Crisis Management: How to Handle Emergencies and Complications

What Really Works in Anesthetic and Perioperative Care

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Things Can Go Wrong!

Anesthesia is intended to be a controlled, benign, and reversible process. Unfortunately, anesthetic drugs produce their effects primarily by limited depression of vital processes. The inherent dangers of anesthesia and the debilitation of injuries and illness that require anesthesia and surgery predispose the patient to risks of serious complications and emergencies. Most anesthetic complications and emergencies can be related to human errors, equipment problems, ventilatory problems, or circulatory problems. Most anesthetic emergencies and complications can be prevented or adequately managed.

Human Error

Human error is ultimately responsible for the majority of problems encountered with anesthetic management. The importance of vigilance in anesthetic care cannot be overemphasized. It has been noted that hundreds of errors are made due to not looking for every one error made due to not knowing.

It should be recognized that there is a significant degree of safety with familiarity. Errors are more common when the anesthetist is not familiar with either the drugs or equipment being used. Miscalculation of anesthetic drug doses is a common error. The narrow therapeutic index of most anesthetic drugs makes correct dose determination or titration crucial. An absolute or relative overdose of anesthetic can cause problems from minor excess physiologic depression to death.

An overdose with barbiturates should be managed with physiologic support of ventilation, continuous monitoring of cardiopulmonary function, and IV fluid therapy to speed recovery and improve cardiopulmonary function. In the context of cumulative overdoses from repeated injections of barbiturates to prolong anesthesia, the intravenous administration of bicarbonate at 0.5 to 1.0 mEq/kg can speed recovery from barbiturate overdose by favoring elimination. The nonspecific stimulant-antagonist drug, doxapram, can be dangerous in treating depression due to barbiturate overdose. This stimulant can result in very deleterious stress and should not substitute for good care and proper dosing of anesthetics. Overdoses with other anesthetics are also managed with supportive care, which is often adequate in mild to moderate overdose situations.

Fortunately there are specific antagonist drugs available to counteract the effects of some anesthetic drugs. For narcotics, the pure antagonist agent, naloxone, will reverse effects of an overdose. With a large overdose or a longlasting narcotic, renarcotization can occur with a return to the effects of the narcotic agent. For the tranquilizer/sedatives xylazine and dexmedetomidine, and other alpha-2 agonists, there are specific antagonists available. One of these,
yohimbine, was approved for use in dogs years ago to reverse the effects of xylazine. Atepamezole is a better antagonist for dexmedetomidine and is often effective by titration of reduced doses (approved for SC administration) to secure prompt recovery with less excitement and stress than would result from the administration of a higher dose.

Nonspecific partial reversal of anesthetic depression is possible by administration of the respiratory stimulant doxapram, but this is usually not an appropriate replacement for positive pressure ventilation and other supportive care. Although the net effect can be life saving, nonspecific reversal has been associated with residual undesirable effects related to CNS stimulation and even deaths! Other stimulants have been advocated to correct excessive effects of various anesthetics, but the benefits are usually very limited.

Anesthetics administered by an incorrect route can have very adverse effects. The extravascular injection of barbiturates can cause severe irritation and sloughing of surrounding tissue. Extravasation should be treated immediately with generous infiltration of the site with lidocaine and saline, followed by warm compresses. Errors in the administration of anesthetics also include the misidentification of drugs and accidental use of the wrong medication.

**Equipment Problems**

Among the most serious anesthetic complications is the failure to deliver oxygen to the patient. This can be caused by respiratory obstruction or misused or defective anesthetic equipment. Empty tanks or disconnected gas lines and breathing circuits prevent the delivery of oxygen. Such problems must be recognized and corrected immediately. Empty anesthetic vaporizers, vaporizers filled with the wrong agent, or overfilled vaporizers are common problems. Delivery of nitrous oxide in combination with too little oxygen should be carefully avoided and is not always prevented by “fail-safe” systems incorporated in modern machines.

Kinked or plugged endotracheal tubes cause respiratory obstruction. Improper cuff inflation can result in obstruction, tracheal injury, or allow for aspiration pneumonitis. Improper placement of endotracheal tubes is very common, even in species that are easily intubated. Correct placement should always be verified.

An inability to adequately fill the rebreathing bag or to provide positive pressure ventilation by squeezing the bag often indicates major leaks or disconnections. These can result in a failure to deliver anesthetics and oxygen and substantially contribute to anesthetic gas pollution of the veterinary hospital. Stuck valves in the anesthesia machine or circuit can cause difficulty in ventilation. Inappropriate rebreathing of exhaled gases or the accumulation of excessive pressure results. Patients that consistently seem to be too deep or too light may indicate that the vaporizer is out of calibration due to wear and tear, there is accumulation of deposits within the vaporizer, or other factors. These common problems emphasize the importance of regular inspection and maintenance of equipment.

