

# ANESTHESIA

## IN THE REAL WORLD

Evaluating preanesthetic patients

Anesthesia for non-anesthesiologists

Turn the gas off—we're done!

Recovery from anesthesia

Mandatory preanesthetic evaluation:

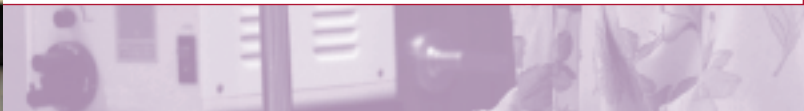
Helping to avoid anesthetic nightmares



# EVALUATING PREANESTHETIC PATIENTS



Karen Faunt, DVM, MS, DACVIM (Small Animal)



Anesthesia is an extremely common procedure in veterinary practice; nonetheless, it carries a risk of morbidity and mortality. A pre-anesthetic evaluation helps practitioners anticipate potential adverse events and proceed with the best course of action: address any abnormalities in advance, refer the patient to a facility equipped for high-risk patients, or even cancel the anesthetic procedure. A systematic approach helps practitioners establish baseline data and completely assess risk factors.<sup>1</sup>

Patients undergoing anesthetic procedures are subject to a number of potential risks, including hypotension, dysrhythmias, hypoxemia, and even death.<sup>1</sup> To ensure that each patient receives a complete diagnostic workup with attention to all potential variables, a systematic approach is best. Consistency eliminates confusion that may occur in busy hospitals with multiple doctors using different protocols, and it also promotes the establishment of best practices. A standardized, systematic approach can also increase clients' respect when they see a procedure in place to ensure the safety of their pets.

The most important goal of the pre-anesthetic examination is an accurate assessment of the patient's health status. The evaluation answers three questions:

1. Is the patient in the best possible condition to undergo anesthesia?
2. Should the patient's condition be improved before the anesthetic procedure?
3. Does the patient's health status or concurrent medication influence the anesthetic event, and should the procedure therefore

be delayed or even canceled? The preanesthetic evaluation may reveal reasons to delay, cancel, or reschedule a procedure until the patient's condition is optimal. In addition to providing time for a patient's condition to stabilize or improve, a delay also allows the practitioner time to conduct additional testing to obtain more information on the patient's health or, if necessary, to find a team that is better equipped to manage high-risk patients during anesthesia.

The importance of collecting baseline data should not be underestimated. Charting trends over time is one of the best ways to facilitate early diagnosis and treatment of disease, and in many cases collecting the preoperative blood sample may be the only opportunity to obtain baseline clinical pathologic data on a patient.

## Evaluation and preparation

A complete preanesthetic evaluation should consider the medical history, physical examination findings, and laboratory data. Because the patient's health status and disease history are critical factors in determining the appropriate anesthetic protocol, evaluation involves more than performing a battery of tests. It requires using all available information to determine the safest anesthesia method—or whether anesthesia is appropriate.

Age, sex, and breed are highly important elements to consider. Different breeds and sexes are predisposed to different conditions, such as dilated cardiomyopathy in cocker spaniels and immune-mediated disease in female dogs. A thorough medical history is

## Preanesthetic assessment goals

The objectives of a preanesthetic medical assessment are to:

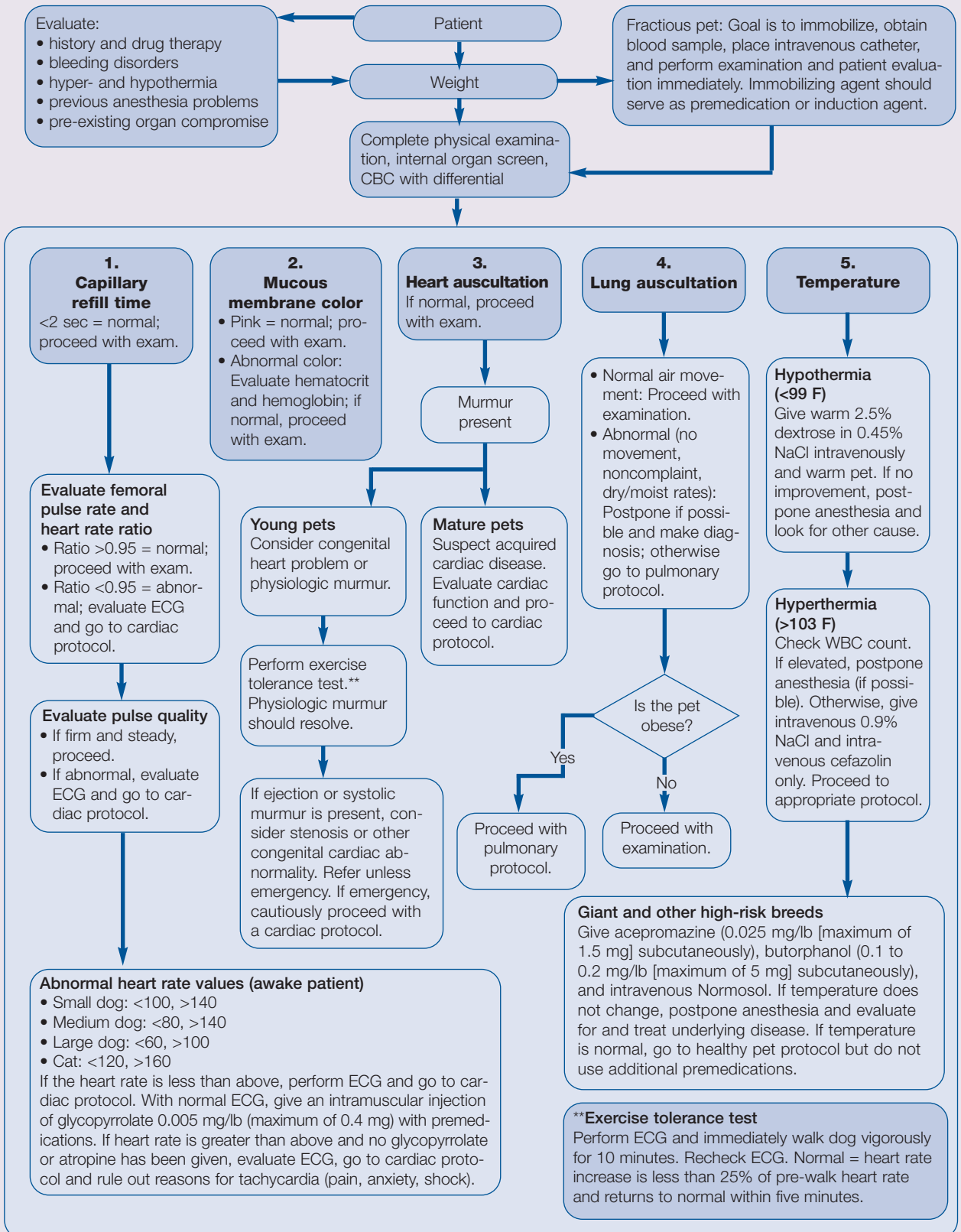
- decrease morbidity and mortality during and after surgery
- determine a patient's health status to minimize the risk of adverse events
- increase the quality of care while decreasing cost
- promote a systematic and problem-oriented approach to the anesthetic procedure
- help earn clients' trust by ensuring their pets' safety and well-being
- provide baseline test results for future healthcare.

likewise essential because it may reveal previous disease and anesthetic complications, concurrent medications, and other circumstances (such as a recent meal) that may affect the procedure. The veterinary team also needs to document preventive care treatments such as vaccinations, deworming, parasite control, dental care, and disease screening tests. If deficiencies in preventive care exist, they should be corrected before any elective procedures are performed.

