when appropriate and in the best interests of the pet</td>
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<tr>
<td>All associates understand human health hazards related to anesthesia</td>
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<tr>
<td>A CPR team is available during normal hours of operation</td>
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<tr>
<td>Do not administer vaccines to an anesthetized patient unless there is a significant pet or associate safety concern to vaccinating a fully conscious pet</td>
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<tr>
<td>Document all perianesthetic physical examination findings, changes in physical status and anesthetic procedure complications in the medical record</td>
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<tr>
<td>Administer all anesthetic medications “to effect” and do not exceed maximum drug dosages</td>
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<tr>
<td>Place an IV catheter and T-port with every general anesthetic event</td>
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<tr>
<td>Administer IV fluids with every general anesthetic event lasting &gt;10 minutes unless patients are hypervolemic</td>
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<tr>
<td>Place an endotracheal tube with every general anesthetic event</td>
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<tr>
<td>Assisted ventilation is available for every anesthetic procedure</td>
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### EQUIPMENT

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<thead>
<tr>
<th>Requirement</th>
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<tbody>
<tr>
<td>Utilize the Anesthetic Machine Checklist for every general anesthetic event</td>
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<tr>
<td>A crash cart containing emergency drugs and equipment is readily available, in a designated place, portable, clearly labeled and appropriately stocked at all times</td>
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<tr>
<td>CLINICAL ESSENTIALS</td>
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<tr>
<td>Thoroughly clean, disinfect, dry and store personal anesthesia equipment in a manner that prevents contamination prior to each use(^7, 21)</td>
<td></td>
</tr>
<tr>
<td>Anesthetic machines and equipment are tested and maintained on a regular basis and a permanent log of maintenance is kept. Anesthetic events are postponed until all equipment is fully functional(^7, 16, 26)</td>
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<tr>
<td>The attending veterinarian ensures all equipment is working correctly prior to proceeding with premedication and anesthesia(^6)</td>
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<table>
<thead>
<tr>
<th>PREANESTHETIC</th>
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<tbody>
<tr>
<td>The attending veterinarian chooses protocols and determines specific drug dosages(^6)</td>
</tr>
<tr>
<td>Assign an ASA status to each pet undergoing general anesthesia and address status appropriately as part of the preanesthetic evaluation. Discuss increased risks of anesthesia for pets with an ASA status of III with owners and postpone, cancel or refer anesthetic procedures when indicated(^3, 7, 8, 10, 15, 24)</td>
</tr>
<tr>
<td>Pre-emptively identify patient-specific factors that may influence anesthesia (e.g., signalment, adverse drug reactions) and adjust protocols appropriately(^7)</td>
</tr>
<tr>
<td>Obtain and review clinical pathology data prior to general anesthesia. Verify, document and address all clinically significant abnormalities prior to premedication, communicate to the team, and discuss with the client. Dismissal of abnormal results is not permitted(^6, 7, 18, 24)</td>
</tr>
<tr>
<td>Perform a thorough physical examination prior to any anesthetic event and obtain a current and accurate weight. Verify, document and address all clinically significant abnormalities prior to premedication, communicate to the team, and discuss with the client. Dismissal of abnormal findings is not permitted(^6, 7, 24)</td>
</tr>
<tr>
<td>The attending veterinarian reviews the medical history of each pet prior to any anesthetic procedure(^6, 9)</td>
</tr>
<tr>
<td>Perform a physical examination (including all cardiovascular parameters) post-premedication and pre-induction for every general anesthetic event(^7, 24)</td>
</tr>
<tr>
<td>Identify pets at greater risk for developing hypothermia (e.g., poor body condition) and institute pre-emptive warming measures(^21, 31)</td>
</tr>
<tr>
<td>Address and resolve physical examination abnormalities that may negatively impact anesthesia (e.g., dehydration, obesity) prior to anesthesia when possible, especially with elective procedures(^6)</td>
</tr>
<tr>
<td>Keep all pets that have been administered preanesthetic medication under visual observation at all times(^6)</td>
</tr>
</tbody>
</table>
## CLINICAL ESSENTIALS

### INDUCTION & INTUBATION

<table>
<thead>
<tr>
<th>Task</th>
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<tbody>
<tr>
<td>Coat endotracheal tube cuffs with sterile, water soluble lubricant(^7,21)</td>
</tr>
<tr>
<td>Fill endotracheal tube cuffs to the amount required to provide a complete seal and deflate prior to removal (unless otherwise directed by veterinarian)(^21)</td>
</tr>
<tr>
<td>Keep endotracheal tubes in place until protective, vigorous laryngeal reflexes return without applying noxious stimuli(^7)</td>
</tr>
<tr>
<td>If patient repositioning is necessary, disconnect intubated pets from the breathing circuit prior to movement and reconnect after attaining proper positioning(^7)</td>
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### MONITORING & RECOVERY

<table>
<thead>
<tr>
<th>Task</th>
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<tbody>
<tr>
<td>Assign at least one hospital associate with the <strong>sole</strong> responsibility of dedicated, continuous patient monitoring and recovery to every immobilization and general anesthetic procedure. If there is not a trained, dedicated associate, the procedure must be rescheduled(^3,6,7,10,21)</td>
</tr>
<tr>
<td>The responsibility for patient monitoring is relinquished only by transfer to another trained team member with their consent(^2)</td>
</tr>
<tr>
<td>Identify and address immediate and postoperative pain(^2)</td>
</tr>
<tr>
<td>Continuously measure temperature, heart and respiratory rates, blood pressure, ECG, SpO(_2), end-tidal CO(_2) (with capnography capability). Document at a minimum of every 5 minutes (or more frequently as clinically indicated) for every general anesthetic event from the time of induction until full recovery(^7,21,24)</td>
</tr>
<tr>
<td>Identify, verify, communicate to the anesthesia team and address abnormal patient monitoring parameters and trends. Presumptions of malfunctioning equipment and dismissal of abnormal parameters are not permitted(^6,7,21,31)</td>
</tr>
<tr>
<td>Abort, as able, elective anesthetic procedures in cases of worsening or refractory patient physical parameters (e.g., hypotension, hypothermia)(^6,24)</td>
</tr>
<tr>
<td>Keep all patients recovering from an anesthetic procedure under visual observation at all times until full recovery(^6,24)</td>
</tr>
<tr>
<td>A final postanesthetic evaluation of each patient is performed by the veterinarian prior to discharge from hospital(^6,7)</td>
</tr>
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ANESTHESIA and ANALGESIA for the Veterinary Practitioner: Canine and Feline

Book 1
PREFACE

- Individual state practice act requirements and DEA regulations must be met or exceeded in all instances.
- Review Medical Quality Standards. Meet or exceed all Clinical Essentials.

STATE REGULATIONS:

- At all times, every medical team must comply with individual state practice acts.
- It is each doctor’s responsibility to know and understand the requirements of his/her specific state, as well as Banfield policies and procedures.
- The doctor must ensure compliance with state regulations regarding:
  - Handling and administration of controlled substances
  - Intubation of pets
  - Anesthetic monitoring
  - Drug administration documentation
  - Which hospital associates can legally perform dental prophylaxis and all other medical procedures
  - Off-label usage of medications

This publication may contain information that is not within the current FDA-approved labeling for several products for companion animals.
Karen Faunt, DVM, MS, DACVIM  
Vice President, Medical Quality Advancement  
Banfield Pet Hospital

Vice President of Medical Quality Advancement, Dr. Faunt is responsible for setting the medical quality standards for Banfield and for driving continual advancements in medical quality for the practice. In her 10+ years with Banfield, Dr. Faunt has served in many roles within the medical division, including medical advisor and university relations. Previously, she worked as a small animal internist in a private referral practice outside of Baltimore, Maryland. Dr. Faunt completed her residency at the University of Missouri, her internship at Alameda East in Denver, Colorado, and veterinary school at Colorado State University. Dr. Faunt and her partner, Robert, have two dogs: Bismark and Juniper, and two cats: Alice and Gertrude.

Lorna Lambert, MS, CPHQ, CPMSM, HACP  
Senior Director of Medical Quality  
Banfield Pet Hospital

Ms. Lambert graduated from Napier University in Edinburgh, Scotland, with a B.Sc. in Biological Sciences, and earned an M.S. in Clinical Psychology from Abilene Christian University in Texas. Ms. Lambert’s previous work experience has been in the human healthcare field. Prior to joining Banfield, Ms. Lambert directed a variety of quality and patient safety programs in acute care and specialty hospitals with primary responsibility for optimizing clinical outcomes, patient safety and patient satisfaction; regulatory and accreditation compliance; medical staff credentialing and privileging and risk management. She has almost 20 years of healthcare experience and holds specialty certifications in healthcare quality, medical services management and healthcare accreditation.

Jo Ann Morrison, DVM, MS, DACVIM  
Senior Manager, Medical Programs  
Banfield Pet Hospital

Dr. Morrison received her DVM degree from Purdue University in 1993. After five years of general and mixed animal practice, she completed a small animal internal medicine internship at Affiliated Veterinary Specialists in Maitland, Florida. From 1999-2002 she completed a residency at Iowa State University, achieving board certification in small animal internal medicine in 2002. After two years of private referral specialty practice in Florida, she returned to Iowa State and was a faculty clinician for 11 years. She completed her master’s degree in veterinary clinical sciences in 2004 and served as the residency program director and the section head of small animal internal medicine. In 2015 she joined Banfield as a senior manager on the Medical Quality Advancement team.
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## MEDICAL QUALITY STANDARDS

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EQUIPMENT

Ancillary Equipment
- Intravenous (IV) catheter
- Laryngoscope
- Endotracheal tube
- Breathing circuits
- Rebreathing bags
- Oxygen masks and diaphragms

Oxygen and Carbon Dioxide
- Oxygen cylinders
- Carbon dioxide absorbent and canister

Anesthesia Machine and Administration
- Evacuation
- Vaporizer and oxygen regulator
- Manometer
- Oxygen flush valve
- Safety pressure relief valve
- Vaporizer

Maintenance

Troubleshooting and Leak Test

PHYSIOLOGY

Introduction
- Perfusion

Pharmacologic Influence on the Nervous System
- Divisions
  - Sympathetic system
  - Alpha-2 agonist medications
  - Parasympathetic system
  - Anticholinergic medications

Stressed/Fractious Pet Physiology
- Stressed versus fractious
- Anesthetic implications
OUR COMMITMENT TO QUALITY

Banfield Pet Hospital is focused on creating a practice that places the delivery of quality veterinary care at the heart of everything we do. We strive to understand the needs of pets and clients to deliver safe, high-quality healthcare to every pet, every time. The quality of our anesthesia practices is built on a solid foundation of evidence-based standards and protocols, sound operational practices, a focus on patient safety and robust team member training and development programs. Our commitment to the continuous improvement of our anesthesia standards and protocols supports our belief that we can create a better world for pets through the delivery of high-quality veterinary care.

WHAT IS QUALITY IN HEALTHCARE?

Quality in healthcare is defined as the degree to which an organization’s processes and results meet or exceed the needs of its patients. Banfield endeavors to meet this definition in part through our continued study and improvement of our anesthetic protocols and processes.
CULTURE OF SAFETY

The concept of a “Culture of Safety” originated outside healthcare, in studies of organizations that consistently minimize adverse events despite performing intrinsically complex and high-risk work. Culture of Safety at Banfield is defined as the collective product of facilities, equipment, standards and training, as well as individual and group attitudes, values, competencies and patterns of behavior that support and promote associate, client and patient safety in the work environment. Key influencers for a Culture of Safety include:

- Facilities that meet or exceed the minimum regulatory standards for the veterinary industry
- Appropriate equipment and formulary to meet patient needs
- Policies and procedures designed to improve patient outcomes and client satisfaction while mitigating associate, client and patient harm
- Ongoing training to develop the knowledge and skills to perform tasks in a safe, efficient and effective manner

Patient Safety

Patient safety, the prevention of errors and adverse events associated with the delivery of healthcare, is a central tenet of a Culture of Safety. It is our intent to create processes that are designed to mitigate and prevent harm from reaching the patient due to human error that is inevitable in complex environments. We strive to ensure that the veterinary care we provide is safe at all times.

When adverse or harmful events are analyzed, it is frequently found that the event was the result of a series of system and process failures that led to a medical professional making an error that ultimately harmed a patient. Safety must therefore be a property of our entire system and all of our processes. Our goal must be to thoughtfully design our systems and processes to prevent patient harm. To accomplish this, every Banfield associate must be involved in identifying opportunities (e.g., patient safety event reporting) where patient care can be made safer. It also requires all of us to be continuously involved in learning from medical errors and “near misses.”
Culture of Safety: Essential Components of Patient Safety

A strong Culture of Safety is an essential component in preventing or reducing medical errors, preventing harm to patients and improving the overall quality of healthcare. At Banfield, we are beginning our journey of creating this culture with the following attributes:

- Associates who value transparency, accountability and mutual respect
- A collaborative environment with a shared commitment to patient safety as a top priority
- Leaders who encourage effective teamwork and promote psychological safety so associates feel comfortable speaking up about safety concerns without fear of blame or retaliation
- Collective mindfulness, in which associates recognize that systems have the potential to fail and view near misses as evidence that the system needs to be further improved to prevent errors
- Associates who report errors and near misses, rather than ignore or cover them up, so the team can learn from them and improve the system flaws that contribute to or enable adverse events

Never Events

A “Never Event” is a preventable, serious, unexpected event that results in death or serious harm to a patient that is not primarily related to the natural course of the patient’s illness or underlying condition. The most obvious anesthesia-related Never Event is the unexpected death of a pet during or following anesthesia due to a medical or procedural error.