Electrical problems with monitoring or supportive equipment risk injury to personnel as well as to patients. Inadequately grounded or protected equipment can cause electrical burns, electrocution, or fires. Unsafe or substandard equipment should be repaired or replaced.
Ventilatory Complications

Hypoventilation due to anesthetic overdose is one of the most frequently encountered and serious complications in anesthesia. Inadequate breathing occurs with either relative or absolute overdoses of many anesthetics. Weakened, debilitated animals are more susceptible to the ventilatory depression that may occur secondary to circulatory depression and inadequate perfusion of CNS respiratory centers, electrolyte imbalances, muscle relaxant drugs, or thoracic injury. Support of ventilation requires endotracheal intubation and positive pressure breathing, preferably with oxygen. Identification and correction of the primary problem is then undertaken.

Hyperventilation is often due to inadequate anesthetic depth and represents an excessive response to surgical stimulation. It is important to rule out the possibility of carbon dioxide accumulation, due to exhausted absorber granules or improper connection of the breathing circuit, as the cause of hyperventilation. Panting can occur with narcotics and thereby decrease the effective ventilation. Most often this represents an inconvenience to the surgeon. A less common cause of panting is actual hyperthermia. Erratic or jerky breathing patterns also usually indicate improper anesthetic depth. As before, airway obstruction and various causes of carbon dioxide accumulation should be ruled out.

Pallor and Cyanosis

Pallor of mucous membranes is a complex sign in that it may occur as a compensatory response to either excessively light or deep planes of anesthesia. Reduced cardiac output due to anesthetic depression or increased sympathetic tone due to pain can cause pallor. It is important to identify the cause in order to appropriately treat the problem. Incorrect management may compound the problem and cause decompensation and immediate deterioration.

Cyanosis rarely occurs in anesthetized patients breathing oxygen. In order for cyanosis to develop, hemoglobin must be present in sufficient quantities and in the reduced (non-oxygenated) state. Hypoxemia that accompanies anemia therefore will not become evident through cyanosis. When cyanosis of either mucous membranes or blood in the operative field does occur, oxygen should be administered and adequate ventilation and pulse quality should be ensured.

Bradycardia

Bradycardia is often associated with procedures or drugs that cause increases in vagal parasympathetic nervous system tone. Difficult endotracheal intubations, deep abdominal surgical procedures, intraocular surgeries, and some surgeries on the neck or in the thorax can all cause vagal-mediated bradycardia. Atropine or glycopyrrolate administration is effective in prevention of most vagal effects. Treatment after the vagal effects become evident is often less rewarding.

Non-vagal bradycardias may result from excessive anesthetic depth, hypoxia, or hypothermia. Bradycardia can be a very serious sign of a significant anesthetic emergency. Administration of atropine and attention to possible causes is imperative.

Cardiopulmonary Arrest and Cardiopulmonary-Cerebral Resuscitation

Every member of a veterinary hospital staff should be prepared to constructively contribute in an emergency resuscitation. Although not addressed here, CPCR must be addressed in every hospital.
Hypotension

Hypotension is caused by either decreased cardiac output, increased capacitance of the vasculature, or inadequate blood volume. Intraoperative fluid therapy at 10 ml/kg/hr is often appropriate for replacement in many surgical patients, but increased volumes can be necessary. Clinical evaluation to distinguish between hypovolemia and reduced cardiac-output states as causes of hypotension can be based on patient history and evaluation, including central venous and arterial pressures.

Vasodilatation is a very common side effect of many anesthetic drugs. The tranquilizer acepromazine is a hypotensive drug, particularly at higher doses. The volatile anesthetics also cause significant vasodilation. Most anesthetics also are potent cardiac depressants, again particularly at higher doses. Hypotension under anesthesia is therefore most appropriately managed by reduction of anesthetics and fluid administration as primary management.

Tachycardia

Heart rates above 180/min in dogs and 200/min in cats are associated with decreased efficiency and increased workload. Tachycardia can be due to fear, pain, inadequate anesthetic depth, pre-anesthetic excitement, or a rough induction of anesthesia. Hypotension causes a compensatory tachycardia. These causes of supra-ventricular tachycardia should be recognized and treated.

Compensatory tachycardia in response to hypovolemia and hypotension results in decreased coronary artery blood flow and increased myocardial workload. If other conditions contribute to hypoxia there is significant risk of development of more serious arrhythmias. Fluid therapy for hypovolemia, adjustment of anesthetic plane, and support measures to avoid cardiovascular deterioration are necessary.