All participating team members should be informed of every procedure being performed on the patient, along with any medical history that could lead to an anesthetic complication. This ensures that the entire team has received the same information, which minimizes the chance of miscommunication during the procedure.

Cover photo of the Olathe Animal Hospital in Olathe, KS taken by Mark McDonald.

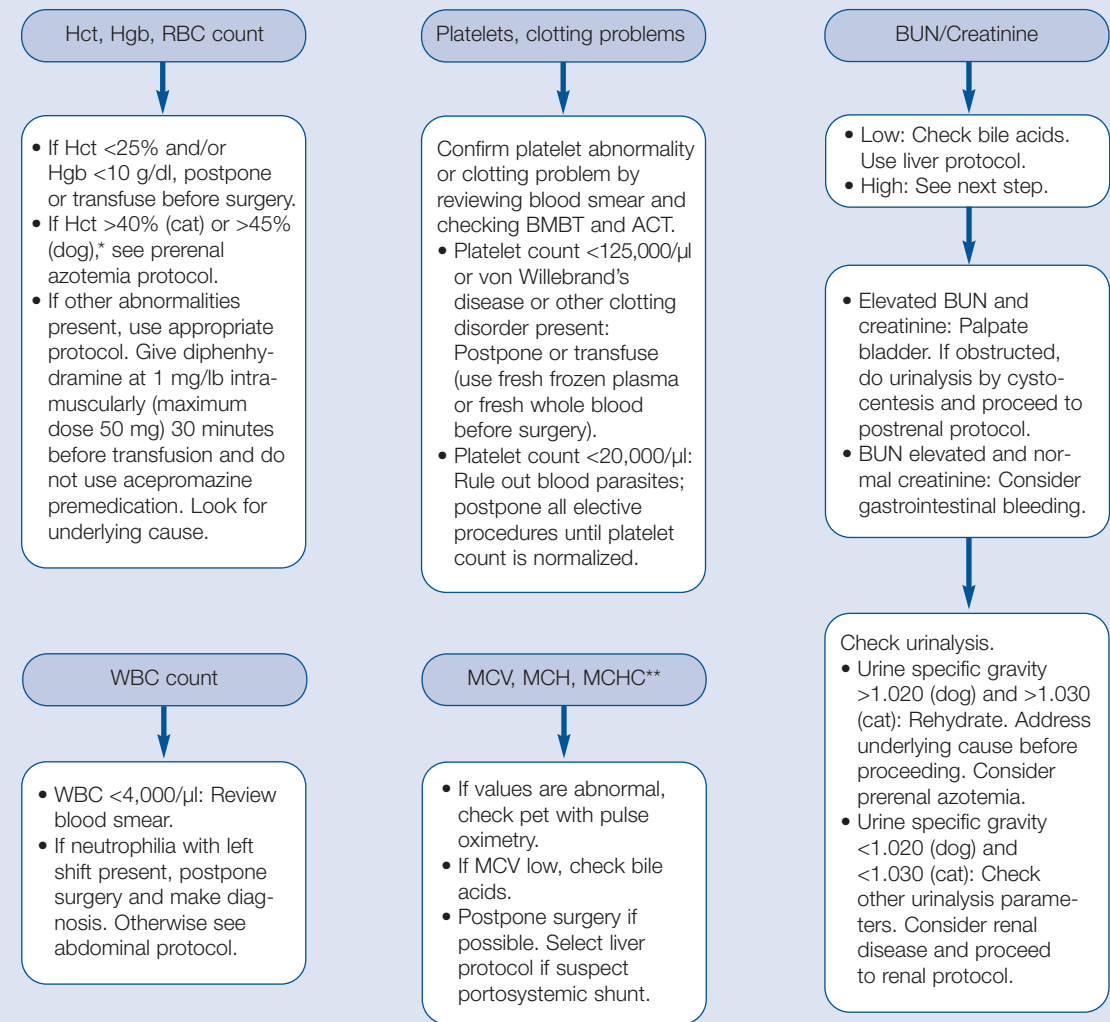
**Figure 1: Canine and Feline Anesthesia Physical Examination\***



\*All protocols referenced in Figure 1 can be found in Novak W. *Anesthesia for the Pet Practitioner*. Portland, Ore: Banfield, 2003.

# EVALUATING PREANESTHETIC PATIENTS

Figure 2: Preanesthetic Blood Work Evaluation



\*Pets living in higher elevations and some breeds such as greyhounds may have naturally occurring hematocrit elevations.

\*\*Normal adult vs. pediatric values will vary.

Source: Novak W. *Anesthesia for the Pet Practitioner*. Portland, Ore: Banfield, 2003.

## Physical examination

Patients should also receive a thorough physical examination as part of the preanesthetic evaluation. Findings should be recorded in the patient's medical record. A detailed evaluation of the cardiovascular, pulmonary, and central nervous systems is vital because all anesthetic drugs depress cardiovascular and pulmonary function. The liver and kidneys also require specific assessment because of their role in metabolizing and eliminating anes-

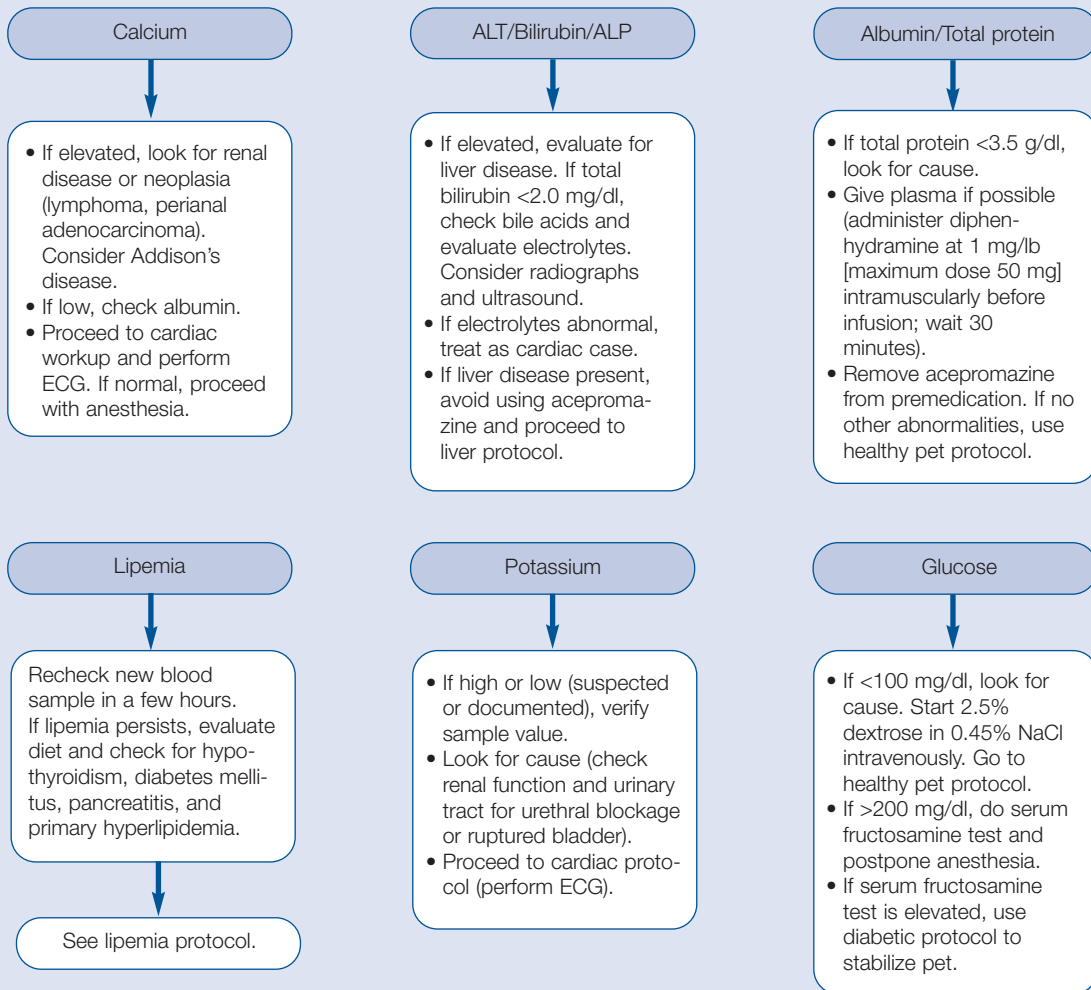
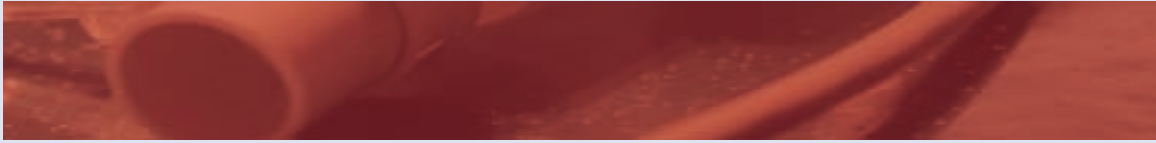
thetic drugs. Any abnormal examination findings should be resolved before anesthesia. The anesthetic protocol may need to be adjusted to ensure the patient's safety.