Such incidents have an enormous impact on individual clients, pets and hospital teams. We strive to thoroughly analyze these events, learn from them, and continuously improve our processes and systems to prevent future harm, because each pet, each client and each associate is important.
MEDICAL QUALITY STANDARDS

Having clear standards is key to ensuring that we deliver safe care and that we are able to continuously improve our processes and systems. In *Anesthesia and Analgesia for the Veterinary Practitioner: Canine and Feline*, we will introduce a tiered standards classification system, consisting of Clinical Essentials and Best Practices. Clinical Essentials are standards of practice that constitute the minimum acceptable level of care required for every Banfield hospital. Best Practices are standards of practice that meet or exceed an expected level of care. It should be noted that individual state practice act requirements must be met or exceeded in all instances.

To improve the quality of anesthesia we deliver, we must shift our focus from only being concerned with outcomes (the *results* of the care we provide) to also being concerned with how we deliver care (the *process* we use to deliver care). The basis of continuous improvement and providing consistency of care is in understanding and standardizing processes. Our anesthesia standards and protocols define processes of care and the requirements – based on current scientific knowledge – that help us ensure that the care we provide is safe, reliable, effective and results in the best possible outcomes for pets every time.

CONCLUSION

The main goal of *Anesthesia and Analgesia for the Veterinary Practitioner: Canine and Feline* is to provide all associates with standards and protocols based on proven fundamentals of quality and medical best practices that will lead to sustainable outcomes for our practice and the best results for each pet. To achieve these goals, we will need to ensure that we:

- Build a culture of quality and safety
- Embrace protocols
- Meet all Clinical Essentials
- Learn from our successes and failures

In this way, we will lead care forward and create a better world for pets.
Further reading for *Anesthesia Quality*:

Institute for Healthcare Improvement (IHI) resources:  
www.ihi.org/resources/Pages/default.aspx

Agency for Healthcare Research and Quality (AHRQ) resources:  

Notes
ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>ABCB</td>
<td>updated name for the MDR gene</td>
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<tr>
<td>ALP</td>
<td>alkaline phosphatase</td>
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<tr>
<td>ALT</td>
<td>alanine aminotransferase</td>
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<tr>
<td>ASA</td>
<td>American Society of Anesthesiologists</td>
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<tr>
<td>BG</td>
<td>blood glucose</td>
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<tr>
<td>BNP</td>
<td>brain natriuretic peptide</td>
</tr>
<tr>
<td>BP</td>
<td>blood pressure</td>
</tr>
<tr>
<td>BUN</td>
<td>blood urea nitrogen</td>
</tr>
<tr>
<td>CBC</td>
<td>complete blood count</td>
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<tr>
<td>CPR</td>
<td>cardiopulmonary resuscitation</td>
</tr>
<tr>
<td>CRT</td>
<td>capillary refill time</td>
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<tr>
<td>DO₂</td>
<td>delivery of oxygen to tissues</td>
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<tr>
<td>ECG</td>
<td>electrocardiogram</td>
</tr>
<tr>
<td>EtCO₂</td>
<td>end tidal carbon dioxide</td>
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<tr>
<td>HCT</td>
<td>hematocrit</td>
</tr>
<tr>
<td>MAP</td>
<td>mean arterial pressure</td>
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<tr>
<td>MDR</td>
<td>multidrug resistant</td>
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<tr>
<td>OVH</td>
<td>ovariohysterectomy</td>
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<tr>
<td>PCV</td>
<td>packed cell volume</td>
</tr>
<tr>
<td>SpO₂</td>
<td>peripheral capillary oxygen saturation</td>
</tr>
<tr>
<td>TP</td>
<td>total protein</td>
</tr>
<tr>
<td>USG</td>
<td>urine specific gravity</td>
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<tr>
<td>vWf</td>
<td>von Willebrand factor</td>
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<td>WBC</td>
<td>white blood cell</td>
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DEFINITIONS

The following definitions are provided to ensure clarity and facilitate communication among hospital teams.

**General anesthesia** refers to a procedure that is performed after administration of a medication(s) that results in analgesia, paralysis and unconsciousness. General anesthesia begins with the preanesthetic evaluation and lasts until complete anesthetic recovery is attained.

**Sedation** involves the administration of a pharmaceutical to facilitate the performance of nonpainful procedures and to reduce pet anxiety. The patient may be ambulatory and all reflexes are intact. The pet cannot be intubated.

**Immobilization** is defined as a nonsurgical plane of anesthesia. The pet is nonambulatory but can be roused with minimal effort. Laryngeal and withdrawal reflexes are intact. Immobilization may be used for nonpainful procedures that are expected to last <10 minutes and cannot be used for brachycephalic pets.

An **anesthetic procedure** may refer to and is inclusive of sedation, immobilization and general anesthesia.

**Anesthetic recovery** is defined as that time when a patient is normothermic (T 100 - 102.5° F), normotensive (mean arterial pressure (MAP) 80 - 100 mm Hg), oxygenating normally (SpO₂ >95 - 100 percent), mentally appropriate, in sternal recumbency, with pain controlled, after extubation.

**Direct supervision** is defined as the physical presence of a licensed veterinarian with visual contact of the procedure.
CLINICAL ESSENTIALS AND BEST PRACTICES

Medical Quality Standards, or clinical essentials and best practices, for anesthetic procedures in Banfield hospitals have been identified. These standards represent the level to which all anesthetic procedures will be provided by Banfield hospitals.

MEDICAL QUALITY STANDARDS

Clinical essentials are standards of practice that constitute the minimum acceptable level of care. Practice below this level of care is below expectations. Failure to provide at least this level of care, or clearly document sound reasons for not providing this care, can result in disciplinary consequences.

Best practices are standards of practice that meet or exceed an expected level of care and encompass a scale of care from “desirable” to “aspirational.”

The clinical essentials and best practices for anesthetic procedures, along with references, are provided inside the front and back covers of this book. Hospital teams should read carefully and familiarize themselves with these Medical Quality Standards.
Clinical essentials are requirements for every anesthetic procedure and are highlighted throughout the text within a yellow box.

Clinical essentials are standards of practice that constitute the minimum acceptable level of care

Through analysis of professional resources, peer-reviewed publications and Banfield data, several key areas have been found to be especially tied to patient safety and anesthetic quality. These areas are emphasized in the anesthesia clinical essentials and additional information is provided in this chapter. These key areas are:

- Performance of a preanesthetic physical examination
  - Signalment
  - Cardiovascular parameters
  - Stressed or fractious pet
- Review of preanesthetic clinical pathology testing
- Determination of American Society of Anesthesiologists (ASA) status

Notes

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PREANESTHETIC PHYSICAL EXAMINATION

A complete preanesthetic physical examination includes a review of the patient’s medical history. A thorough history is critical to give an accurate evaluation and timeline of any underlying disease processes and allow identification of other abnormalities or comorbidities that may affect anesthetic or surgical outcome.

Prior to any anesthetic procedure, the patient should be systematically examined during the physical examination and all body systems should be evaluated. Findings should be documented in the patient’s medical record. Underlying issues should be resolved prior to anesthesia if possible, especially if procedures are elective.

The goals of the preanesthetic assessment are to:
- Determine the health status of a pet to minimize the risk of adverse events
- Identify and prepare for anticipated complications
- Promote a problem-oriented approach to pet management, including drug choices
- Decrease perioperative morbidity and mortality and improve pet care

CLINICAL ESSENTIAL
Perform a thorough physical examination prior to any anesthetic event and obtain a current and accurate weight. Verify, document and address all clinically significant abnormalities prior to premedication, communicate to the team, and discuss with the client. Dismissal of abnormal findings is not permitted.
Signalment

In some instances, particular breeds of dogs or cats may be predisposed to conditions that may impact drug metabolism, distribution, anesthesia and surgery. Due to wide individual variations within a breed, specific anesthetic protocols for each breed are not possible. The following (Table 1.1) lists a few examples of different breeds, genetic conditions and subsequent clinical considerations for each. Individual pet decisions remain the responsibility of the attending veterinarian.

This is not a comprehensive list of breeds, conditions or clinical considerations.

Table 1.1

<table>
<thead>
<tr>
<th>Breed</th>
<th>Condition</th>
<th>Clinical Consideration</th>
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<tbody>
<tr>
<td>Boxer</td>
<td>Cardiac disease</td>
<td>Cardiac evaluation*</td>
</tr>
<tr>
<td>Doberman Pinscher</td>
<td>Von Willebrand’s factor (vWF) deficiency**/cardiac disease</td>
<td>vWF factor analysis or buccal mucosal bleeding time, cardiac evaluation*</td>
</tr>
<tr>
<td>German Shepherd</td>
<td>Congenital cardiac disease</td>
<td>Cardiac evaluation*</td>
</tr>
<tr>
<td>King Charles Cavalier Spaniel</td>
<td>Myxomatous mitral valve disease, macrothrombocytosis</td>
<td>Cardiac evaluation*, platelet inspection</td>
</tr>
<tr>
<td>Soft Coated Wheaten Terrier</td>
<td>Protein-losing enteropathy and nephropathy</td>
<td>Evaluate blood albumin and urine protein levels</td>
</tr>
<tr>
<td>Maine Coon</td>
<td>Cardiac disease</td>
<td>Cardiac evaluation*, blood pressure</td>
</tr>
<tr>
<td>Persian</td>
<td>Polycystic kidney disease</td>
<td>Urinalysis, renal imaging, blood pressure</td>
</tr>
<tr>
<td>Breed</td>
<td>Condition</td>
<td>Clinical Consideration</td>
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<td>--------------------------</td>
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</table>
| **Brachycephalic breeds:**  
Boston Terrier, Boxer, Bulldog, Himalayan, Lhasa Apso, Pekingese, Persian, Pug, Shar Pei, Shih Tzu | Brachycephalic airway syndrome                                               | Pre-oxygenation, NEVER immobilize these pets, use brachycephalic-specific protocols    |
| **Giant breeds:**  
Great Dane, Newfoundland                                           | Cardiac disease, acepromazine sensitivity                                       | Cardiac evaluation*, decrease acepromazine dose                                          |
| **Herding breeds:**  
Australian Shepherd, Collie, Shetland Sheepdog                       | ABCB1 mutations                                                               | Decrease doses of acepromazine and opioids                                              |
| **Sighthounds:**  
Afghan Hound, Greyhound, Irish Wolfhound                              | Cardiac disease, acepromazine sensitivity, slower recovery from propofol, propensity for hypothermia due to low body fat | Cardiac evaluation*, decrease acepromazine dose, perioperative warming                  |
| **Toy breeds:**  
Chihuahua, Toy Poodle                                                 | Propensity for hypoglycemia and hypothermia                                    | Monitor blood glucose levels, perioperative warming                                       |

* Cardiac evaluation may include, but is not limited to, ECG, blood pressure, thoracic radiographs, echocardiogram or clinical pathology testing (Brain Natriuretic Peptide (BNP), cardiac troponin I)
** Many breeds may be affected by vWF deficiency
Cardiopulmonary Parameters

Temperature, pulse and respiration (TPR) parameters and cardiovascular status are of great importance as they can be the root cause of a life-threatening problem throughout anesthesia. The key to pet survival is adequate delivery of oxygen to tissues (DO₂). Therefore, a detailed evaluation of the cardiovascular, respiratory and central nervous systems should occur before any anesthetic procedure. Cardiovascular parameters are evaluated again after premedications have taken effect, prior to induction.

Notify veterinarian of any abnormalities at the time they are noticed.

Postpone procedures if possible, especially elective procedures, if abnormalities are noted.

Figure 1.1

**TEMPERATURE**

**NORMAL RANGE:**

99.5 - 102.5 °F

**IF ELEVATED:**

- If T > 102.5°F = hyperthermia or fever
- If fever, perform appropriate diagnostics
- If hyperthermic, institute clinically indicated cooling measures and postpone anesthesia

**IF HYPOTHERMIC:**

- Institute appropriate patient warming methods
- If temperature decreases, postpone/stop procedure and recover patient as quickly and safely as possible
HEART RATE/PULSE

NORMAL RANGE:
Awake and non-stressed pets:
- Large dogs: 60 - 100 bpm
- Medium dogs: 80 - 140 bpm
- Small dogs: 100 - 140 bpm
- Cats: 120 - 180 bpm

IF BRADYCARDIC OR TACHYCARDIC:
- Perform ECG and assess

IF PERSISTENTLY TACHYCARDIC AFTER PREMEDICATION:
- Postpone elective procedure
- Evaluate for underlying cardiac disease
- Use Cardiac protocol if emergency

IF CARDIAC MURMUR IS AUSCULTED:
- Determine if acute (new) or chronic (known)
- Consider cardiac evaluation, especially in cats or in juvenile pets where murmurs may indicate congenital disease
- Use Cardiac protocol if emergency
Figure 1.3

**PULSE QUALITY**

**NORMAL:**
Strong, synchronous, no pulse deficits

**IF ABNORMAL:**
- Postpone elective procedure
- Evaluate for underlying disease
- Use *Cardiac* protocol if emergency

Figure 1.4

**RESPIRATORY**

**NORMAL:**
Ranges highly variable

**IF ABNORMAL:**
- Postpone elective procedure
- Evaluate for underlying disease
- Use *Respiratory Compromise* protocol if emergency
**Figure 1.5**

**BLOOD PRESSURE**

**NORMAL RANGE (MAP):**
80 - 180 mm Hg

**IF HYPERTENSIVE:**
- Assess pain and volume status
- Consider cardiac disease. Postpone elective procedure if possible.
- Use appropriate protocol if emergency

**IF HYPOTENSIVE:**
- Institute appropriate measures
- If BP refractory or worsens, stop procedure and recover patient as quickly and safely as possible

**Figure 1.6**

**MUCOUS MEMBRANES**

**NORMAL:**
Pink - red, capillary refill time (CRT) <2 sec

**IF ABNORMAL OR CHANGING:**
- Perform appropriate diagnostics
Physical Examination for Stressed Pets

If pets are too stressed or fractious to examine, the physical examination must be performed as soon as safely possible or the procedure postponed. Ensure pet weight is current and accurate. Reweigh if necessary to ensure accurate drug dosing for anesthetic and cardiopulmonary resuscitation (CPR) drugs. See the Physiology chapter for more details on stressed/fractious pet physiology.