Ventricular tachycardias are a much more serious emergency. An occasional ventricular ectopic beat is cause for concern but not necessarily indicative of patient distress. When ventricular arrhythmias become frequent or progress to ventricular tachycardia, immediate treatment is required. Ventricular arrhythmias indicate an irritated, hypoxic, or diseased myocardium.

Ventricular tachycardia should be treated with intravenous bolus injection of 2% lidocaine at a dose of 1, 2, or 3 cc in small-, medium-, or large-size dogs respectively. This rule of thumb will allow for immediate therapy without an accurate dose calculation, which could contribute to a life-threatening delay. It has been recommended that propranolol is the drug of choice for treating ventricular arrhythmias in cats. Lidocaine is also effective in cats. Total dose limitation is more important in cats due to their smaller body size and blood volume.

Success in emergency management of ventricular arrhythmias is evaluated by continuous ECG monitoring. Bolus injections of lidocaine can be repeated to a total accumulated dose of about 10 mg/kg without significant risk of overdose. When two or three injections are required over a period of 15–20 minutes, it is necessary to convert to a continuous IV infusion of lidocaine at 30–80 micrograms/kg/min. Refractory arrhythmias may require conversion to therapy based on alternative antiarrhythmic medication.

Delayed Recovery

Delayed recovery from anesthesia is managed by recognition of differential causes and a rule-out of
individual possibilities. A systematic approach to potential causes will provide for balanced care, with correction of often multiple factors such as hypothermia, inadequate fluid support, reduced metabolism or clearance of drugs, and debilitation associated with the stress of anesthesia and surgical trauma. Deterioration due to a hypoxic episode must be considered.

Hypothermia

Hypothermia is among the most common of anesthetic complications. Body heat is lost with preparation of the surgical site, contact with cool surfaces such as surgical tables, breathing of dry anesthetic gases, and evaporation from the airways and the surgical field. Moderate hypothermia is a frequent problem, even with attention to each of these factors. Body temperatures down to approximately 92°F increase oxygen and energy requirements during recovery, but most patients can tolerate this level of hypothermia. More extreme hypothermia causes delayed recovery, reduces tissue perfusion, and increases morbidity and mortality.

The risks of thermal injury are so great with older consumer-style electric heating pads that their use in anesthetized, sedated, or depressed (many critically ill) patients is considered extremely hazardous. A very different dispersed field or amorphous resistance electrical heating blanket to avoid thermal injury and safely warm the patient is now available from at least two sources. These new dispersed field resistance electric heating systems are very effective and can be much less costly to use.

Warm water bottles or surgical gloves filled with warm water have been shown to be rather ineffective in raising the body temperature of hypothermic patients and at the same time constitute a significant risk of causing thermal burns at the site of contact. Circulating warm water blankets are a much better alternative to warm water bottles or gloves, but these are of limited efficacy in rewarming hypothermic patients. Forced warm air heating systems are more effective than circulating warm-water blankets and can also be used to cool hyperthermic patients when set to deliver unheated ambient air. Proper use of forced air systems must include some type of dispersive blankets to envelop the patient in warmed air and avoid hot spots by distributing the warmed air. The dispersive blankets and the high consumption of electricity both increase the cost of use of the forced warm air systems.

Other Complications

Many other complications and emergencies can occur during or be associated with anesthesia. These include anaphylactic-like reactions, hyperthermia, biochemical imbalances, gastroesophageal reflux, regurgitation, vomiting, aspiration, and many surgical complications such as hemorrhage and pneumothorax. Avoidance of complications and effective management of emergencies requires continued vigilance and immediate appropriate action.
In recent years, anesthesia has become better and safer, in that we are now able to provide successful anesthetic management for patients who would not have had a reasonable chance a few years ago. In many cases, these are even managed as outpatients, quickly returned to their owners in full recovery. Our choice of anesthetic drugs has greatly expanded, and safer anesthetic agents are indeed responsible for much of the improvement noted. The use of more sophisticated monitoring and better physiologic support has become widespread, with continued rapid growth apparent in this area. In spite of increased owner expectations and the fact that veterinarians now have sicker patients presenting with concurrent diseases, injuries, or debilitation, we can increasingly manage our patients successfully with the improvements in anesthesia and related perioperative care.