Our hospitals use a five-step approach in conjunction with a physical examination before any anesthetic procedure to assess major organ function and the patient's overall health (Figure 1):

1. Monitor capillary refill time, femoral pulse-to-heart-rate ratio,

pulse quality, and heart rate. These parameters are key to evaluating perfusion, and adequate perfusion is vital to a successful anesthetic outcome.

2. Evaluate mucous membrane color for evidence of anemia, hyperemia (sepsis, hyperthermia, or polycythemia), icterus, or cyanosis.
3. Auscultate the heart. In young patients, a murmur may indicate a congenital heart abnormality, which can pose a considerable risk



of an adverse anesthetic event. Such patients should be considered high-risk and undergo anesthetic procedures only at a practice equipped to address these special needs. In adults, it is important to know if abnormalities represent a new finding or whether there is evidence of disease progression or heart failure. If any complications exist, a cardiac workup should be completed before anesthesia, if possible.

4. Auscultate the entire lung field to ensure normal sounds, airflow, oxygenation, and ventilation.
5. Evaluate the patient for hypo- or hyperthermia. Both are important, and their cause must be identified and corrected before anesthesia.

This approach allows accurate evaluation of the patient's condition and helps detect abnormal findings. When problems are recognized, an appropriate anesthetic protocol provides guidelines for proceeding.

## Laboratory data

In order to evaluate the patient's current health status, a complete blood count (CBC) and serum chemistry profile (including electrolytes) should be performed during the 48 hours before general anesthesia. Laboratory data are especially important in apparently healthy patients to ensure that potential problems are uncovered. Depending on the results, additional diagnostics may be needed. Because sick patients' condition and laboratory values can change



# EVALUATING PREANESTHETIC PATIENTS

### Value of preanesthetic testing

All patients on wellness plans at Banfield, The Pet Hospital, are evaluated once or twice annually with a CBC, serum chemistry analysis, and urinalysis. All patients are also tested before anesthesia and during diagnostic evaluations, when indicated.

During the five-year period from January 2001 to December 2005, Banfield, The Pet Hospital practitioners performed approximately 700,000 anesthetic procedures that were accompanied by preanesthetic laboratory assessment in conjunction with a complete medical history and physical examination. Approximately 65% of Pets had at least one value that was technically outside of the normal range. However, only 17.5% of these Pets had one or more clinically relevant abnormal value(s). Banfield's practice standards call for a careful review of all case data for these Pets before deciding whether to proceed with anesthesia, repeat the blood work, or cancel the procedure.

A similar review of Banfield's data published in the *Banfield* journal showed that an overwhelming majority (99.9%) of the procedures were performed without delay while others were postponed (0.1%). In some cases of apparently healthy pets being admitted for elective surgery, preanesthetic testing led to the cancellation of surgery because of elevated BUN or creatinine levels (more than 1,300 cases), anemia (more than 100 cases) or elevated hepatic enzyme activities. Conditions uncovered during preanesthetic screening include renal disease, anemia, pyometra, neoplasia, hepatopathy, and cardiac disease.

### Frequency of top 10 clinically relevant abnormal laboratory results: Preanesthetic screens

Feline		
Parameter	Criterion for abnormality	Percent*
Platelets	<150 or >550 x 10 <sup>3</sup> /μl	5.07%
WBC	<4 or >20 x 10 <sup>3</sup> /μl	4.89%
Bilirubin	>1 mg/dl	4.77%
ALT	>120 IU/L	4.11%
MCV	<35 or >50 fl	2.99%
MCHC	<25% or >38%	1.92%
Creatinine	>3 mg/dl	1.43%
BUN	<10 or >40 mg/dl	1.36%
ALP	>250 mg/dl	0.85%
Globulin	>5 g/dl (kittens) and >6 g/dl (adult)	0.84%

Canine		
Parameter	Criterion for abnormality	Percent*
BUN	<5 or >30 mg/dl	2.71%
Bilirubin	>1.5 mg/dl	2.65%
MCHC	<30% or >40%	2.51%
Platelets	<150 or >550 x 10 <sup>3</sup> /μl	2.10%
ALP	>400 mg/dl	1.92%
MCV	<55 or >75 fl	1.67%
WBC	<4 or >20 x 10 <sup>3</sup> /μl	1.40%
ALT	>200 IU/L (puppy) and >400 IU/L (adult)	1.32%
Globulin	>5 g/dl	0.89%
Creatinine	>2 mg/dl	0.71%

\* Note: Percent of Pets with blood values outside Banfield's normal range.

chemistry profile results. If lipemia is discovered, a new blood sample should be drawn after a few hours. If the second sample is also lipemic, further evaluation may be warranted. However, if anesthesia cannot be delayed, an anesthesia protocol without propofol is preferred because propofol can be associated with seizure activity in grossly lipemic human patients.

This approach to evaluating pre-anesthetic patients helps determine the best anesthesia protocol for the pet. Once premedications are administered, it is essential to reevaluate major organ systems using the five-step approach previously discussed; drugs can have profound effects on cardiovascular and pulmonary systems before induction. This reevaluation may change the preferred anesthetic protocol or prompt postponement of anesthesia until further assessment can be performed.

## Conclusion

When preanesthetic evaluation reveals abnormalities, it is the practitioner's responsibility to appropriately address each one before proceeding. But what exactly does this mean? There is no simple answer; it depends on the situation and the abnormality.