Remember that the best and safest decision may be to stop the procedure, recover the pet and reschedule.

For pets that appear stressed or fractious, remember that most aggressive behavior is a result of underlying fear or pain.

Consider use of the following techniques:

- If present, address pain with analgesics. Allow time for onset of action and reassess pet.
- Administer pheromone therapy (both dogs and cats). Options include towels, blankets and bandanas for larger dogs.
- Environmental manipulation:
  - Move the pet to a quiet area/room, away from other patients
  - Provide soft, clean bedding
  - Reduce lighting
  - Consider classical music
  - Be aware of smells: alcohols, disinfectants, cleaning solutions.
    - **Canines**: Use non-skid surfaces, handle big dogs on the floor.
    - **Felines**: Have cats wait separately from dogs, use cage door covers or provide a hiding option (e.g., patient-sized box).
- If the procedure can be postponed, and is in the best interest of the pet, postpone and reschedule. Consider instituting a counter-conditioning plan.
- If none of the above are successful, consider the Stressed/Fractious Pet protocol.
The stressed/fractious, brachycephalic pet presents a unique safety challenge for both hospital associates and pets.

- If it is determined that the procedure cannot be completed safely, abort the procedure.
- Stabilize and recover the pet.
- Reschedule the procedure.
- Implement a counter-conditioning program.
- **The key point with any brachycephalic pet is oxygenation and a protected airway.**
  - Provision of oxygen and tracheal intubation should be provided as quickly as possible and whenever medically indicated.

**If the brachycephalic pet is overweight/obese, and the procedure can be postponed, institute a weight loss program and schedule procedures when an ideal body condition has been attained.**

**Notes**

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
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________________________________________________________________________
PREANESTHETIC CLINICAL PATHOLOGY EVALUATION

There are multiple clinical essentials focused on the preanesthetic clinical pathology evaluation and assessment. The importance of this step in the preanesthetic examination cannot be overemphasized.

**CLINICAL ESSENTIAL**

Obtain and review clinical pathology data prior to general anesthesia. Verify, document and address all clinically significant abnormalities prior to premedication, communicate to the team, and discuss with the client. Dismissal of abnormal results is not permitted.

**STOP**

➤ Perform further diagnostics to look for underlying causes
➤ Postpone elective procedures if possible

**CRITICAL STOP**

➤ DO NOT PROCEED WITH GENERAL ANESTHESIA
➤ Institute medical management of underlying disorder or consider referral
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Stop</th>
<th>Critical Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blood Glucose (BG) (mg/dL)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canine: &gt;175</td>
<td>OR</td>
<td>Feline: &gt;250</td>
</tr>
<tr>
<td>OR</td>
<td>Repeat in several hours with the pet in as minimally stressed environment as possible</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>If no change, or worsening, consider evaluation for hyperglycemia</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>If nonelective, proceed with most appropriate protocol</td>
<td></td>
</tr>
<tr>
<td>&lt;50 OR &gt;600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;70</td>
<td>Recheck to ensure accuracy</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>If nonelective procedure, proceed with appropriate IV dextrose supplementation and recheck BG frequently</td>
<td></td>
</tr>
<tr>
<td><strong>Total Protein (TP) (g/dL)</strong></td>
<td>&lt;4.5</td>
<td>OR</td>
</tr>
<tr>
<td>OR</td>
<td>If nonelective procedure, provide colloid support</td>
<td>3</td>
</tr>
<tr>
<td><strong>Albumin (g/dL)</strong></td>
<td>&lt;2</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>If nonelective procedure, provide colloid support</td>
<td>1</td>
</tr>
<tr>
<td><strong>Calcium (Ca²⁺) (mg/dL)</strong></td>
<td>&lt;8</td>
<td>OR</td>
</tr>
<tr>
<td>OR</td>
<td>&gt;12</td>
<td>7</td>
</tr>
<tr>
<td>OR</td>
<td>Check albumin levels</td>
<td>OR</td>
</tr>
<tr>
<td>OR</td>
<td>If nonelective procedure, proceed with Cardiac protocol</td>
<td>16</td>
</tr>
<tr>
<td>Parameter</td>
<td>Stop</td>
<td>Critical Stop</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Sodium (Na⁺) (mEq/L)</td>
<td>&lt;135 OR 170</td>
<td>&lt;125 OR 180</td>
</tr>
<tr>
<td></td>
<td>■ Recheck to ensure accuracy, assess hydration and neurologic status</td>
<td></td>
</tr>
<tr>
<td>Chloride (Cl⁻) (mEq/L)</td>
<td>&lt;100 OR 135</td>
<td>&lt;90 OR 145</td>
</tr>
<tr>
<td></td>
<td>■ If hyperchloridemic, ensure pet is not receiving potassium bromide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Recheck to ensure accuracy, assess hydration and neurologic status</td>
<td></td>
</tr>
<tr>
<td>Potassium (K⁺) (mEq/L)</td>
<td>&lt;3.5 OR 6</td>
<td>&lt;2.5 OR 6</td>
</tr>
<tr>
<td></td>
<td>■ Obtain ECG tracing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ If nonelective procedure, provide appropriate fluid support and <strong>recheck K⁺ before proceeding to anesthesia</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ If K⁺ improves, recheck frequently</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ If nonelective procedure, use appropriate protocol</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Stop</td>
<td>Critical Stop</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------------------------------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td>Hematocrit % (HCT)</td>
<td><strong>Canine: &lt;25 or &gt;55</strong></td>
<td><strong>Feline: &lt;15</strong></td>
</tr>
<tr>
<td>Packed Cell Volume % (PCV)</td>
<td><strong>OR</strong></td>
<td><strong>Canine: &lt;20</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Feline: &lt;20 or &gt;45</strong></td>
<td><strong>OR</strong></td>
</tr>
<tr>
<td></td>
<td>If nonelective procedure:</td>
<td><strong>&gt;60%</strong></td>
</tr>
<tr>
<td></td>
<td>■ Provide transfusion support for anemia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Assess volume status for hemoconcentration</td>
<td></td>
</tr>
<tr>
<td>Platelets (/µl)</td>
<td><strong>&lt;200,000</strong></td>
<td><strong>&lt;60,000</strong></td>
</tr>
<tr>
<td></td>
<td>■ Confirm with peripheral blood smear and manual count</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>&lt;125,000</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Confirm as above and perform appropriate diagnostic testing for thrombocytopenia</td>
<td></td>
</tr>
<tr>
<td>White Blood Cells (WBC) (/µl)</td>
<td><strong>WBC &lt;4000</strong></td>
<td><strong>WBC &lt;2000</strong></td>
</tr>
<tr>
<td>Neutrophils (/µl)</td>
<td><strong>OR Neutrophils &lt;2000</strong></td>
<td><strong>OR Neutrophils &lt;1000</strong></td>
</tr>
<tr>
<td></td>
<td>■ Confirm with blood smear and manual differential count</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>WBC &gt;30,000</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Perform manual differential to assess for stress leukogram</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Perform appropriate diagnostics to determine most likely etiology of leukocytosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ If nonelective procedure, use disease appropriate protocol</td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Normal Range</td>
<td>Critical Stop</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Blood Urea Nitrogen (BUN)</strong> (mg/dL)</td>
<td><strong>Normal range</strong>&lt;br&gt;- Perform appropriate diagnostics&lt;br&gt;- <strong>Canine:</strong> &gt;27&lt;br&gt;- <strong>Feline:</strong> &gt;35&lt;br&gt;Check urine specific gravity (USG)&lt;br&gt;- If USG &gt;1.030 (canine)&lt;br&gt;- OR &gt;1.035 (feline)&lt;br&gt;- If nonelective procedure, use <em>Renal/Post-renal</em> protocol</td>
<td><strong>Critical Stop</strong>&lt;br&gt;- Rehydrate as appropriate and recheck values prior to using <em>Renal/Post-renal</em> protocol</td>
</tr>
<tr>
<td><strong>Creatinine</strong> (mg/dL)</td>
<td><strong>Normal range</strong>&lt;br&gt;- Perform appropriate diagnostics&lt;br&gt;- <strong>Canine:</strong> &gt;1.8&lt;br&gt;- <strong>Feline:</strong> &gt;2.2&lt;br&gt;Check urine specific gravity (USG)&lt;br&gt;- If USG &gt;1.030 (canine)&lt;br&gt;- OR &gt;1.035 (feline)&lt;br&gt;- If nonelective procedure, use <em>Renal/Post-renal</em> protocol</td>
<td><strong>Critical Stop</strong>&lt;br&gt;- Rehydrate as appropriate and recheck values prior to using <em>Renal/Post-renal</em> protocol</td>
</tr>
<tr>
<td>Parameter</td>
<td>Stop</td>
<td>Critical Stop</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Alanine Aminotransferase (ALT) (U/L)</td>
<td><strong>Canine: &gt;2 x upper limit of normal range</strong></td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td><strong>OR</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Feline: &gt;normal range</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Postpone procedure if appropriate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Hepatic evaluation if medically indicated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ If nonelective procedure, use <em>Abdominal/Hepatic</em> protocol</td>
<td></td>
</tr>
<tr>
<td>Alkaline Phosphatase (ALP) (U/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilirubin (mg/dL)</td>
<td><strong>&gt;2.0</strong></td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>■ Pet should be clinically icteric</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Recheck to assess for iatrogenic hemolysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Check PCV/HCT/blood smear/slide autoagglutination to evaluate for hemolysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ If nonelective procedure, use <em>Abdominal/Hepatic</em> protocol</td>
<td></td>
</tr>
<tr>
<td>Lipemia</td>
<td>■ Collect another blood sample in several hours and check to see if lipemia has resolved</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>■ If nonelective procedure, proceed with most appropriate protocol</td>
<td></td>
</tr>
</tbody>
</table>
ASA STATUS

The ASA has established guidelines for the health status in human patients and has devised a Physical Status Classification System for patients undergoing anesthesia. This is a quick and effective tool designed to standardize assessment of patient physical status and to assess anesthetic risk.

In veterinary medicine, it has been shown that a pet’s ASA status is directly related to the risk of perianesthetic death; the perianesthetic death rate in dogs and cats for status I and II was 0.12 percent whereas it increased to 4.8 percent for patients status III - V (a fortyfold increase).16

Determine patient ASA status and document status in the medical record for every anesthetic event. Pets scoring I or II have little to no significant increase in anesthetic risk.

Pets with an ASA status of III - V have a significant increase in anesthetic risk

CLINICAL ESSENTIAL
Assign an ASA status to each pet undergoing general anesthesia and address status appropriately as part of the preanesthetic evaluation
### Table 1.3

<table>
<thead>
<tr>
<th>Status</th>
<th>ASA Classification</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Healthy pet, no disease</td>
<td>Elective OVH or castration</td>
</tr>
<tr>
<td>II</td>
<td>Mild systemic disease or localized disease</td>
<td>Healthy geriatric pet, mild anemia or obesity</td>
</tr>
<tr>
<td>III (fair)</td>
<td>Moderate systemic disease limiting activity but not life-threatening</td>
<td>Mitral valve insufficiency, collapsing trachea, poorly controlled diabetes</td>
</tr>
<tr>
<td>IV (poor)</td>
<td>Severe systemic disease; incapacitating; life-threatening; not expected to live without surgery</td>
<td>Hemoabdomen from splenic rupture, severe traumatic pneumothorax, organ failure</td>
</tr>
<tr>
<td>V (grave)</td>
<td>Moribund; not expected to live &gt;24 hours, with or without surgery</td>
<td>Multi-organ failure, severe shock, terminal malignancy</td>
</tr>
</tbody>
</table>

### Figure 1.7

**DETERMINE ASA STATUS**

- History
- Clinical Pathology Data
- Physical Exam

- I - II
  - There is little to no increase in risk

- III - V
  - Discuss increased risk with the client
  - Maximize preanesthetic medical management
  - Cancel or refer procedure as clinically indicated
Is immediate anesthesia required to address a life-threatening situation? (Immediate anesthesia within 10-15 minutes)

Examples:
- Airway obstruction
- Severe acute hemorrhage

**YES**
- Proceed using *Emergency* protocol
- See *Emergency* protocol for details

**NO**
- Unstable pet:
  - Diagnostic intervention, medical stabilization
- Stable pet:
  - Proceed with most appropriate protocol

After/upon stabilization
SEDATION, IMMOBILIZATION, GENERAL ANESTHESIA

Multiple factors influence the decision to sedate, immobilize or anesthetize a patient, including: patient ASA status, diagnostic or therapeutic needs and patient tolerance to manipulation. The anesthetic team must be prepared to adjust plans and not compromise patient safety.