Better Training and Ongoing Training
This paper on veterinary anesthesia helps to provide an update on current and developing methods. Continuing education seminars and numerous other contemporary publications attempt to further these same goals. The education of veterinarians and veterinary technicians now includes rather extensive attention to anesthesia and related topics. Veterinarians with advanced training in anesthesia and board certification by the American College of Veterinary Anesthesiologists are now involved in the training of new veterinary students at almost all North American colleges of veterinary medicine. Through the North American Veterinary Technician Association, licensed veterinary technicians may now pursue Veterinary Technician Specialist certification in anesthesia with advanced training and skills in veterinary anesthesia and membership in the Association of Veterinary Technician Anesthetists.

Monitoring and Attention to Detail
In addition to veterinarians, well-trained technicians continuously evaluate the patient throughout anesthesia. Awareness of the ever-changing condition of the anesthetized patient is a shared responsibility that can only be shared effectively and safely when the medical team works together. We intend to remain aware of even subtle changes in patient status under anesthesia. We must always recognize that challenges to the welfare of our patients come not only from their underlying illness or injury, but also as undesired effects that even the best anesthetic care may present.

Modern monitoring equipment is increasingly available at reasonable cost for veterinary use. We no longer need to rely upon out-of-date, poorly serviced, unsafe, and inappropriate equipment that has been discarded from human patient use. Fortunately, however, there is good-quality equipment still available from the human patient market. Increasingly, that equipment now can be found with good warranty protection,
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recent service records, and, importantly, with design and function capabilities well suited to veterinary patient needs. There is also good-quality equipment available specifically for the veterinary patient. Medical equipment sold exclusively for veterinary use does not receive the degree of oversight and approval required for human-use equipment. In spite of this, there is very good veterinary-specific medical equipment. The demands of veterinarians, and of animal owners, for improved anesthetic delivery, monitoring, and support has fueled the growth of this industry.

No longer is the application of relatively advanced monitoring equipment and anesthesia machines limited to academic institutions or referral practices with heavy surgical caseloads. Monitoring of electrocardiogram, temperature, blood pressure, and pulse oximetry are rapidly becoming more routine, even in general veterinary practices. Airway monitoring of carbon dioxide and anesthetic gases in the breathing circuit is also becoming more popular. Proper use of these technologies requires a good working knowledge of the normal values, the significance of deviations, and an understanding of appropriate management options.

New Options in Anesthetics

Through the use of a good variety of injectable and inhalant anesthetics, great anesthetic safety and convenience is possible for our patients. Remarkable improvements have developed in outpatient anesthesia. The recent popularity of several injectable anesthetics, most popularly propofol, has greatly improved our options. Product shortages have resulted from the removal of defective generic products, but we can manage this temporary supply-and-demand issue. Isoflurane has been the strongly predominant inhalant anesthetic for several years. The more newly available inhalant, sevoflurane, can be used to provide for a remarkably rapid yet smooth induction and recovery from anesthesia, and can provide for a rapid change in the level of anesthesia as needed. Appropriate use of these new agents requires skill and knowledge and will be addressed more fully. All anesthetics have a limited therapeutic index, or margin of safety. All can depress vital functions, and inappropriate use can result in loss of life. It is useful to remember the old guideline: “There are no safe anesthetics, just safe anesthetists.”

While we enjoy a wealth of new options and opportunities in veterinary anesthesia, we must make changes in our anesthetic strategies carefully, recognizing that experience is necessary to identify any abnormal responses from those that should be expected. Careful and conservative use of any new anesthetic or technique is crucial. “Nobody likes an adventurous anesthetist!”

Individualized Anesthetic Care

Much more important than the choice of which specific anesthetic drugs or equipment we use, however, is the manner in which we select them and the skill and care with which they are used in our patients. Best use of various options requires an individualized approach to anesthetic management. In treating infectious diseases, veterinarians wouldn’t choose the same antibiotic for every patient or condition encountered. Similarly, the best choice among options in anesthetic care requires recognition of individual needs and individual risk factors, which vary widely among veterinary patients. We recognize breed sensitivities and relative contraindications in the choice of anesthetics. For many years, breed associations have provided warnings based on anecdotal reports. With continued research, some of these have been or will be substantiated. Others perhaps will
be refuted. In the absence of clarifying data, caution dictates selection and use of the best anesthetics from among the many choices available.

Patient differences that are important in anesthetic care are obviously not only those that relate to species, breed, and age differences. As a simple example, patients undergoing elective surgery or those who are traumatically injured both need analgesic therapy. Opioid analgesics, for instance, have varying efficacy and duration of action. The range of choices allows for brief, mild analgesia such as for an outpatient neuter, all the way to profound analgesia for the care of a substantially traumatized animal.