Ideally, the practitioner decides whether further diagnostics or supportive care is necessary. How long to administer supportive care before the anesthetic procedure (minutes, hours, days, or weeks) is based on the practitioner's assessment. In emergency situations, the patient may be stabilized for only a short time—as when there is only enough time to administer shock fluids to optimize perfusion. On the other hand, elective procedures may be delayed until the abnormalities are resolved or stabilized.

In all cases, the practitioner's goal is to place the patient in the best condition possible before the anesthetic procedure or to decide that anesthesia is not in the patient's best interest. The patient's condition on recovery should always be as good as or better than it was before anesthesia.

## References

1. Gaynor JS, Dunlop CI, Wagner AE, et al. Complications and mortality associated with anesthesia in dogs and cats. *J Am Anim Hosp Assoc* 1999;35:13-17.

in just a few hours, the CBC and serum chemistry profile for these patients should be collected and evaluated just before the anesthetic procedure. Using a systematic diagnostic approach (*Figure 2*, page 4) helps doctors appropriately and thoroughly address aberrant findings before anesthesia and thereby place the patient in the best possible condition to undergo the procedure.


Many compromised patients have

electrolyte abnormalities. Depending on the underlying cause, abnormalities may or may not be clinically significant. Again, abnormalities should be addressed before anesthesia.

Lipemic blood samples may be seen if the patient has recently eaten or has an underlying condition such as hypothyroidism, diabetes mellitus, pancreatitis, or primary hyperlipidemia, and lipemia may interfere with some serum

# ANESTHESIA FOR NON-ANESTHESIOLOGISTS

Nora S. Matthews, DVM, DACVA



In any discussion of the basic principles of successful anesthesia in general practice, two assumptions are in order. The first is that practitioners are already anesthetizing patients successfully on a routine basis and therefore have a good understanding of and comfort level with anesthetic drugs and combinations. The second is that these practitioners are looking for simple ways to improve their existing protocols rather than desiring to make extensive changes or use completely new drugs. This article will make some simple recommendations to answer a question these practitioners may be asking: “What can I do to make anesthesia safer?”

## Don't treat all patients alike

In a busy practice it is easy to use standard anesthesia and analgesia protocols that treat all patients alike. While it is imperative to perform a complete preoperative evaluation and physical examination on each patient, it is important to treat all abnormalities detected individually. If you find a problem, you must then ask yourself, “Does this procedure really have to be done today?” Clients do have expectations about when a procedure will occur, but when you explain to them that you have their animal's safety in mind, they will usually agree to further diagnostics so that the animal can be safely anesthetized.

It is also wise to pay attention to that “little voice in your head” telling you that something is not right with a patient. We often ignore that voice when we are in a hurry, often with bad results. Anesthesia is one of the areas where you can't afford to be in a hurry but must always be thorough and attentive to detail.

If you have detected an abnormality in the patient—for instance an abnormal lab result or a slight heart murmur—how do you handle it? It may simply be a matter of deleting a drug (such as acepromazine) from your usual regimen or

decreasing the dosage used. Let the patient's condition dictate the amount to give rather than always giving the same dosage; this goes for premedications and induction drugs as well as the amount of inhalant used (*i.e.*, the vaporizer setting).

## The benefit of oxygen

As veterinarians we recognize the benefit of maintaining patients on oxygen with inhalant anesthesia, but we often forget that preoxygenation can make induction safer by preventing the desaturation that can occur immediately after induction. Use of a mask or flow-by oxygen (*i.e.*, from anesthetic tubing placed in front of the animal's nose) for three to five minutes before induction is indicated for any geriatric or sick patient without cardiopulmonary reserves. Oxygen after extubation also increases patient safety, especially if the patient is shivering (which increases metabolic requirements) or has underlying cardiac disease. Upper airway muscle relaxation seems to considerably impair breathing in some pets, especially brachycephalic dogs and cats. You can't just extubate them and walk away; they need to have some flow-by oxygen until they are awake enough and able to maintain saturation. Respiratory depression caused by residual anesthetic drugs can be fatal; the patient may breathe well when stimulated, but when you leave it alone and it relaxes, hypoventilation recurs.

## Premedication and induction: Are fewer drugs safer?

Anesthesia induction is probably the most dangerous time for the patient because of the changes taking place in the cardiopulmonary and central nervous systems. Many veterinarians therefore think that avoiding any premedicants and masking with only one drug is safer than using multiple drugs.

However, this may not be the case; the amount of cardiopulmonary depression produced by high percentages of isoflurane or sevoflurane (which is required for induction with no premedications) may overwhelm the patient. A more balanced approach, such as using some premedications or injectable drugs for intubation and to decrease the percent inhalant needed for maintenance, may be smoother and safer. Wrestling with a big, healthy dog—or even a small, apprehensive dog or cat—can cause the release of catecholamines, which can trigger arrhythmias or cardiovascular collapse.

Another way to make induction safer is to monitor the patient closely through this period. Consider attaching electrocardiograph (ECG) leads and a blood pressure cuff before induction. Not all patients will tolerate this, but many will, especially if they have been premedicated. If a problem occurs during induction, you will see it immediately.

## Maintenance: How much to use?

Currently used inhalants such as isoflurane and sevoflurane allow rapid control of the anesthetic plane, which helps make anesthesia safer. It is important, however, to understand that patients' inhalant requirements vary widely; for example, the vaporizer setting should be decreased with hypothermia, concurrent illness, and other drugs. The patient must be closely monitored and the vaporizer adjusted based on the individual patient; guidelines about setting the vaporizer at X percent for X minutes are just that: guidelines.

Some patients may not tolerate inhalants well, and the percent used must be kept very low: less than 1 minimum alveolar concentration (MAC) for the inhalant (1 MAC = 1.3% isoflurane and 2.3% sevoflurane). In these cases analgesia must be provided by giving other drugs, such as opioids, intermittently or

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as a constant-rate infusion (CRI). Pre-loading the patient with intravenous fluids and using inotropic agents intraoperatively may also be necessary.

Some practitioners may be comfortable with these more advanced techniques, but if not, they should refer these patients to a boarded anesthesiologist for more advanced management. At Texas A&M, we have had patients referred for routine surgical procedures because the anesthetic management of the case was not routine.

## Monitoring: How much is enough?

The purpose of monitoring is to alert the anesthetist to problems before they become serious (*i.e.*, before cardiac arrest occurs). This requires great vigilance as well as accurate interpretation of monitor readings. There are certainly anesthetists who can maintain and monitor patients with no equipment, but in today's litigious society, I would not recommend this approach or consider it a reasonable standard of care. It is also possible for a patient to be fully monitored with a pulse oximeter, ECG, and blood pressure monitor and still suffer an anesthetic death. However, the well-monitored patient generally stands a better chance of not only surviving under anesthesia, but of recovering rapidly and feeling better postoperatively. Monitoring heart and respiratory rate, heart rhythm and depth of respiration, mucous membrane color, and capillary refill time are basics. Blood pressure is tremendously helpful in assessing depth of anesthesia, guiding fluid therapy, and allowing the use of inotropic drugs such as dobutamine. In cases of anesthetic arrest, blood pressure usually declines or is low for a period of time before the arrest occurs, therefore giving the practitioner a warning and time to react to the problem. Since accurate, noninvasive blood pressure monitors are now relatively inexpensive, it seems logical to encourage their use. Maintenance of adequate blood pressure (*i.e.*, systolic blood pressure >90 mm of Hg and mean blood pressure >60 mm of Hg) indicates good tissue perfusion and adequate renal perfusion, which helps prevent postoperative renal failure. If practitioners are determined to improve their

standard of anesthesia, blood pressure monitoring is the place to start.