Sedation may need to advance to immobilization and immobilization may need to convert to general anesthesia.

Monitor the following when deciding to convert to a different procedure:
- Time
- Patient physiologic parameters
- Analgesic needs
- Patient stress

Table 1.4

<table>
<thead>
<tr>
<th>CONSIDERATIONS FOR PROCEDURES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factor</strong></td>
</tr>
<tr>
<td>Invasiveness</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Expected pain</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Patient drug metabolism</td>
</tr>
<tr>
<td>abilities</td>
</tr>
<tr>
<td>Patient requirements</td>
</tr>
</tbody>
</table>
The following charts list the definitions and monitoring requirements for sedation, immobilization and general anesthesia, including those for brachycephalic pets. Consider the unique situation of each pet when choosing which procedure is most appropriate.

**Table 1.5**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Uses</th>
<th>Pet Status</th>
<th>Reflexes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sedation</strong></td>
<td>- Nonpainful procedures</td>
<td>- Ambulatory</td>
<td>- All intact</td>
</tr>
<tr>
<td></td>
<td>- Decrease anxiety</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Immobilization</strong></td>
<td>- Nonsurgical plane of anesthesia</td>
<td>- Non-ambulatory</td>
<td>- Laryngeal and withdrawal reflexes intact</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Pet roused with minimal effort</td>
</tr>
<tr>
<td><strong>General Anesthesia</strong></td>
<td>- Surgery</td>
<td>- Non-ambulatory</td>
<td>- Lack of laryngeal, withdrawal or blink reflexes</td>
</tr>
<tr>
<td></td>
<td>- Invasive or painful diagnostic or therapeutic procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td>Examples</td>
<td>Additional Information</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------</td>
<td>-------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Sedation</td>
<td>■ Otoscopic examination</td>
<td>■ Pet CANNOT be intubated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Blood collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immobilization</td>
<td>■ Clipping matted hair</td>
<td>■ Procedure is not painful and lasts &lt;10 minutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Radiographic positioning</td>
<td>■ <strong>Do not use in brachycephalic pets</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Pedicure in aggressive pets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Anesthesia</td>
<td>■ Castration</td>
<td>■ Pet MUST be intubated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ OVH</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Dental prophylaxis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 1.6

<table>
<thead>
<tr>
<th>Procedure</th>
<th>TPR, CRT, MM Color and Pulse Quality</th>
<th>BP, ECG, Pulse Oximetry</th>
<th>Oxygen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sedation</strong></td>
<td>Required if not ambulatory</td>
<td>As directed by veterinarian</td>
<td>Flow by if necessary</td>
</tr>
<tr>
<td><strong>Brachycephalic-specific sedation</strong></td>
<td>Required if not ambulatory</td>
<td>Pulse oximetry required</td>
<td>Flow by required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BP and ECG as directed by veterinarian</td>
<td></td>
</tr>
<tr>
<td><strong>Immobilization</strong></td>
<td>Required along with anesthetic depth until full recovery</td>
<td>BP and pulse oximetry required</td>
<td>Flow by for all immobilized pets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ECG as directed by veterinarian</td>
<td>Appropriate-sized endotracheal tubes and laryngoscope ready</td>
</tr>
<tr>
<td><strong>General anesthesia</strong></td>
<td>Required until full recovery</td>
<td>All required with TPR, capnography (EtCO₂) as able per hospital</td>
<td>Inhaled oxygen via endotracheal tube</td>
</tr>
</tbody>
</table>

Continuous monitoring of required parameters should always be performed; documentation in the anesthetic medical record should occur at minimum of every five minutes or more often as indicated for quality patient care and when medically indicated.
<table>
<thead>
<tr>
<th>Procedure</th>
<th>IV Catheter and Fluids</th>
<th>Sterile Eye Lubrication</th>
<th>Additional Requirements</th>
</tr>
</thead>
</table>
| **Sedation**               | ■ As directed by veterinarian | ■ As directed by veterinarian | ■ Visual observation at all times  
■ Brachycephalic pets have unique requirements |
| **Brachycephalic-specific sedation** | ■ As directed by veterinarian | ■ As directed by veterinarian | ■ Visual observation at all times  
■ Minimal physical restraint and no muzzle |
| **Immobilization**         | ■ Recommended for all immobilized pets  
■ Catheter required for propofol | ■ Required and repeated as needed | ■ Visual observation at all times  
■ **DO NOT perform on brachycephalic pets** |
| **General anesthesia**     | ■ Required            | ■ Required and repeated as needed | ■ Preanesthetic clinical pathology data  
■ Food (2 - 12 hours) and water (0 - 2 hours) withheld based on veterinarian decision  
■ ASA status determined |
MONITORING AND SUPPORTIVE EQUIPMENT

Safe and successful patient care (whether via sedation, immobilization or general anesthesia) depends upon:

- Functional equipment in good working order
- Appropriate pet monitoring devices
- Emergency preparedness

Appropriate use by trained associates of the items on the following lists helps to minimize pet risk and avoid anesthetic complications.

- Sterile IV catheters (male adapter plugs and tape)
- Dedicated surgical scrub
- Clean and disinfected clippers
- Permanent surgical lighting with additional supplemental lighting (e.g., head lamp)
- Endotracheal tubes in multiple sizes, adequate for each-sized pet
- Laryngoscope (long and short blades) with functional light
- Portable pulse oximeter
- Equipment sufficient to provide monitoring for pet parameters:
  - Temperature
  - Systolic/diastolic/mean arterial blood pressure
  - SpO2
  - Heart and respiratory rates
  - ECG
  - EtCO2 – if hospital is equipped with multi-parameter monitor
- Anesthesia machine
- Resuscitation bag sufficient for pet size or other means to assist ventilation
- Breathing circuit appropriately sized for the pet
- Approved pet warming device for use with anesthetized or unconscious patients (circulating warm water blanket or forced air)
- Stethoscope
Emergency Drug Items

The following labeled and non-expired items for providing emergency care and intervention are required should an adverse event occur. These items are to be maintained and accessible at all times when providing anesthesia to any pet (examples of emergency crash kits are shown in figures 1.9, 1.10):

<table>
<thead>
<tr>
<th>Table 1.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aminophylline</td>
</tr>
<tr>
<td>Atipamezole</td>
</tr>
<tr>
<td>Atropine</td>
</tr>
<tr>
<td>Calcium chloride 10% (or calcium gluconate)</td>
</tr>
<tr>
<td>Colloid fluid solution</td>
</tr>
<tr>
<td>Dexamethasone SP</td>
</tr>
<tr>
<td>Dextrose 50%</td>
</tr>
<tr>
<td>Diphenhydramine injection</td>
</tr>
<tr>
<td>Dopamine</td>
</tr>
<tr>
<td>Ephedrine</td>
</tr>
</tbody>
</table>

Note:

- Certain items may periodically be unavailable or on backorder. Suitable replacements may be found if possible.
- Multi-dose vial usage must follow the clinical essentials for fluid administration and intravenous access requirements.

**CLINICAL ESSENTIAL**

Crash cart containing emergency drugs and equipment is readily available, in a designated place, portable, clearly labeled and appropriately stocked at all times.
Example 1: Emergency Crash Kit

Example 2: Emergency Crash Kit
PERIOPERATIVE ANTIBIOTICS

Numerous studies have evaluated the use of prophylactic, perioperative antibiotics in elective surgical procedures (e.g., OVH and castration). Results of those studies and concerns about antibiotic usage, nosocomial infections and the development of multidrug resistant organisms have led to a reduction in the routine administration of prophylactic antibiotics. The ultimate decision to administer antibiotics lies with the veterinarian.

Adhere to the following for every surgical procedure:

- Vigorously promote aseptic technique.
- Minimize surgical time.
- Minimize tissue manipulation.

The following should be considered when determining if antibiotic use is indicated:

- Factors that increase post-operative wound infection rates:
  - Increased surgical time
  - Decreased veterinarian experience
  - Increased wound contamination level
  - Pet obesity
  - Increased number of associates in surgery room
  - Higher pet debilitation (need for intensive care)
  - Presence of foreign material (e.g., drain)

- Type of procedure being performed:
  - Sterile, elective procedures lasting <90 minutes (for example, OVH and castration)
    - Prophylactic antibiotics not indicated unless directed by the veterinarian
  - Dental prophylaxis
    - Prophylactic antibiotics used at the discretion of the veterinarian
    - Indications may include pets with a history of infectious valvular endocarditis, pets with implanted hardware or congenital cardiac disease.
    - The American Veterinary Dental College (AVDC) has developed a position statement on the use of antibiotics in veterinary dentistry (www.avdc.org/statements.html).
- Oral clindamycin: 5.5 - 11 mg/kg PO q 12h
  - Started two to three days prior to dental
  - OR
    - Administered at minimum of two hours prior to anesthesia
    - Extend therapy as indicated by pet condition
- Oral chlorhexidine rinse
  - Apply to teeth and gingiva immediately after intubation
  - Allow to stay in place 10 minutes before proceeding with dental
- Pets with pyoderma or requiring orthopedic procedures
  - Cefazolin: 22 mg/kg IV (unless contraindicated in patient)
    - Reschedule surgery if possible to allow treatment of pyoderma
    - Administer as slow IV injection
    - Most effective when given just prior to skin incision
    - Repeat in 90 minutes if surgery not completed

Notes
CHECKLISTS

In human medicine, patient morbidity, mortality and complication rates have been significantly reduced with the introduction and usage of checklists. To best support a culture of safety, two checklists have been developed: the Anesthesia Machine Checklist and the Pre-Induction Timeout Checklist.

Anesthesia Machine Checklist (Clinical Essential)

The Anesthesia Machine Checklist is designed to accomplish the following:

- Facilitate communication among anesthetic team members
- Help ensure critical components of anesthesia are verified
- Verify anesthetic equipment is functioning properly
- Allow an objective evaluation of machinery and equipment
- Help minimize patient and associate risk

Directions for correct usage of the checklist are as follows:

- Complete entire checklist prior to each general anesthetic event, ideally prior to premedication administration.
- Address and correct any machine problems or abnormalities prior to premedication.
- If any item on the checklist cannot be completed or verified, do not proceed to general anesthesia.
- Start with the first item and complete each item in order.
- Mark each item box on the checklist once completed.
- For items with a ‘Record’ box, write the value for each item in the corresponding box.
- Document successful completion of the checklist in the anesthesia medical notes.
Options for completing the checklist:
- Checklist may be completed by the veterinarian or dedicated monitoring associate.
- Checklist may be completed collaboratively by the anesthesia team or individually.
- The veterinarian ensures completion of the checklist prior to induction.

A laminated reusable checklist should be maintained with every anesthesia machine in the hospital.

CLINICAL ESSENTIAL
Utilize the Anesthetic Machine Checklist for every general anesthetic event

Notes

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________________________________________________________________________
# ANESTHESIA MACHINE CHECKLIST

Follow and complete prior to every general anesthesia procedure

<table>
<thead>
<tr>
<th>Check <strong>Anesthesia Cart Preventive Maintenance Sticker</strong> to ensure all maintenance has been performed (record date)</th>
<th>Mark</th>
<th>Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verify <strong>Primary Oxygen</strong> source (record volume)</td>
<td>Mark</td>
<td>Record</td>
</tr>
<tr>
<td>Verify available <strong>Back-Up Oxygen</strong></td>
<td>Mark</td>
<td></td>
</tr>
<tr>
<td>Verify <strong>O₂ Flowmeters</strong> working</td>
<td>Mark</td>
<td></td>
</tr>
<tr>
<td>Verify <strong>Vaporizer</strong> full and port tightly closed (record volume)</td>
<td>Mark</td>
<td>Record</td>
</tr>
<tr>
<td>Perform Anesthetic Machine <strong>Leak Test</strong> (If leak is present, DO NOT proceed. See troubleshooting guide.)</td>
<td>Mark</td>
<td></td>
</tr>
<tr>
<td>Verify <strong>Scavenging</strong> on and functional</td>
<td>Mark</td>
<td></td>
</tr>
<tr>
<td>Verify <strong>CO₂ absorbent</strong> fresh or newly replaced (record date replaced)</td>
<td>Mark</td>
<td>Record</td>
</tr>
<tr>
<td>Verify <strong>Monitoring</strong> equipment functional</td>
<td>Mark</td>
<td></td>
</tr>
<tr>
<td>Verify <strong>Emergency Medication</strong> available and expiration dates checked</td>
<td>Mark</td>
<td></td>
</tr>
</tbody>
</table>
Pre-Induction Timeout Checklist (Best Practice)

Purpose

- The Pre-Induction Timeout Checklist is provided as a tool to assist anesthesia teams in ensuring that all preanesthetic clinical essentials have been met.
  - Use of the Pre-Induction Timeout Checklist is considered an anesthetic best practice.

The Pre-Induction Timeout Checklist provides a method to:

- Verify completion of key components of the preanesthetic evaluation prior to induction
- Maximize anesthetic safety and minimize preventable errors
- Facilitate communication among the anesthesia team

Some of the key components of this checklist include:

- Confirmation of patient name and surgical procedure and site
- Identification and discussion of unique patient risks
- Verification of patient ASA status and completion of Anesthesia Machine Checklist

For those teams using the Pre-Induction Timeout Checklist, directions for correct usage of the checklist are as follows:

- The veterinarian and dedicated monitoring associate should complete entire checklist prior to each general anesthetic event.
- Complete checklist prior to administration of medications if pet is tractable OR as soon as possible if the pet is stressed or fractious.
- Complete checklist prior to anesthetic induction.
- If any item on the checklist cannot be completed or verified, DO NOT PROCEED to general anesthesia.
- Start with the first item and complete each item in order.
- Mark each item box on the checklist once completed.
- It is the responsibility of the attending veterinarian to ensure completion of the checklist.
- Document successful completion of the checklist in the anesthesia medical notes.
### PRE-INDUCTION TIMEOUT CHECKLIST

Each task to be completed and checked off by the attending veterinarian or dedicated monitoring associate prior to induction for each general anesthetic procedure

<table>
<thead>
<tr>
<th>Task</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete <strong>physical examination</strong> performed</td>
<td></td>
</tr>
<tr>
<td><strong>Verify Anesthetic Machine Checklist</strong> completed</td>
<td></td>
</tr>
<tr>
<td><strong>Dedicated</strong> monitoring associate assigned</td>
<td></td>
</tr>
<tr>
<td><strong>Patient name</strong> confirmed</td>
<td></td>
</tr>
<tr>
<td>Owner <strong>permission</strong> confirmed</td>
<td></td>
</tr>
<tr>
<td>Complete <strong>patient history</strong> obtained and reviewed</td>
<td></td>
</tr>
<tr>
<td><strong>Clinical pathology</strong> data reviewed and addressed</td>
<td></td>
</tr>
<tr>
<td><strong>Patient ASA status</strong> determined</td>
<td></td>
</tr>
<tr>
<td><strong>Procedure, site, positioning</strong> and <strong>location</strong> confirmed</td>
<td></td>
</tr>
<tr>
<td><strong>Endotracheal tube cuffs</strong> checked and laryngoscope available</td>
<td></td>
</tr>
<tr>
<td><strong>Breathing system</strong> connected, leak free and pop-off valve open and in bag position</td>
<td></td>
</tr>
<tr>
<td>Complete <strong>physical examination</strong> performed after premedications have taken effect</td>
<td></td>
</tr>
<tr>
<td><strong>Patient risks</strong> identified and discussed among anesthetic team</td>
<td></td>
</tr>
<tr>
<td><strong>Emergency</strong> doses precalculated, within reach</td>
<td></td>
</tr>
<tr>
<td><strong>Antibiotics</strong> available (if indicated)</td>
<td></td>
</tr>
</tbody>
</table>
CONCLUSIONS

Safe and successful anesthesia requires a well-trained team working together on behalf of the pet and can be characterized, in part, by the following statements:

- Places the pet in the best condition possible prior to an anesthetic procedure
- Recognizes those times when an anesthetic procedure is not in the pet’s best interests and intercedes on behalf of the pet
- Meets or exceeds all clinical essentials, federal regulations and state practice acts

Remember that the pet’s condition on recovery should be as good, or better, than before an anesthetic procedure.

Any hospital associate has the ability to identify a problem and pause the procedure if there are concerns about pet or associate safety. If concerns have not been addressed, then any associate also has the ability to escalate the issue.


A comprehensive review of all anesthetic equipment and supplies is beyond the scope of this chapter. The following information is meant to provide a summary of important points regarding selection and use of various anesthetic-related items. While other members of the hospital team can select and prepare equipment, it is the responsibility of the attending veterinarian to ensure that the proper anesthetic equipment is chosen for each pet and that the equipment is in good working order prior to induction.
ANCILLARY EQUIPMENT

IV catheters

- When selecting catheter sizes, the largest catheter that will not traumatize the vein should be used.
- The size recommendations (Table 1.8) can be used as a guideline to aid in selecting catheters, and should be used in conjunction with evaluating the patient’s body condition score (BCS), physical condition and vascular status.
- Normal (non-heparinized) saline should be used to flush catheters, T-ports and extension sets prior to use.
- IV fluids are administered via extension sets and T-ports and are not to be delivered via needle through a catheter cap.

Laryngoscopes

- A laryngoscope should always be used to aid intubation.
  - This is especially important when intubating cats and brachycephalic dogs.
- Using a laryngoscope to visualize the trachea reduces the risks of complications during intubation.
- The small blade is typically used for cats and small dogs, and the large blade is typically used for medium and large dogs.
- See *Induction, Monitoring and Recovery* chapter for details regarding intubation.
- Test the laryngoscope and light prior to inducing anesthesia.
- Replace worn or damaged laryngoscopes as needed to ensure proper use and function.
Endotracheal tubes

- **Selection:**
  - Correct endotracheal (ET) tube size will depend on the breed and body condition of the patient.
  - The ET tube must be an appropriate diameter and length for each pet.
  - The largest tube that will fit easily and not irritate or traumatize the trachea is recommended.
  - The length of the ET tube should be measured from the nose to the point of the shoulder (thoracic inlet). The distal end of the tube is appropriately positioned when it is located at the point of the shoulder (just cranial to the thoracic inlet). (Figure 1.13)

**Two methods to determine ET tube diameter:**

1. Palpating the patient’s trachea will often help indicate optimal tube size.
2. The distal end of the endotracheal tube can be measured against the width of the patient’s nasal septum (Figure 1.14). While this method is effective, there is the possibility of selecting an improper size.

- Have at least three ET tubes ready prior to intubation—the tube intended for use, along with one larger and one smaller in diameter.
- This will ensure that additional tubes are at hand if the tracheal diameter is over- or underestimated.
Leak testing:
- Cuffs should be tested for integrity before each use.
- Replace damaged or leaking ET tubes.
- When checking the cuff for leaks, do not overinflate as this will destroy the cuff. (See Induction, Monitoring and Recovery chapter for additional details)

Breathing Circuits

Selection:
- There are two types of breathing circuits available:
  - Non-rebreathing circuit (NRB)
  - Rebreathing circuit
- Breathing circuit selection should be based on the patient’s ideal body weight.
  - Lung size and breathing capacity do not change with weight gain.
  - Use patient history, breed standards and previous BCSs to estimate ideal body weight.
    - See table 1.8 for recommendations on selecting breathing circuit sizes.

Leak testing:
- Breathing circuits are leak tested before each use per the Anesthesia Machine Checklist.
  - At least two of each type of breathing circuit should be in the hospital in case a leak develops in a circuit.
**Non-rebreathing circuit**

- The NRB (e.g., Bain, Jackson-Rees) circuit should be utilized on pets that are 7 kgs or less.
- It is important to remember that a NRB circuit does not utilize the CO₂ absorbent.
  - In order to prevent rebreathing of CO₂, the flow rate of oxygen must be higher than the patient’s respiratory volume.
    - Therefore, the oxygen flow rate should be 150 - 300 mLs/kg/minute when using a NRB system.
- The NRB circuits are consumable items.
  - Replace annually or more frequently as needed.
- **Rebreathing circuit**
  - The rebreathing circuits (pediatric or adult) should be utilized on pets that are greater than 7 kgs.
  - It is important to remember that the rebreathing circuit utilizes the CO₂ absorbent.
    - CO₂ absorbent must be monitored closely and changed regularly.
      - See CO₂ absorbent section for more details.
  - Both sizes of rebreathing circuits are consumable items.
    - Replace every three months or more frequently as needed.

Directions for connecting the pediatric (7 - 10 kg) and adult (>10 kg) rebreathing circuit:

- The patient end is the portion of the breathing circuit connected to the endotracheal tube
- The inhalation limb attaches to the anesthesia machine at the designated port
- The exhalation limb on the rebreathing circuit should be inserted into the anesthesia machine at the rebreathing bag. Always verify that the pop-off valves are open before connecting the patient.

*Always trace the flow of gas and oxygen through the anesthesia machine to ensure that the rebreathing circuit has been set up properly.*  
(see Figure 1.22)
Anesthetic rebreathing bags

■ Selection:
  ● When selecting which size bag to use for rebreathing systems, the decision should be based on the patient’s ideal body weight. (See Table 1.8)
  □ Lung size and breathing capacity do not change with weight gain.
  □ Use patient history, breed standards and previous BCSs to estimate ideal body weight.
  □ Rebreathing bag size should be three to five times tidal volume.
    ○ Tidal volume is estimated to be 10 - 15 mL/kg.

■ Leak testing:
  ● Anesthetic rebreathing bags should be leak tested before each use.
  ● Keep at least two of each bag size on hand in case a leak develops in a bag.
  □ Bags are consumable items.
    ○ Replace every six months or more frequently as needed with the exception of the 5L bag, which is replaced annually or more frequently as needed.

Oxygen masks and diaphragms

■ Selection:
  ● Masks should fit snugly over pet’s muzzle without causing undue stress or anxiety.
  □ Rubber diaphragm can be used to minimize gaps around pet muzzle.
  □ Beware of potential ocular trauma in brachycephalic pets.
    ○ Consider use of ophthalmic lubricating ointment if prolonged usage is anticipated.
  ● If pet resents use of oxygen mask, do not use excessive physical restraint.
  ● Ensure masks and diaphragms are clean, dry and free of visible debris prior to use.
  ● Inspect for signs of wear or damage and replace as needed.
### Table 1.8

#### PERSONAL ANESTHESIA EQUIPMENT SIZING CHART

<table>
<thead>
<tr>
<th>Wt. (kg)</th>
<th>Catheter Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2 kg</td>
<td>22 - 24 gauge</td>
</tr>
<tr>
<td>2 - 8.9 kg</td>
<td>20 - 22 gauge</td>
</tr>
<tr>
<td>9 - 16 kg</td>
<td>18 - 20 gauge</td>
</tr>
<tr>
<td>&gt;16 kg</td>
<td>18 gauge</td>
</tr>
</tbody>
</table>

#### Breathing Circuit

**Less than 7 kg = Non-rebreathing circuit (NRB)**

<table>
<thead>
<tr>
<th>Wt. (kg)</th>
<th>Bag Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;7 kg</td>
<td>Use NRB system</td>
</tr>
<tr>
<td>7 - 13 kg</td>
<td>0.5 - L bag</td>
</tr>
<tr>
<td>13 - 26 kg</td>
<td>1 - L bag</td>
</tr>
<tr>
<td>26 - 40 kg</td>
<td>2 - L bag</td>
</tr>
<tr>
<td>40 - 66 kg</td>
<td>3 - L bag</td>
</tr>
<tr>
<td>66 kg and above</td>
<td>5 - L bag</td>
</tr>
</tbody>
</table>

**Greater than 7 kg = Rebreathing Circuit**

- Bain
- Jackson-Rees

**7 to 10 kg:** Pediatric (pink)

**Greater than 10 kg:** Adult (blue)
OXYGEN AND CARBON DIOXIDE

Oxygen cylinders

There are various sizes of oxygen cylinders available.

The approximate minutes of oxygen remaining in a partial tank can be calculated based on the oxygen tank’s capacity and the oxygen flow rate (L/min).

- **Full tanks, regardless of size, are pressurized to approximately 2,000 psi (pounds per square inch).**
  - This pressure decreases proportionally as the tank empties.

Table 1.9

<table>
<thead>
<tr>
<th>OXYGEN VOLUMES</th>
<th>Small E Tank</th>
<th>Watermelon Tank</th>
<th>Large H Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Tank Volume</td>
<td>600 L</td>
<td>1,200 L</td>
<td>7,000 L</td>
</tr>
<tr>
<td>Full Tank Pressure</td>
<td>2,000 psi</td>
<td>2,000 psi</td>
<td>2,000 psi</td>
</tr>
</tbody>
</table>

Notes

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The volume of oxygen remaining in the tank can be calculated from the tank capacity and the psi:

\[
\text{Current oxygen volume (L)} = \left(\frac{\text{current psi}}{2000 \text{ psi of the full tank}}\right) \times \text{oxygen tank capacity in L}
\]

Minutes of anesthesia time left = \frac{\text{current oxygen volume (L)}}{\text{oxygen flow rate (L/min)}}

**Example 1:**

**600 L tank at a pressure of 500 psi**

Current \(O_2\) volume = \(\frac{500 \text{ psi}}{2000 \text{ psi}} \times 600 \text{ L} = 150 \text{ L}\)

Minutes of anesthesia time left at 1 L/min = \(\frac{150 \text{ L}}{1 \text{ L/min}} = 150 \text{ minutes}\)

**Example 2:**

**1200 L tank at a pressure of 800 psi**

Current \(O_2\) volume = \(\frac{800 \text{ psi}}{2000 \text{ psi}} \times 1200 \text{ L} = 480 \text{ L}\)

Minutes of anesthesia time left at 2 L/min = \(\frac{480 \text{ L}}{2 \text{ L/min}} = 240 \text{ minutes}\)

**Example 3:**

**7000 L tank at a pressure of 1200 psi**

Current \(O_2\) volume = \(\frac{1200 \text{ psi}}{2000 \text{ psi}} \times 7000 \text{ L} = 4200 \text{ L}\)

Minutes of anesthesia time left at 0.5 L/min = \(\frac{4200 \text{ L}}{0.5 \text{ L/min}} = 8400 \text{ minutes}\)
Carbon dioxide absorbent and canister

One of the most important maintenance items on the anesthesia machine is the absorber assembly, which contains the canister for the CO$_2$ absorbent (e.g., soda lime, Carbolime®, Amsorb®, etc.). This removes carbon dioxide from the rebreathing circuit. (Figure 1.15)

The canister and absorbent are common areas for malfunctions in the anesthetic system.