Pulse oximeters and capnographs (which measure expired  $\text{CO}_2$ ) can be helpful in evaluating patient oxygenation, peripheral perfusion ( $\text{SpO}_2$ ), and ventilation ( $\text{PaCO}_2$ ), and I encourage the use of these monitors as well. However, it is outside the scope of this article to describe the indications and shortcomings of both, and many good references exist.<sup>1</sup>

“The purpose of monitoring is to alert the anesthetist to problems before they become serious.”

## Disaster preparedness

Of course, it doesn't help to monitor the patient if you aren't prepared to treat the problems you encounter. It's essential to have emergency drugs readily available (and to check them frequently for expiration dates) along with appropriately sized syringes and needles. Dosing charts should be easy to read and allow rapid drug preparation (*e.g.*, they should be set up in 5-kg intervals rather than mg/kg, which requires calculation). Emergency drug charts can be laminated and posted in all locations where they might be needed. Another good option is to use an emergency drug calculator program, such as the one from the Colorado State University emergency and critical care website ([www.csuvs.colostate.edu](http://www.csuvs.colostate.edu)), and to print an emergency drug sheet for each patient—or at least each high-risk patient.

## Does fluid administration help for routine anesthetic procedures?

In my opinion, yes. Many if not most patients are dehydrated when they are

hospitalized and after food and water have been withheld for a number of hours. Intravenous fluids have the advantage of requiring an intravenous catheter (which is a safety factor in itself), and they rapidly expand the vascular space, which helps improve tissue and renal perfusion. Especially when nonsteroidal anti-inflammatory drugs (NSAIDs) are used perioperatively, fluids may help prevent renal compromise. Crystalloids, such as lactated Ringer's solution, can be given at 10 ml/kg/hr unless the patient cannot tolerate this fluid volume (*e.g.*, the patient with cardiac disease that is prone to pulmonary edema). Since crystalloids don't remain in the intravascular space very long, use of a colloid such as hetastarch, blood, or plasma may be required for patients that are anemic, hypoproteinemic, or not responding to treatment of hypovolemia with crystalloids alone.

There is evidence in people that patients given fluids during short procedures feel better and experience less nausea and headaches than those who don't get fluids.<sup>2</sup> Unfortunately, we can't ask our patients about this, but it seems likely that it would be true for them as well. Subcutaneous fluids are better than none if this is the only route available.

## Take-home thoughts

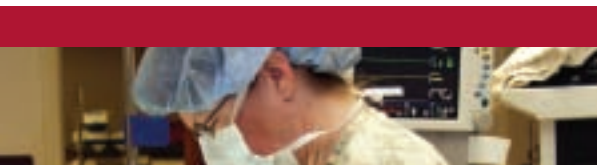
In summary, I think it is possible to improve anesthetic management of patients without radically changing protocols and procedures by paying close attention to important basics. Make sure you have evaluated the patient thoroughly before anesthesia, tailor the anesthetic protocol for that particular patient, and be prepared for expected and unexpected problems. Careful monitoring and patient support (attention to oxygenation, fluid therapy, patient comfort, and support of body temperature during and after anesthesia) are key ingredients in safe anesthesia.

## References

1. Hartsfield SM. Equipment and monitoring. In: Tranquilli WJ, Thurmon JC, Benson GJ, eds. *Essentials of small animal anesthesia and analgesia*. Philadelphia, Pa: Lippincott Williams and Wilkins, 1999.
2. Maharaj CH, Kallam SR, Malik A, et al. Preoperative intravenous fluid therapy decreases postoperative nausea and pain in high risk patients. *Anesth Analg* 2005;100:675-682.



# TURN THE GAS OFF—WE'RE DONE! RECOVERY FROM ANESTHESIA



Tamara Grubb, DVM, MS, DACVA  
Uniontown, Wash.

Did you know that most adverse events associated with anesthesia occur during recovery? That's right; of the three anesthetic periods—induction, maintenance, and recovery—the recovery period is often the most critical. Why? Many factors can play a role: the unrecognized residual effects of anesthetic agents, the termination of oxygen and fluid support, and, perhaps most importantly, a lack of monitoring or personnel.

In anesthetized people, one study found a 26% overall complication rate when intraoperative and postoperative complications were combined. Of the 26%, only 3% occurred intraoperatively and 23% occurred in recovery.<sup>1</sup> Contrary to what might be expected, these complications did not occur primarily in severely compromised patients but in patients only mildly to moderately compromised (American Society of Anesthesiologists classification ASA II to ASA III—*Table 1*).<sup>1</sup> Unfortunately, without a thorough physical examination and appropriate chemistry and ancillary tests (e.g., an electrocardiogram or thoracic radiographs) before induction, mild disease that might change an ASA I patient to an ASA II or III can be easily overlooked. This oversight can put patients at extreme risk for postanesthetic complications.

The most common complications in anesthetized people include respiratory compromise (15.2%), cardiovascular abnormalities (12.3%), and excessive pain (7.2%).<sup>2</sup> Respiratory complications include general respiratory depression, upper airway dysfunction, apnea, and hypoxemia-hypercarbia, while cardiovascular complications include hypotension and arrhythmias. One veterinary study from a major referral center reported an overall anesthetic complication rate of 12% in dogs and 10.5% in cats, with respiratory and cardiovas-

**Table 1: American Society of Anesthesiologists classification of patients undergoing anesthesia**

<b>ASA I:</b>	A normal, healthy patient
<b>ASA II:</b>	A patient with mild systemic disease (compensated cardiac disease, mild fever)
<b>ASA III:</b>	A patient with severe systemic disease (moderate dehydration, anemia, cachexia, hypovolemia)
<b>ASA IV:</b>	A patient with severe systemic disease that is life-threatening
<b>ASA V:</b>	A patient not expected to live

**Table 2: Monitoring recommendations for the recovery period**

Heart rate and rhythm
Pulse strength
Mucous membrane color and capillary refill time
Respiratory rate, rhythm, and depth (using thoracic excursions as a guide)
Core body temperature
ECG
Blood pressure (e.g., using oscillometric or Doppler methods)
Pulse oximetry (if possible)
End-tidal CO <sub>2</sub> or arterial blood gases (in select cases)
Urinary output (in select cases)
Blood glucose and serum electrolytes (in select cases)

cular complications most common.<sup>3</sup> In a Canadian study, the most common causes of anesthetic complications in dogs and cats were respiratory and cardiovascular dysfunction, and complications occurred in both the maintenance and recovery phases of anesthesia.<sup>4</sup> And a British study of anesthetic risk in small animals found that 25% of all fatalities occurred postoperatively.<sup>5</sup> Since mammals are affected similarly by anesthetic drugs, it is not surprising that postanesthetic complications in veterinary patients are similar to those in people.

In addition, hypothermia should be considered in veterinary patients. Because of the rapid heat loss associated with a small body mass and large body surface area, veterinary patients often become hypothermic under anesthesia. Hypothermia can cause a wide array of side effects and should be prevented when possible.