- When filling, be aware that the CO$_2$ absorbent canisters hold approximately one, full 3-pound bag of absorbent.
  - Specific volumes are dependent on the type of canister.
  - There may be granules left over in the bag when the canister is full.
  - Always discard absorbent left in the bag after filling the canister. Absorbent is not safe for use after storage.
- The absorbent has an expected life span based on anesthesia time, or a maximum of four weeks with exposure to room air.

Leaks can result from failure to create a tight seal when replacing the canister.

- This can be caused by misalignment of the canister threads to the monometer threads or by absorbent granules becoming lodged in the threads.
  - Gently shake the canister while filling it with absorbent.
  - This helps prevent loose packing (increased amounts of air between granules) and channeling (development of specific, dedicated pathways through the absorbent within the canister, which minimizes exposure of gasses to absorbent).
  - Packing tightly causes dust formation and increases resistance to ventilation.
When pouring the absorbent into the canister, use care and do not allow granules to fall into the center tube of the canister.

- If granules enter the center tube while filling, empty the canister, clear the center tube of granules and reattempt.
- Granules in the center tube are a safety hazard that have the potential to enter the breathing circuit and the pet’s airway.

CO₂ absorbents will become exhausted or desiccated when used beyond their capacity to hold carbon dioxide.

- Absorbent desiccation occurs from:
  - Utilization within the breathing circuit during anesthesia
  - Unused absorbent in the canister
  - Exposure to room air once bag is opened
- Indications of desiccation are:
  - Fresh granules: soft enough to crush
  - Exhausted granules: chemically altered and hard
- Once the granules become hardened, they will no longer absorb CO₂ and should be thrown away and replaced immediately.
  - Many CO₂ absorbents will turn from white to violet as the granules become exhausted.
  - **Granules may revert back to white after a period of time; this does not indicate that the granules are safe to continue using.**

Dangerous levels of carbon monoxide and compound A may be generated within the anesthesia system if granules are not replaced regularly.
**Required schedule:**

**Figure 1.16: CO₂ absorbent sticker**

- Change the CO₂ absorbent based on anesthesia time or every 30 days, whichever comes first.
  - Absorbent MUST be changed every 30 days, even if maximum anesthesia time has not been reached.
- Mark every 15 minutes of anesthesia time on the canister sticker.
  - When the anesthesia time is reached for the specific type of canister on the machine, change the CO₂ absorbent.
- Remove the old sticker and replace with new every time the absorbent is changed. (Figure 1.16)
ANESTHESIA MACHINE AND ANESTHETIC ADMINISTRATION

Evacuation system

The evacuation system must be hooked up and adjusted correctly to ensure that inhalant anesthesia is delivered properly to the pet.

Set-up

- Connect one end of the evacuation tubing to scavenger output and the other end to the waste gas interface valve on the machine.
  - **Do not connect tubing from output directly to the pop-off valve (rebreathing system) or bag bleed valve (NRB system).**
- Connect one end of the scavenging tubing to either the pop-off valve on the rebreathing head or the bag bleed valve on the NRB system; the other end attaches to the waste gas interface valve on the machine.

Use

- All Banfield hospitals should have a scavenger system.
  - This system has been installed for the safe removal of waste anesthesia generated during anesthesia.
  - It is imperative for associate safety and quality anesthesia that this system is functioning.
  - This unit is turned on and off by a lighted wall switch commonly located inside or directly outside the surgery suite.
    - The switch should be clearly labeled as the scavenger system.
  - It is the doctor’s responsibility to ensure each veterinary technician/assistant understands how the scavenger system works and why it is important to utilize it correctly.
Vaporizer
The vaporizer holds and administers the sevoflurane anesthetic gas.

- Fill new/empty vaporizers with sevoflurane 45 minutes prior to use to saturate the wick.
- Level of sevoflurane within the vaporizer can be determined by visualization of the liquid sevoflurane in the fill chamber.
- Refill vaporizer when the level drops below 50%.

Oxygen Regulator
The oxygen regulator is a medical grade, preset, nonadjustable regulator designed to reduce oxygen tank pressure from approximately 2,000 psi, when full, to approximately 50 psi. The oxygen regulator can fail, resulting in pressure being too high or too low. (Figure 1.17)

Results of high-pressure failure include:
- Failure of the oxygen quick-disconnects
- Failure of the oxygen check valves in dual gas supply
- Failure of tubing
- Failure of oxygen flush
- Oxygen leak from regulator

Results of low-pressure failure include:
- Improper or insufficient oxygen flush
- Improper or insufficient oxygen delivered to patient
- Failure of oxygen to pass through the regulator
Manometer

The manometer indicates the pressure (in cm H₂O) of the gasses (anesthetic gas and oxygen) in the pet’s airways and lungs. Reading the manometer provides a safety measure to ensure that maximum pressures are not exceeded during anesthesia when performing manual ventilation. (Figure 1.18)

 › Damage, including fatal pneumothorax, can result if maximum pressures are exceeded
 › Pressures should not exceed 20 cm H₂O in dogs or 15 cm H₂O in cats
 › Puppies and kittens have even lower maximum pressures, as do some adult animals with respiratory disease. See Protocols for details.

Calibration

■ When not in use, the needle on the manometer gauge should be at zero.
  ● The re-zero screw is located at the 12 o’clock position under the crystal manometer cover.
  ● Remove the cover by turning counterclockwise.
  ● Adjust the screw mechanism until the needle is zeroed.
  ● Replace manometer cover.
■ If the manometer will not re-zero it should be replaced.
■ If the manometer cover is cracked, broken or missing, it should be replaced.
**Oxygen flush valve**

The oxygen flush valve allows the delivery of a high flow rate of oxygen (35 to 75 L/min), while bypassing the vaporizer, quickly filling the breathing system with pure oxygen. (Figure 1.19)

- **Can produce a rapid decrease in anesthetic depth!**
- **Do not use the flush valve when a patient is attached to the anesthesia machine.**
- **Use only** for leak testing procedure.

The flush valve is only used when performing a leak test on the anesthesia machine, prior to attaching the pet to the machine. Do not use the flush valve to inflate the rebreathing bag during an anesthetic procedure. Instead, turn up the oxygen flow rate until the bag fills.

**Notes**

_________________________________________________________________

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_________________________________________________________________
Safety pressure relief valve

Comprised of a “screw-down” portion and the push button (also described as the “pop-off”) valve. (Figure 1.20)

- High pressure can only be maintained in the system when BOTH the screw portion and the pop-off valve are completely depressed.
- The pressure relief valve is designed to stay open to help avoid dangerously increased pressures and resultant trauma to the pet.

When the pop-off valve is forcefully depressed, anesthesia gas and oxygen cannot leave the system.

- Depressing the pop-off valve should only be performed in conjunction with manual ventilation.
- Valve must stay open at all other times to prevent gasses from building to a dangerous pressure within the system and the pet’s airways.

Notes
<table>
<thead>
<tr>
<th>Function</th>
<th>Additional comments</th>
<th>Manometer (cm H₂O)</th>
<th>Pop-off valve</th>
<th>Screw-down valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual ventilation</td>
<td>Higher pressure leak will occur at pop-off valve.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual ventilation</td>
<td>Build to perform partial pressure ventilation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual ventilation</td>
<td>Allows pressure to build.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>Up</td>
<td></td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>Normal ventilation</td>
<td>Default position on machine.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal ventilation</td>
<td>Patient respiration fluctuations slight. May have up.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td>Open</td>
<td>Open</td>
</tr>
<tr>
<td>Open</td>
<td></td>
<td></td>
<td>Open</td>
<td>Open</td>
</tr>
</tbody>
</table>

**Table 1.10**

**SAFETY PRESSURE RELIEF VALVE SETTINGS AND FUNCTIONS**
<table>
<thead>
<tr>
<th>Screw-down valve</th>
<th>Pop-off valve</th>
<th>Function</th>
<th>Manometer reading (cm H₂O)</th>
<th>Additional comments</th>
<th>High pressure leak check</th>
<th>Leak check performed before each anesthetic procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed</td>
<td>Closed</td>
<td>Pet safety</td>
<td>0.5</td>
<td>System will leak to avoid increasing pressure if screw-down valve is accidentally left closed</td>
<td>Do not perform with pet connected to system</td>
<td>Open screw-down valve after leak check is completed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Up</td>
<td>25 - 30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Down</td>
<td>Closed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1.21

NON-REBREATHTING SYSTEM

Oxygen Tank

Oxygen Flow Meter

Vaporizer

100% O₂

100% O₂

O₂ + Sevoflurane

O₂ + Sevoflurane

Non-Rebreathing System

Inhaled O₂ + Sevo

Exhaled Gas

Exhaled Gas

Scavenger System

Patient
Figure 1.22

REBREATHERING SYSTEM

Oxygen Flow Meter

Oxygen Tank

Vaporizer

Soda Lime Canister

Rebreathing Bag

Manometer

Scavenger System

Patient

100% O₂

O₂ + Sevo

CO₂ Removed

O₂ + Sevo + CO₂

100% O₂

Inhaled O₂ + Sevo

Exhaled Gas

O₂ + Sevo
ORDERING AND MAINTENANCE

Please refer to the Ordering and Maintenance Guides per individual piece of equipment.

Notes
TROUBLESHOOTING

When performing any troubleshooting on the anesthesia machine, it is imperative to consider how each part works together and to check each part to accurately identify any leaks or broken equipment.

If patients are not staying anesthetized even with the vaporizer set to 4% or higher, complete the steps below using the information outlined in the following pages:

1. Ensure the appropriately sized breathing apparatus/circuits/ET tubes/etc. are used, and that cuffs are working properly.

2. Check for single bronchus intubation. If the endotracheal tube is accidentally placed down a single bronchus, anesthetic gas is only being administered to one lung and anesthesia will be difficult to maintain. Check for the distal end of the ET tube and back out if necessary.

3. Check the system for any leaks — **check the entire system as there may be more than one leak.**

4. Check that the vaporizer is filled and working correctly.

5. Check the evacuation system for the appropriate balance of positive and negative pressure.

6. Check the oxygen flowmeter and regulator.

7. Check the breathing circuit and ET tube for physical obstructions — if found, remove.
Table 1.11

## ANESTHESIA CART

<table>
<thead>
<tr>
<th>Test procedure</th>
<th>Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform prior to each anesthesia procedure. DO NOT PERFORM with pet attached to machine.</td>
<td>If:</td>
</tr>
<tr>
<td>1. Close pop-off valve</td>
<td>- Manometer drops</td>
</tr>
<tr>
<td>2. Occlude end of anesthesia tube</td>
<td>- Bag deflates</td>
</tr>
<tr>
<td>3. Push oxygen flush valve until:</td>
<td>- Audible hissing noise</td>
</tr>
<tr>
<td>a. Manometer reads 20 cm H₂O</td>
<td>______</td>
</tr>
<tr>
<td>OR</td>
<td>= System Leak</td>
</tr>
<tr>
<td>b. Rebreathing bag is filled</td>
<td></td>
</tr>
<tr>
<td>4. If manometer stays constant with oxygen off = no leaks</td>
<td></td>
</tr>
<tr>
<td>5. Reopen pop-off valve to normal position</td>
<td></td>
</tr>
<tr>
<td>6. Squeeze rebreathing bag to evacuate gas</td>
<td></td>
</tr>
<tr>
<td>7. Remove occlusion from anesthesia tube</td>
<td></td>
</tr>
</tbody>
</table>

### Sources of Leaks

- All hoses
- Rebreathing bags
- Pressure relief valve
- Vaporizer
- Any mechanical fittings
- CO₂ absorbent canister

### Next Steps for Leaks

- Repair or replace leaking equipment
- Repeat leak test. May have more than one source for leaks.
- Ensure proper function prior to anesthesia
# TROUBLESHOOTING GUIDE

## SYSTEM LEAKS

### Table 1.12

## OXYGEN FLOW METER AND REGULATOR

<table>
<thead>
<tr>
<th>Test procedure</th>
<th>Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO NOT PERFORM THIS TESTING WITH PET ATTACHED TO ANESTHESIA MACHINE</strong></td>
<td>■ If needle is stable = no leak</td>
</tr>
<tr>
<td>1. Turn off oxygen flowmeter</td>
<td>■ If needle drops = leak</td>
</tr>
<tr>
<td>2. Turn on oxygen tank</td>
<td>■ The faster the drop, the bigger the leak</td>
</tr>
<tr>
<td>3. Watch oxygen tank pressure gauge</td>
<td></td>
</tr>
<tr>
<td>4. When needle is stable, turn off oxygen tank</td>
<td></td>
</tr>
<tr>
<td>■ Check oxygen flowmeter knob for correct function</td>
<td></td>
</tr>
<tr>
<td>■ Check oxygen tank is on</td>
<td></td>
</tr>
<tr>
<td>■ If oxygen flush and flowmeter do not work with tank turned on:</td>
<td></td>
</tr>
<tr>
<td>● Oxygen tank or regulator needs to be replaced</td>
<td></td>
</tr>
<tr>
<td>● Replace with new oxygen tank or change regulator</td>
<td></td>
</tr>
<tr>
<td>■ Oxygen regulator or hose nut is loose</td>
<td>■ Tighten nuts</td>
</tr>
<tr>
<td>■ Oxygen flowmeter is stuck in open position (float ball in tube does not go to zero)</td>
<td>■ Replace flowmeter</td>
</tr>
<tr>
<td>■ Oxygen flush valve seal is defective</td>
<td>■ Replace flowmeter and flush systems</td>
</tr>
<tr>
<td>■ Fitting on back of flowmeter is loose</td>
<td>■ Tighten fitting</td>
</tr>
<tr>
<td>■ Faulty check valve in dual gas supply</td>
<td>■ Replace check valve</td>
</tr>
</tbody>
</table>