Optimally, postoperative complications can be minimized by thorough preoperative assessment and stabilization and appropriate intraoperative management and support. However, attentive monitoring and support well into the recovery period is imperative for a successful anesthetic outcome. Although young, healthy patients may recover rapidly with a minimum amount of support required, aged and compromised patients may recover slowly and require an extended monitoring period (*Table 2*). Regardless of the duration, patients should be monitored until they are fully recovered from anesthesia. After anesthesia, sleep from sedatives and analgesics is acceptable, but residual anesthesia is not. The difference is that patients still anesthetized are not rousable when stimulated, while patients that are sleeping comfortably due to analgesia and light sedation are rousable with stimulation.

# RECOVERY FROM ANESTHESIA

**Table 3: Cardiovascular effects of commonly used anesthetic drugs**

Cardiovascular component affected	Drug(s)	Effect
Heart rate	Ketamine, tiletamine	Increased rate
	Propofol, alpha-2 agonists	Decreased rate
Contractility	Inhalant anesthetic agents, propofol, thiobarbiturates	Decreased contractility
	Ketamine, tiletamine	Indirect increase in contractility (direct decrease in contractility)
Preload	Acepromazine, isoflurane, sevoflurane	Vasodilators = decreased preload (decreased cardiac return)
Afterload	Alpha-2 agonists, halothane, ketamine, tiletamine	Vasoconstriction = increased afterload
Relaxation	Ketamine, halothane	Impaired relaxation

## Respiratory complications

All anesthetic agents cause some degree of dose-dependent respiratory depression (both depression of respiratory rate and tidal volume), and this depression is not eliminated when the vaporizer is turned off. Instead, residual depression lasts well into the recovery period and, when unrecognized, is one of the major contributors to postanesthetic morbidity and mortality. Furthermore, both upper and lower airway dysfunction occur in recovery, and either condition can lead to hypoxemia and hypercarbia.

Upper airway complications include laryngeal dysfunction, paralysis, edema, and collapse of the soft palate or other tissues into the airway. Brachycephalic patients and patients who have suffered traumatic intubation are likely to experience postoperative upper airway dysfunction. All patients should be left intubated until they are swallowing vigorously, and patients with suspected upper airway dysfunction should remain intubated until they will no longer tolerate the endotracheal tube. Patients should not be excessively stimulated for extubation. Excessive stimulation may rouse the patient enough to allow extubation but not enough to ensure adequate ventilation. Lower airway dysfunction includes atelectasis and ventilation-perfusion mismatch, both of which can contribute to impaired ventilatory function. Airway disease, age, and

anesthesia of long duration all contribute to lower airway dysfunction.

In order to prevent respiratory complications, patients should be closely monitored during recovery. Respiratory rate and volume (as judged by thoracic excursions) and mucous membrane color should be assessed routinely. As people transition from 100% oxygen during anesthesia to 21% oxygen after anesthesia, hemoglobin in the red blood cells (RBCs) rapidly desaturates,<sup>6</sup> and we can assume that the same phenomenon also occurs in veterinary patients. Pulse oximetry may be useful during recovery to detect RBC desaturation, and supplemental oxygen should be provided if desaturation is expected or suspected. Oxygen can be delivered through the endotracheal tube or through a nasal cannula if the patient is already extubated.

## Cardiovascular complications

Hypotension and arrhythmias are anesthetic complications that can occur in both human and veterinary patients. Hypertension may also occur in people, but it is rarely a problem in veterinary medicine unless linked to a specific cause (e.g., pain or a hypertensive disease, such as hyperthyroidism). Most anesthetic agents, including inhalant agents, cause a dose-dependent decrease in systemic arterial blood pressure through a variety of mechanisms

(Table 3). As with anesthetic-induced respiratory depression, anesthetic-induced cardiovascular depression is not eliminated when the vaporizer is turned off; instead, function improves over time. In veterinary medicine, blood pressure is not routinely measured in the recovery period, so we are unsure of the incidence of hypotension in dogs recovering from anesthesia. However, since most of the commonly used anesthetic drugs cause hypotension, we should expect residual hypotension to occur in our patients during the recovery period.

Arrhythmias may occur secondary to a whole array of anesthesia-related factors, including the arrhythmogenic effects of the drugs themselves, hypoxia, and hypercarbia. As with hypotension, cardiac arrhythmias may occur more often than we recognize. In a study of healthy dogs anesthetized with either isoflurane or propofol, arrhythmias occurred in the first 24 hours after anesthesia in 56 out of 60 dogs, although the overall number of arrhythmias per patient was low.<sup>7</sup>

To detect cardiovascular complications, both blood pressure and electrocardiogram (ECG) monitoring should continue well into the recovery period whenever possible. Intravenous fluid therapy should be continued in hypovolemic and hypotensive patients, and positive inotropic agents such as dopamine or dobutamine should be

**Table 4: Analgesic drug dosages commonly used during anesthetic recovery\***

Drug	Class	Dosage	Comments
Morphine	Opioid, full agonist	0.25 to 2.0 mg/kg IM, SQ in dogs; 0.1 to 0.3 mg/kg IM, SQ in cats	Potent opioid, may cause excitement in cats
Morphine	Opioid, full agonist	0.05 to 0.2 mg/kg/hr in dogs (use sedation in cats)	Run as constant rate infusion (CRI)
Hydromorphone	Opioid, full agonist	0.05 to 0.2 mg/kg IM, SQ, IV in dogs and cats	Potent opioid, may cause hyperthermia in cats
Hydromorphone	Opioid, full agonist	0.05 to 0.1 mg/kg/hr in dogs; 0.01 to 0.05 mg/kg/hr in cats	Run as CRI
Fentanyl	Opioid, full agonist	5 to 20 µg/kg/hr in dogs and cats	Potent opioid, short duration, run as CRI
Buprenorphine	Opioid, partial agonist	0.01 to 0.03 mg/kg IM, SQ, IV in dogs and cats; buccally in cats	Long-lasting analgesia, minimal sedation
Butorphanol	Opioid, agonist-antagonist	0.2 to 0.4 mg/kg IM, SQ, IV in dogs and cats	Short-lasting analgesia, mild sedation
Medetomidine	Alpha-2 agonist	1 to 5 µg/kg IV, IM, SQ in dogs and cats	Moderate analgesia, moderate sedation
Ketamine	NMDA-receptor antagonist	2 to 10 µg/kg/min in dogs and cats	Run as CRI with a true analgesic agent
Lidocaine	Local anesthetic agent	2 to 4 mg/kg local block in dogs and cats	May need to sedate patient to perform block
Lidocaine	Local anesthetic agent	25 µg/kg/min	Run as CRI
Bupivacaine	Local anesthetic agent	1 to 2 mg/kg local block in dogs and cats	May need to sedate patient to perform block. Do not give IV.
Carprofen, deracoxib	NSAIDs	See individual drug recommendations	Other NSAIDs are not FDA-approved for surgical pain in dogs

\*Not all of the drugs or dosages referenced are approved by the FDA. Please check drug labels or [www.fda.gov/cvm](http://www.fda.gov/cvm) for more information on individual drugs.

available for patients in which hypotension persists despite appropriate fluid therapy. Specific antiarrhythmic therapy should also be available to treat arrhythmias that develop. Drugs used to treat hypotension and arrhythmias have been reviewed elsewhere.<sup>8</sup>

### Uncontrolled pain, stress, and excitement

Uncontrolled pain in recovery is a problem in both veterinary and human patients.<sup>9-11</sup> Unfortunately, uncontrolled pain can become a pathology in itself, producing such adverse effects as tachycardia, hypertension, tachypnea, gastric ulcerations, ileus, decreased renal function, catabolism, altered hemostasis, and impaired wound healing.<sup>12</sup> Furthermore, pain can cause

excitement as the patient regains consciousness, resulting in a turbulent recovery.<sup>13</sup> In fact, it can be difficult to differentiate the effects of pain from “emergence delirium” caused by the anesthetic drugs themselves. Fortunately, differentiation really isn’t necessary since excitement, regardless of the cause, is not appropriate in the recovery period. Excitement with subsequent physiologic stress can lead to respiratory and hemodynamic compromise, and all forms of stress should be treated.<sup>14-15</sup>

Drugs that provide both sedation and analgesia should be considered. Options in this category include opioids and alpha-2 agonists. Opioids are often the first choice because of their analgesic potency. However, if opioid therapy is already being used and the

patient remains painful, alpha-2 agonists should be considered. These drugs augment the analgesia provided by opioids and decrease the anesthesia-induced stress response. Alpha-2 agonists are often used in human medicine to control excitement and pain following recovery from anesthesia.<sup>15</sup> If pain persists after initial treatment, other possible analgesic protocols include local anesthetic blockade and constant rate infusions. See the drug recommendations and dosages in *Table 4*.

Appropriate use of analgesic drugs in the preoperative and intraoperative period will decrease pain in recovery;<sup>16</sup> however, breakthrough pain often occurs. Thus, regardless of the use of preemptive or intraoperative analgesia, pain should still be anticipated,

# RECOVERY FROM ANESTHESIA

**Table 5: Effects of hypothermia**

Some of the problems that can arise when an animal's core body temperature decreases are as follows:\*

- >96 F—no adverse effects from hypothermia. Shivering and nonshivering thermogenesis increase in conscious patients.
- 90 to 94 F—cerebral depression with reduced anesthetic requirements, prolonged anesthetic recovery. Shivering is impaired in conscious patients. *Note:* Animals often get this cold during anesthesia. Anesthetic gas delivery should be decreased, but this is often overlooked.
- 82 to 86 F—marked cerebral depression with little or no anesthetic required. Atrial arrhythmias occur; shivering is nonexistent in conscious patients.
- 77 to 80 F—cold-induced ECG changes (prolonged P-R interval, widened QRS) and increased myocardial automaticity occur. Oxygen delivery is usually inadequate (due to extreme vasoconstriction) and lactic acidosis occurs, normal reflexes and pain responses are absent, blood viscosity is increased, and microcirculatory sludging occurs.
- 72 to 74 F—spontaneous ventilation ceases, ventricular fibrillation and coagulation disorders occur.
- <68 F—asystole and ECG silence occur.

\* Haskins SC. Operating room emergencies. In: Slatter D, ed. *Small animal surgery*, 3rd edition. Philadelphia: Saunders, 2003;2521-2532.

and all patients should be assessed for pain in recovery.

## Hypothermia

Hypothermia develops rapidly in patients under anesthesia, and the cause of the drop in body temperature is multifactorial. Some contributing factors include direct suppression of thermoregulatory activity of the hypothalamus by general anesthesia; anesthesia-induced vasodilation, which redistributes warm blood from the body's core to the skin where heat is released; evaporation of surgical scrub solutions from the body surface; equilibration of core body temperature with ambient temperature through open body cavities; delivery of cold anesthetic gases to the large surface area of the alveoli; and conduction of heat to the metal table.

Hypothermia causes a variety of complications, including clotting dysfunction, increased risk of infection, tissue hypoxia, acidosis, abnormal electrical conduction in the heart, and myocardial ischemia.<sup>17</sup> Hypothermia also causes cerebral effects that decrease the patient's anesthetic needs. Unfortunately, the decreased anesthetic need is not always recognized and anesthesia delivery is not changed, resulting in an anesthetic overdose. Although shivering in recovery may increase the body temperature, the intensive muscle movements associated with shivering cause discomfort and increase oxygen consumption

by as much as 200%.<sup>18</sup> In fact, in human medicine, one area of research focus is prevention of shivering in the postoperative period. Finally—and importantly—hypothermia is the main cause of prolonged recovery in small animal patients. Listed in *Table 5* are some of the problems that arise as core body temperature decreases.<sup>19</sup>

Prevention of hypothermia should be the goal for all patients, and active rewarming should begin immediately once hypothermia has occurred. Forced air blankets have been shown to be the most effective means of rewarming.<sup>20</sup> Increasing ambient temperature also contributes significantly to warming. This can involve everything from heating an entire room to creating a warmed area around the patient using hot water bottles or sand bags with a blanket covering the patient and the warming devices. As always, insulation should be placed between heated items and the patients so that the skin is not burned.

## Summary

Unfortunately, the importance of the anesthetic recovery period is often overlooked even though most unexpected anesthetic deaths occur during recovery. Common complications include hyperventilation, hypotension, hypothermia, and excessive pain. For a successful anesthetic outcome, appropriate moni-

toring and patient support must occur well into the recovery period.

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# MANDATORY PREANESTHETIC EVALUATION: HELPING TO AVOID ANESTHETIC NIGHTMARES



Fred Metzger, DVM, DABVP

While statistically rare, adverse anesthetic events can be disastrous in veterinary practice. Many variables can affect the outcome of an anesthetic procedure, including individual patient characteristics, the anesthetic agents being used, the anesthetist in charge, and the procedure being performed. Veterinary patients pose a greater anesthetic challenge than their human counterparts because of weight and breed variables, clients' monetary limitations, and often the absence of a comprehensive anesthetic history. A thorough preanesthetic evaluation aids in the identification of pre-existing conditions, which improves anesthetic safety and also provides invaluable baseline data for future diagnostic use. Beyond the numerous medical benefits, offering a comprehensive preanesthetic evaluation that includes diagnostic testing can protect your practice from liability issues and help to prevent anesthetic nightmares.

## Improved preanesthetic patient care

A comprehensive preanesthetic evaluation that includes laboratory profiling allows for a thorough evaluation of organ systems, including the hematopoietic, renal, hepatic, and endocrine systems. Proper interpretation frequently involves assessing individual test results in relation to others—for example, evaluating calcium levels in light of albumin levels or amylase levels with regard to renal function. Hematology is a critical part of the preanesthetic evaluation because it helps identify anemia, polycythemia, leukopenia, leukocytosis, and thrombocytopenia, all of which may contribute to adverse anesthetic events.<sup>1</sup> Pre-existing renal or hepatic disease

may interfere with anesthetic metabolism and excretion, especially in anesthetics requiring biotransformation for elimination. Undetected hypoglycemia may result in serious cerebral dysfunction and death. Electrolyte abnormalities such as hyperkalemia may predispose the patient to life-threatening cardiac arrhythmias.

A policy of mandatory preanesthetic evaluation and testing helps eliminate client confusion because no additional forms or signatures are required. It also communicates a consistent message that the practice believes this kind of evaluation is critical. Moreover,

“Mandatory preanesthetic evaluation including diagnostic testing is becoming the standard of care in our profession.”

mandatory preanesthetic evaluation creates a simplified workflow in the veterinary hospital, from the front office to technicians to veterinarians. A standardized policy eliminates confusion and procedural variation, which minimizes technical and billing errors. Mandatory preanesthetic evaluation including diagnostic testing is becoming the standard of care in our profession.