## Sources of Leaks

<table>
<thead>
<tr>
<th>Sources of Leaks</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen regulator or hose nut is loose</td>
<td>Tighten nuts</td>
</tr>
<tr>
<td>Oxygen flowmeter is stuck in open position (float ball in tube does not go to zero)</td>
<td>Replace flowmeter</td>
</tr>
<tr>
<td>Oxygen flush valve seal is defective</td>
<td>Replace flowmeter and flush systems</td>
</tr>
<tr>
<td>Fitting on back of flowmeter is loose</td>
<td>Tighten fitting</td>
</tr>
<tr>
<td>Faulty check valve in dual gas supply</td>
<td>Replace check valve</td>
</tr>
</tbody>
</table>

## Additional Checks

- Check oxygen flowmeter knob for correct function
- Check oxygen tank is on
- If oxygen flush and flowmeter do not work with tank turned on:
  - Oxygen tank or regulator needs to be replaced
  - Replace with new oxygen tank or change regulator
**TROUBLESHOOTING GUIDE**

**SYSTEM LEAKS**

### Table 1.13

<table>
<thead>
<tr>
<th>ENDOTRACHEAL TUBE</th>
<th>Test procedure</th>
<th>Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test procedure</strong></td>
<td><strong>Leaks</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Perform with pet anesthetized, intubated and attached to machine. | ■ Hissing or sound of airflow around tube  
■ Unable to maintain pressure |       |
| 1. Close pop-off valve | | |
| 2. Gently squeeze rebreathing bag to pressure of 18 - 20 cm H₂O | | |
| ■ Do not hold breath for more than 2 - 3 seconds | | |
| 3. Listen for hissing or leaking around tube | | |

**Sources of Leaks**

- May occur around ET tube with pet relaxation
- Inadequate inflation of ET tube cuff
- Defective ET tube cuff

**Next Steps for Leaks**

- If leaking, add small increments of air to cuff, only until leak stops
- If unable to resolve leak, extubate and place alternate ET tube
### EVACUATION SYSTEM

<table>
<thead>
<tr>
<th>Test procedure</th>
<th>Next Steps for Leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gently squeeze rebreathing bag to pressure of 18 - 20 cm H&lt;sub&gt;2&lt;/sub&gt;O.</td>
<td>■ Contact CTS Facilities team for pressure imbalance assistance</td>
</tr>
<tr>
<td>a. Hold a tissue to the opening of the scavenger tube</td>
<td></td>
</tr>
<tr>
<td>b. Tissue should be gently pulled to the tube</td>
<td></td>
</tr>
<tr>
<td>2. Do not allow tissue to be pulled into the tube</td>
<td></td>
</tr>
<tr>
<td>3. Ensure adjustment handle is set to approximately 45 degrees (if applicable)</td>
<td></td>
</tr>
</tbody>
</table>

### VAPORIZER

<table>
<thead>
<tr>
<th>Ensure the following:</th>
<th>Additional Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ Appropriately filled</td>
<td>■ System is self-contained</td>
</tr>
<tr>
<td>■ Cap and drain are both tightly closed</td>
<td>■ Do not attempt to adjust or tighten other parts of vaporizer</td>
</tr>
<tr>
<td>■ Inlet and outlet adaptors fit snugly</td>
<td></td>
</tr>
</tbody>
</table>

**CLINICAL ESSENTIAL**

Anesthetic machines and equipment are maintained and a permanent log of maintenance is kept
ABBREVIATIONS

- ANS: autonomic nervous system
- ASA: American Society of Anesthesiologists
- BP: blood pressure
- BPM: beats per minute
- CNS: central nervous system
- CO: cardiac output
- CRI: constant rate infusion
- HCM: hypertrophic cardiomyopathy
- HR: heart rate
- MAP: mean arterial pressure
- PNS: peripheral nervous system
- SNS: somatic nervous system
- SV: stroke volume

DEFINITIONS

- **Adrenergic**: Related or responsive to epinephrine and/or norepinephrine
- **Agonist**: Substance that combines with a receptor and initiates a physiologic response
- **Antagonist**: Substance that blocks a receptor or blocks/reverses a physiologic response
- **Cholinergic**: Related or responsive to acetylcholine
INTRODUCTION

A comprehensive review of physiology is beyond the scope of this update. The following information is meant to provide a summary of important points regarding:

- Neurologic and cardiovascular physiology
- Resultant effects of anesthetic and analgesic agents on canine and feline physiology
- Physiology of stressed or fractious pets

PERFUSION

Defining Good Perfusion

- Good perfusion is the state of blood flow and blood volume adequate to push red blood cells to the lungs, carry oxygen and deliver it to the tissues.
- A pet with good perfusion can be described as having adequate circulating blood volume, blood pressure, oncotic pressure and cardiac output (CO) to maintain normal physiology and function.

Perfusion and Anesthesia Maintenance

- All anesthetic drugs affect perfusion to some extent.
  - The vast majority of anesthetic and preanesthetic agents will decrease cardiac output and decrease perfusion.
  - Most drug effects are dose dependent.
  - Understanding the mechanisms of how drugs alter perfusion during anesthesia is critical to be able to maintain a pet’s perfusion when placing them under anesthesia.

Cardiac Output (CO) = Heart Rate (HR) x Stroke Volume (SV)

- CO is defined as the volume of blood pumped by the heart.
- SV is defined as the amount of blood pumped with each contraction.
- SV is dependent on venous return to the heart (preload), total peripheral resistance (afterload) and cardiac contractility.
It is important to note that preload and afterload affect cardiac output.

- Pets with systemic hypertension have a higher afterload which can decrease cardiac output, due to the heart pumping against higher pressure.
  - Control hypertension prior to anesthesia.
- Pets with hypotension often have reduced preload and, therefore, decreased cardiac output.
  - Assess hydration status and administer fluids as medically indicated.

- Pets with abnormal blood pressures must be stabilized prior to anesthesia. Postpone/reschedule anesthesia if cardiac output cannot be stabilized.

Cardiac output is fundamental to perfusion.

- Pets with diseased heart muscles, excessively high heart rates or excessively small cardiac chamber sizes, as in feline hypertrophic cardiomyopathy (HCM), may have stroke volumes so small that cardiac output is severely compromised.
  - These pets are often subclinical upon presentation and decompensate rapidly under anesthesia.
- Heart rate reduction is expected after administration of preanesthetic medications.
  - Re-evaluation of vital signs impacting cardiac output is important to ensure adequate perfusion in the post-premedication, pre-induction phase of anesthesia.
  - If the heart rate does not decrease after premedications are administered and allowed to take effect, or if heart rate is increased, the hospital team should stop and re-evaluate whether anesthesia is appropriate. (Table 1.16)

**CLINICAL ESSENTIAL**

Perform a preanesthetic physical examination. Reevaluate vital signs (cardiovascular parameters) after premedication prior to induction.
### Table 1.16

**EXAMPLES OF HEART RATES AND PREMEDICATION EFFECTS (FELINE)**

<table>
<thead>
<tr>
<th>Prior to Premedication</th>
<th>Post Premedication</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR = 200 beats per minute (BPM)</td>
<td>HR = 140 BPM</td>
<td>Proceed with procedure if all other physical parameters normal.</td>
</tr>
<tr>
<td>HR = 230 BPM</td>
<td>HR = 220 BPM</td>
<td>Reassess the patient, paying particular attention to the cardiovascular system. Evaluate for underlying cardiac disease. Reschedule anesthesia when medically indicated.</td>
</tr>
</tbody>
</table>

- Circulating blood volume is critical to maintaining blood flow.
  - Protocols include IV fluids (colloids and crystalloids) to help maintain cardiovascular volume and tissue perfusion that could be compromised during anesthesia.

- Oncotic pressure also affects perfusion.
  - If albumin and total protein levels are significantly below normal, pulmonary edema can result from fluid movement into the interstitium.
  - Ensure total protein and albumin concentrations are within normal limits prior to anesthesia.

**CLINICAL ESSENTIAL**

Obtain and review clinical pathology data prior to general anesthesia.
PHARMACOLOGIC INFLUENCE ON THE NERVOUS SYSTEM

Divisions (Figure 1.23)

The nervous system can be divided into two broad anatomic categories:

<table>
<thead>
<tr>
<th>Central Nervous System (CNS)</th>
<th>Peripheral Nervous System (PNS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain and spinal cord</td>
<td>Nerves located outside the CNS extending into the “periphery”</td>
</tr>
</tbody>
</table>

Anesthesia will affect both of these systems in different ways, depending on the specific subset of receptors associated with the nervous tissue in these different regions.

Central Nervous System

- Various sections of the brain are associated with different clusters of nervous tissue with unique functions.
- Anesthetic induction and maintenance agents affect these areas to cause the unconsciousness, immobilization and amnesia associated with anesthesia.
  - Some agents also modulate the centrally mediated perception of pain.

Peripheral Nervous System

Comprised of the following:

<table>
<thead>
<tr>
<th>Cranial Nerves</th>
<th>Spinal Nerves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originate from the brain stem</td>
<td>Arise from the spinal cord</td>
</tr>
</tbody>
</table>

- Involved with the control and sensation of the various effector sites (muscles, sensory systems and glandular tissue)
- Includes both autonomic nervous (ANS) and somatic nervous (SNS) subsystems (also called involuntary and voluntary, respectively)
  - The autonomic subsystem is further divided into the parasympathetic and sympathetic nervous system.
  - Understanding these functional systems of the ANS is important for the safe use of anesthesia and the drugs that modulate anesthesia.
Figure 1.23

THE NERVOUS SYSTEM

CNS
Central physiologic integration and control centers

PNS
Communication lines between CNS and rest of body

ANS
Conducts impulses from CNS to heart, smooth muscles and glands

SNS
Conducts impulses from CNS to skeletal muscles

SYMPATHETIC DIVISION
Mobilizes body systems during activity (“fight or flight”)

PARASYMPATHETIC DIVISION
Conserves energy. Promotes “housekeeping” functions (e.g., digestion) during rest
Sympathetic (Adrenergic) Nervous System – “Fight or Flight” (Figure 1.24)

- Acute stimulation of this system causes rapid release of epinephrine, as well as acetylcholine and norepinephrine.
- Effects of stimulation are mediated through the alpha and beta receptors. (Table 1.17)

![Figure 1.24](image_url)

**SYMPATHETIC RESPONSES MEDIATED BY ALPHA AND BETA RECEPTORS**

- Increased cardiac contractility
- Increased heart rate (HR)
- Bronchodilation
- Mydriasis (pupil dilation)
- Peripheral vasoconstriction
- Increased shunting of blood to the internal, larger vessels and dilation of skeletal blood vessels
Table 1.17

<table>
<thead>
<tr>
<th>Receptor Type</th>
<th>Alpha-1</th>
<th>Alpha-2</th>
<th>Beta-1</th>
<th>Beta-2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Site of Receptors</strong></td>
<td>Blood vessels</td>
<td>Neural tissue and blood vessels</td>
<td>Cardiac tissue</td>
<td>Respiratory tract</td>
</tr>
<tr>
<td><strong>Stimulation Results In</strong></td>
<td>Peripheral vasoconstriction leading to increased blood pressure (BP)</td>
<td>CNS: sedation and mild analgesia</td>
<td>Cardiac effects predominate: Increased HR and contractility resulting in increased CO</td>
<td>Respiratory effects predominate: Bronchodilation due to relaxation of bronchiolar smooth muscle</td>
</tr>
<tr>
<td></td>
<td>Use of antagonist will result in decreased BP</td>
<td>PNS: peripheral vasoconstriction, transient hypertension, reflex bradycardia</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agonists</strong></td>
<td>Epinephrine, ephedrine</td>
<td>Dexmedetomidine</td>
<td>Epinephrine, ephedrine, dobutamine</td>
<td>Epinephrine, albuterol, terbutaline</td>
</tr>
<tr>
<td><strong>Antagonists</strong></td>
<td>Acepromazine</td>
<td>Atipamezole</td>
<td></td>
<td>Beta blockers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Atenolol, propranolol</td>
<td>Propranolol</td>
</tr>
<tr>
<td><strong>Additional Information</strong></td>
<td>See stressed/fractious pet physiology for discussion of “epinephrine-reversal”</td>
<td>Powerful sedatives with the potential for significant side effects</td>
<td>Beta-1 effects are typically cardiac in nature. Atenolol is a relatively specific beta-1 antagonist.</td>
<td>Albuterol is a relatively specific beta-2 agonist</td>
</tr>
</tbody>
</table>
Utilizing Alpha-2 Agonists

CAUTION:

- Pets can still be roused while under the influence of an alpha-2 agonist.
  - Immobilized pets may still pose an associate safety risk.
  - Utilize extreme caution, especially when handling a stressed/fractious pet.
- Alpha-2 agonists significantly lower or eliminate the need for induction agents.
  - Induction doses of propofol may be as low as 1 mg/kg.
    - Titrate propofol carefully and follow administration instructions closely.
- Use of alpha-2 agonists may reduce the minimum alveolar concentration of sevoflurane.
  - Maintenance under general anesthesia may require significantly less inhalant anesthetic gas.
- May cause vomiting, especially in cats.
  - Fasting is recommended to reduce stomach contents.