It is still crucial that the veterinary

team educate clients about the risks of anesthesia and the surgical procedure, as well as the safety benefits of thorough patient evaluation, testing, and monitoring. Remind clients that there is no such thing as a “routine” surgery and that every precaution will be taken to ensure their pet's safety. During discharge, review the preanesthetic blood work with the client and emphasize the importance and medical significance of normal findings. Sharing the test results not only adds value but also emphasizes your hospital's high level of care and commitment to its clients and patients. Encourage clients to maintain pet records, including blood work, which can later serve as important baseline data should their pet become ill. Emphasize that your practice and the client are partners in caring for pets.

## Risk vs. benefit

The cost of preanesthetic evaluation and testing must be weighed against the benefits. In a recent preanesthetic-profiling study of approximately 700,000 patients, 65% of patients had at least one value that was outside the normal range. However, only 17.5% of these patients had one or more clinically relevant abnormal value(s).<sup>2</sup> (See *Value of pre-anesthetic testing*, page 6, for more information on this study and the relative incidence of various preanesthetic abnormalities.) Preanesthetic testing included a complete blood count (CBC) and a 12-test serum chemistry profile. Electrolytes were not part of the preanesthetic protocol, which undoubtedly would have increased the percentage of patients with results deviating from the reference range. Not every abnormality significantly affects anesthesia or surgery; however, factors such as hematocrit, platelet count, and creatinine can significantly affect patient recovery and survival.



# MANDATORY PREANESTHETIC EVALUATION

## History of preanesthetic evaluation at Metzger Animal Hospital

Preanesthetic profiling of young patients was a new concept in the 1980s and became more common in the late 1990s. To overcome compliance challenges, doctors at Metzger Animal Hospital developed a client consent form for preanesthetic testing in 1996. Clients would choose from among three health screening options based on their pet's age and health status and then sign the form, which resulted in compliance of approximately 65% to 70%.

In 1997, compliance increased to more than 80% after the hospital started mailing the form to the client's home before the scheduled surgery. In 1998, doctors instituted mandatory preanesthetic testing for all surgical and dental procedures. Tests include a complete blood count, serum chemistry profile with electrolytes, urinalysis, and, for patients over 7 years of age, total  $T_4$  testing. Advantages include a more comprehensive testing protocol, less client confusion, and better team member efficiency.

## Case Study



### Patient case history

**Patient name:** Ruca

**Patient data:** 6-month-old female chocolate Labrador retriever

**Presenting reason:** Routine ovariohysterectomy

**History:** Normal, active puppy

**Physical examination findings:** Patient is alert with normal temperature, and auscultation of the chest reveals no murmurs or abnormal lung sounds.

**Plan:** Preanesthetic blood work and urinalysis before surgery

### Hematology profile

RBC	5.73 M/ $\mu$ L		(5.50 to 8.50)
<b>HCT</b>	<b>35.7%</b>	<b>Low</b>	<b>(37.0 to 55.0)</b>
<b>HGB</b>	<b>11.9 g/dL</b>	<b>Low</b>	<b>(12.0 to 18.0)</b>
MCV	70 fL		(60 to 77)
MCH	24.2 pg		(19.5 to 26.0)
MCHC	33.3 g/dL		(32 to 36)
WBC	11.4 K/ $\mu$ L		(5.70 to 16.30)
Neutrophil	8.40 K/ $\mu$ L		(3.00 to 11.50)
Band	0.0 K/ $\mu$ L		(0.00 to 0.30)
Lymphocyte	1.80 K/ $\mu$ L		(1.00 to 4.80)
Monocyte	1.20 K/ $\mu$ L		(0.15 to 1.35)
Eosinophil	0.0 K/ $\mu$ L		(0.10 to 1.25)
Platelets	333 K/ $\mu$ L		(164 to 510)

Erythron: Mild nonregenerative anemia (normocytic, normochromic, and lack of reticulocytosis)

Leukon: Normal

Thrombon: Normal

For more information about Ruca's case, visit the website created by Ruca's owner, Mel Fox: [www.personal.psu.edu/users/m/k/mkr127/tribute.htm](http://www.personal.psu.edu/users/m/k/mkr127/tribute.htm)

The following case illustrates the value of preanesthetic testing.

## A case of mandatory evaluation

Ruca, a 6-month-old chocolate Labrador retriever, was presented at Metzger Animal Hospital for a routine ovariohysterectomy. The client was informed that preanesthetic diagnostic

testing would be performed and was included in the cost of the procedure. Unfortunately, the results revealed evidence of kidney failure (see *Patient case history*). The blood work was repeated and an abdominal ultrasound was performed, which confirmed the presence of kidney abnormalities that were likely congenital. The patient's prognosis was poor to grave.

The client was devastated, but she expressed appreciation that the condition had been diagnosed. She was able to take Ruca home and make her as comfortable as possible in her remaining weeks.

## Summary

Ruca's case emphasizes the value of preanesthetic evaluation and testing— anesthesia could have resulted in many

**Chemistry profile**

<b>BUN</b>	<b>90 mg/dL</b>	<b>High</b>	<b>(7 to 27)</b>
<b>Creatinine</b>	<b>5.9 mg/dL</b>	<b>High</b>	<b>(0.4 to 1.8)</b>
<b>Phosphorus</b>	<b>7.3 mg/dL</b>	<b>High</b>	<b>(2.1 to 6.3)</b>
Calcium	11.0 mg/dL		(8.2 to 12.4)
Sodium	154 mmol/L		(141 to 156)
Potassium	4.7 mmol/L		(4.0 to 5.6)
Chloride	112 mmol/L		(105 to 115)
Total protein	6.3 g/dL		(5.1 to 7.8)
Albumin	2.9 g/dL		(2.5 to 3.6)
Globulin	3.4 g/dL		(2.8 to 4.5)
ALT	58 U/L		(5 to 60)
ALP	133 U/L		(10 to 150)
Total bilirubin	0.2 mg/dL		(0.0 to 0.4)
Cholesterol	148 mg/dL		(112 to 328)
Amylase	1300 U/L		(500 to 1500)
Glucose	81 mg/dL		(60 to 125)

**Urinalysis**

Urine chemistries: 1+ protein  
 Negative for glucose, ketones, bilirubin  
 Urine SG: 1.018  
 Sediment: Unremarkable

**Additional testing**

Urine protein creatinine ratio: 0.9  
 (normal <0.5)  
 Urine culture and sensitivity: No growth  
 Leptospirosis titer: Negative  
 SNAP 3 Dx: Negative  
 Basal cortisol: Normal  
 Ultrasound evaluation: Decreased renal size and abnormal architecture

**Interpretation**

Azotemia, hyperphosphatemia, non-concentrated urine specific gravity, and nonregenerative anemia indicate renal failure (most likely chronic because of the unremarkable history and nonregenerative anemia).

**Presumptive diagnosis**

Renal failure (congenital)  
 Note: A necropsy was performed, which confirmed chronic renal failure (renal dysplasia).

complications, including death. If Ruca had survived surgery only to present with renal failure several days later, the owner (and perhaps the veterinarian) might have speculated that the surgical procedure resulted in renal failure. Ill feelings and even legal action are potential consequences of not performing a thorough preanesthetic evaluation that includes diagnostic

testing—or at least offering this service to every client. While anesthetic complications are rare and significant preanesthetic testing abnormalities uncommon, when they do arise they can be deadly. Remember, statistics are irrelevant to a grieving pet owner. The benefits of a thorough preanesthetic evaluation and testing program are numerous, and each veterinary hospi-

tal must develop and implement a program that is suited to their needs.

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