**Recommended that only clinically healthy dogs and cats (ASA status I or II) be treated with alpha-2 agonists due to the cardiovascular effects**

Clinical Use:

- Powerful sedative and analgesic effects utilized for:
  - A preanesthetic sedative-analgesic agent
  - A constant rate infusion (CRI) supplement to inhalant anesthesia and in the post-operative period
  - A synergistic supplement to local anesthetics in regional nerve blocks
Side Effects:

- Can be very significant, often impacting cardiovascular function
  - Stimulation of post-synaptic alpha-2 receptors causes constriction of blood vessels resulting in significant, yet transient, hypertension.
  - The body responds with a decrease in heart rate (reflex bradycardia).

  - **Cardiac output may be diminished by as much as 40 to 50%**

- Clinically, the peripheral vasoconstriction can cause significant blanching of the gums and, sometimes, decreased palpable pulse pressure.
- Use of an alpha-2 agonist in combination with other medications (usually ketamine and butorphanol) helps to decrease the dose required and mitigates these cardiovascular effects.

Notes

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Parasympathetic (Cholinergic) Nervous System – “Housekeeping”

- The parasympathetic, cholinergic system is functionally and anatomically separate from the sympathetic (adrenergic) system.
- Primarily responsible for effects that are essentially opposite of the sympathetic pathways.
- Receptor types include nicotinic and muscarinic receptors; however, the division between receptors is not as clear in the parasympathetic system.

Table 1.18

<table>
<thead>
<tr>
<th>Cholinergic Pathway</th>
<th>Potential Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agonists</strong></td>
<td></td>
</tr>
<tr>
<td>Acetylcholine</td>
<td>Decreased heart rate</td>
</tr>
<tr>
<td>Bethanechol</td>
<td>Increased respiratory secretions</td>
</tr>
<tr>
<td></td>
<td>Increased gastrointestinal motility</td>
</tr>
<tr>
<td></td>
<td>Increased secretion of gastric fluid</td>
</tr>
<tr>
<td></td>
<td>Increased urination</td>
</tr>
<tr>
<td><strong>Antagonists/Anticholinergic drugs</strong></td>
<td></td>
</tr>
<tr>
<td>Atropine</td>
<td>Increased heart rate</td>
</tr>
<tr>
<td>Glycopyrrolate</td>
<td>Decreased respiratory secretions</td>
</tr>
<tr>
<td></td>
<td>Decreased salivation</td>
</tr>
<tr>
<td></td>
<td>Effects may be mediated by vagus nerve</td>
</tr>
</tbody>
</table>
Utilizing Anticholinergic Drugs

Clinical Use:

- Anticholinergic drug therapy will not always cause an increase in heart rate.
- Administration of an anticholinergic drug (atropine or glycopyrrolate) does not increase the heart rate above the basal rate.
  - **Increased heart rate is a result of decreased vagal tone.**
    - Innervation from the vagus nerve to the heart helps control normal heart rate.
    - The vagus nerve functions to slow the heart rate by inhibiting the sinoatrial node or "pacemaker" of the heart.
  - Heart rate may be elevated after administration of anticholinergic drugs due to the presence of epinephrine in the system affecting the beta-1 pathways.
    - Beta-1 pathway must be stimulated (e.g., via epinephrine release) if the heart rate is to be increased above the basal rate with administration of anticholinergics.
- Anticholinergic drug administration blocks the ability of the heart to slow in response to appropriate vagal stimulation.
  - May result in unwanted tachycardia (elevated heart rate)
  - Pets with a normal heart rate and blood pressure before anesthesia rarely benefit from pre-emptive anticholinergic administration.
  - **Not applicable to pediatric pets**
    - Pediatric cardiac output is much more dependent upon heart rate.
    - Preventing bradycardia is very important.
    - An anticholinergic is included as a premedication in pediatric protocols.
Side Effects:

- Tachycardia after anticholinergic drug administration is difficult to manage therefore careful and cautious use of anticholinergics is warranted.
  - Supporting subsequent increased myocardial oxygen demand with supplemental oxygen, and administering IV fluids to support circulating volume, is helpful.
  - If tachycardia is present prior to anticholinergic drug administration, give supplemental oxygen and IV fluids and postpone induction of anesthesia until the heart rate normalizes or the primary cause is identified and treated (e.g., pain).

Table 1.19

<table>
<thead>
<tr>
<th>HR</th>
<th>Mean Arterial Pressure (MAP)</th>
<th>Comments</th>
<th>Use of Anticholinergic</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 BPM</td>
<td>100 mm Hg</td>
<td>Bradycardia is tolerated with a normal MAP as perfusion should be maintained</td>
<td>Not indicated Monitor HR and BP</td>
</tr>
<tr>
<td>50 BPM</td>
<td>50 mm Hg</td>
<td>Bradycardia may not be tolerated with a below normal MAP as this would be expected to result in poor perfusion</td>
<td>Consider use of an anticholinergic to improve perfusion</td>
</tr>
</tbody>
</table>
STRESSED/FRACTIOUS PET PHYSIOLOGY

Stressed Versus Fractious

The terms “stressed” and “fractious” are often used interchangeably, and while there may be physiologic similarities, the stressed or anxious pet should not be treated as a fractious pet.

- Stressed pets may also be described as fearful, anxious or distressed.
- Fractious pets may also be described as unruly, reactive or difficult to control. They may or may not have an underlying reason (e.g., pain) for their behavior.
Stress may be significant even when a pet is not fractious. Examples include:
- Pets that are in pain
- Pets that are experiencing an airway obstruction
- Pets that are fearful

Epinephrine may be present in both the stressed and the fractious pet, mediating the physiologic responses. However, the circulating half-life of epinephrine is short. The danger to the stressed pet may be reversed or minimized by:
- Providing sedation
- Minimizing stress triggers
- Giving time
- Implementing a counter-conditioning plan

Stressed and/or fractious pets are at a greater risk for adverse events associated with anesthesia

The best decision for the stressed or fractious pet may be to stop the procedure and reschedule for a later time

Identify potential stress triggers for pets and reschedule for a time when stresses can be minimized.

- Considerations for potential triggers:
  - Exposure to other pets and unfamiliar people
  - Environmental (e.g., activity, smell, noise)
  - Gender of hospital associate
  - Handling techniques of hospital associate
  - Unfamiliar kennels/carriers/crates

- Implement a counter-conditioning plan (see References for details)
Anesthetic Implications

Periodically there may be stressed or fractious pets where anesthetic procedures are medically indicated and cannot be postponed or rescheduled.

Stressed and fractious pets release a significant amount of catecholamines (e.g., epinephrine, norepinephrine) that lead to physiological effects such as tachycardia, hypertension, tachypnea (increased respiratory rate), hyperthermia (increased body temperature) and mucous membrane color changes.

All these effects increase the risk of anesthesia in these pets. Close monitoring of the cardiovascular, respiratory and central nervous systems is required to anticipate complications and prevent anesthetic accidents.

Stressed or fractious cats pose a particular challenge to safe anesthesia, due to the potential for underlying cardiac disease.

- HCM in cats is often subclinical and not evident until the cat is physiologically challenged (as with anesthesia) or the disease is advanced.
- One study demonstrated cardiomyopathy in 15 percent of apparently normal cats.4
- Hypertrophic myocardial changes render pets more susceptible to myocardial hypoxia, ischemia and arrhythmias.
- During stressful episodes such as anesthesia and surgery, activation of the sympathetic nervous system leads to an accelerated heart rate, decreased cardiac filling time and myocardial perfusion and increased myocardial oxygen demand.

Stressful episodes may exacerbate cardiac disease and cause clinical decompensation

Handle stressed/fractious cats with extreme caution and remember that the best decision for the pet may be to postpone anesthesia
Acepromazine in stressed/fractious pets and “epinephrine reversal”

- Epinephrine is often released endogenously during stressful events.
  - Epinephrine stimulates both alpha and beta receptors.
- When acepromazine (an alpha-1 antagonist) is given as a premedication it blocks the effect of epinephrine on alpha, but not beta receptors (beta receptors are still stimulated).
  - Arteriole constriction does not occur but heart rate and contractility are increased.
  - This vasodilation results in pooling of the circulatory volume in the peripheral vascular bed of skeletal muscles.
  - As a result, there is decreased venous return, reduced preload and decreased cardiac output, resulting in a relative hypovolemic shock.
  - This is termed “epinephrine reversal”.

Avoid acepromazine in fractious pets

Table 1.20

<table>
<thead>
<tr>
<th></th>
<th>Canines</th>
<th>Felines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalloids</td>
<td>20 mL/kg bolus Repeat as needed up to 80 mL/kg</td>
<td>5 mL/kg bolus Repeat as needed up to 40 mL/kg</td>
</tr>
<tr>
<td>Colloids</td>
<td>5 mL/kg bolus Repeat as needed or begin constant rate infusion (CRI) up to 20 mL/kg/day</td>
<td>2.5 mL/kg bolus Repeat as needed or begin CRI up to 10 mL/kg/day</td>
</tr>
</tbody>
</table>

Monitor cardiac output and adjust fluid therapy and supportive measures as medically indicated:

- Heart rate
- Blood pressure
- Mucous membrane color, etc.
References and suggested reading for Physiology:


Notes

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References and suggested reading for *Clinical Essentials* and *Best Practices*:

<table>
<thead>
<tr>
<th>Aseptically place a sterile IV catheter and T port for every patient receiving IV fluids(^{12, 14, 20})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mark fluid bags with date, time and all additives when initially accessed or when administration sets are attached (fluid bags are spiked), using the available label(^{13})</td>
</tr>
<tr>
<td>Use aseptic technique when accessing patient IV lines, multi-use vials and fluid bags(^{12, 14, 20})</td>
</tr>
<tr>
<td>Change extension sets between each patient undergoing general anesthesia. Use a new, sterile extension set for each patient receiving IV fluids(^{12, 13})</td>
</tr>
<tr>
<td>Discard ALL used fluid bags and administration sets at the end of the day(^{12, 32})</td>
</tr>
<tr>
<td>Discard fluid bags and administration sets immediately if contamination is noted or suspected and replace with new(^{28})</td>
</tr>
</tbody>
</table>
| Discard fluid bags and administration sets upon discontinuation of fluid therapy and replace with new in ANY of the following\(^{11, 14, 20}\):
  - If backflow of blood into any portion of the fluid line is noted
  - After fluids have been used on a pet with a known infection
  - If any supplemental therapeutics have been injected into the bag or administration line
  - If fluid bags and administration sets are used to deliver a fluid which may promote microbial growth |
| Clamp administration sets closed in between procedures (within day of use window) and place new, sterile needle with cap in place over end of administration set. Hang administration set when not in use so as to not contact patients, tables, or other materials\(^{13, 14, 28}\) |
| For fluid bags and administration sets used for SC fluid administration\(^{12, 32}\):
  - Discard immediately if any signs of gross contamination
  - Use a new extension set and needle for each patient
  - Discard at end of day |
| Multi-dose vials\(^{11, 14, 20, 28}\):
  For medication/dilution/reconstitution:
  - Use aseptic technique
  - Discard immediately if any signs of gross contamination
  - Obtain a new, sterile syringe and needle for each use
  - Discard syringe and needle after each use
  If fluid bags used for medication dilution, reconstitution, or preparing flush solution:
  - Follow requirements for multi-use vials
  - Discard fluid bag at end of day |
**MEDICAL QUALITY STANDARDS**

**Best Practices** are standards of practice that meet or exceed an expected level of care and encompass a scale of care from “desirable” to “aspirational.”

<table>
<thead>
<tr>
<th>GENERAL</th>
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<tbody>
<tr>
<td>Designate dedicated anesthetic induction and recovery areas⁷, 21, 26</td>
</tr>
<tr>
<td>Review anesthetic human safety hazards annually with all hospital associates²</td>
</tr>
<tr>
<td>Review current CPR recommendations and provide CPR training at least annually to all hospital associates², 25</td>
</tr>
<tr>
<td>Use a new fluid bag and fluid administration set for each pet, regardless of route of fluid administration. Identify each bag with pet name, in addition to date and time¹², 13, 14, 20, 28, 32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
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</thead>
<tbody>
<tr>
<td>Utilize esophageal instrumentation to provide further means of patient monitoring⁷</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PREANESTHETIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify, discuss and address genetic conditions that may impact anesthesia⁷</td>
</tr>
<tr>
<td>Provide pre-oxygenation to all pets who will benefit from and tolerate the procedure⁷, 18</td>
</tr>
<tr>
<td>Utilize the preanesthetic timeout checklist for every general anesthetic procedure⁷</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MONITORING &amp; RECOVERY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train all hospital associates in the appropriate use of pain scales and recognizing pain in pets. Bring concerns of patient analgesia to the attending veterinarian’s attention. Review pain recognition training annually⁵, ¹⁶</td>
</tr>
<tr>
<td>Utilize advanced analgesic therapies (soaker catheters, spinal blocks, etc.) appropriately to contribute to pet safety and comfort¹⁶</td>
</tr>
<tr>
<td>Encourage and pursue additional training in advanced anesthetic administration and monitoring for hospital associates⁷</td>
</tr>
<tr>
<td>Utilize and follow an anesthetic recovery form with all general anesthetic procedures³, ⁶</td>
</tr>
</tbody>
</table>
The pets featured on the front and back covers of these books were adopted from rescues and shelters across the country. Banfield Pet Hospital supports the efforts of companion animal rescues and shelter societies to provide safe and loving homes to pets in need and encourages the adoption of those pets awaiting a forever home.