Pre-anesthetic Evaluation and Screening
Better anesthetic care also includes a more thorough pre-anesthetic evaluation, which can fit nicely into a comprehensive approach of well-patient care and the work-up of the non-elective patient. Pre-anesthetic evaluations should be tailored to the needs of the patient. For example, the pre-anesthetic evaluation of a diabetic patient would include blood glucose determination(s) to help guide physiologic support as a part of the anesthetic care. Basic physical findings may lead to more extensive evaluations. For example, if a heart murmur is detected in a young cat, an echocardiogram may be performed to rule out cardiomyopathy before subjecting the animal to the stresses of anesthesia. Not all patients need the same level or intensity of pre-anesthetic evaluation or screening. Matching the process to the patient becomes cost effective for the pet owner as well as for the practice owner.

Geriatric Patient Care
It is fortunate that the improved role of pets in our society has in various ways kept animals as a part of the family for more years. With an aging pet population, and with keen interest in keeping pets as very functional members of the family group, we have the opportunity to care for many more geriatric patients. These much-loved pets often receive more extensive pre-anesthetic evaluations, which help to identify marginal reserve function and any subclinical organ disease or dysfunction. Geriatric patients have dramatically reduced requirements for many anesthetics and could be overdosed at standard recommended drug doses. Armed with this information, the veterinarian can individualize anesthetic care to minimize the risks of complications. Typical of this patient type would be the older dog presented for routine dental care. Through our improved care, we can extend not only the lifespan, but also the “healthspan” of these animals.

Outpatient Anesthesia
As human patients, we expect to have most minimally invasive medical procedures, and even many substantial surgeries, conducted on an outpatient or same-day basis. Reduced hospital costs are not the only concern driving this change in human patient care. Everyone is happier and can return to daily routines more quickly with shorter hospital stays. This applies to veterinary medicine as well. Better anesthetic care is a major component of this change. Clients personally experience it in their own medical care from the perspective of patients, and now they expect it in the veterinary care we deliver for their pets as well. Reliable, fast, and smooth recovery from anesthesia is a wonderful feature of many of the more modern anesthetic methods. While every patient differs, we’ve come to expect more and more of our patients to bounce back quickly.

Prior Preparation Prevents Problems
Readiness includes anticipation of contingencies and
willingness to consider, and perhaps move along to, what we have in mind as the “Plan B” for that patient. This is recognition of whatever else might be likely to happen for this animal other than the expected course of events. Those who are ready for these contingencies can intercept developing problems before they reach the “crisis” stage. This requires attentiveness to warning signs. Good anesthetic monitoring and appropriate responses to changing patient status are much more successful strategies for patient care than would be any level of expertise in crisis management.

Pain Management

Our clients expect optimal control of animal pain. Clients expect the best in anesthetic survival and in relief of pain. Their most basic expectations are that their pet will survive and that it will not hurt. We do have the tools available to effectively manage procedural, traumatic, and perioperative pain. We also have increasingly fine methods for very effectively managing the more chronic pains of degenerative joint disease and cancer. The three principles of effective pain management are: (1) preemptive analgesia, (2) balanced analgesia, and (3) willingness to dose to effect. Application of these principles can help us devise very effective pain management for every patient. Smart use of analgesic strategies offers tremendous benefit through relief of unnecessary pain and suffering. Improvements in the areas of the recognition and management of animal pain have been arguably greater than in any other aspect of veterinary anesthesia. Benefits include not only improved patient comfort, but also reduced anesthetic requirements, shortened hospital stays, improved immune function, and reduced morbidity and mortality.

Good quality pain relief is also very cost effective.

Supportive Care

As an example of basic physiological support, the provision of fluid therapy and appropriate patient warming devices is increasingly commonplace in veterinary anesthetic care. Fluid therapy is an appropriate measure to compensate for the vasodilatation and hypotension that can commonly occur with the best of anesthetic techniques. We also recognize, through the increased use of blood pressure monitoring, that many of our patients can become hypotensive. Our older patients may be particularly susceptible to deleterious consequences of inadequate tissue perfusion.

Patient warming devices that gently circulate warm air or warm water have replaced dangerous electric heating pads and bags or bottles of warm (or hot) water. All too often, electric heating pads and hot water bags and bottles have either burned animals or failed to properly prevent hypothermia. With individualized patient management, which includes physiologic support, those animals with particular needs or susceptibilities are better prepared for the rigors of anesthesia and surgery.

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and the high consumption of electricity both increase the cost of use of the forced warm air systems.

**Summary**

There seems to be little upper limit to the sophistication of medical care demanded by the pet-owning public. Improvements in all areas of veterinary medicine are being rapidly embraced. The standard of care is indeed moving forward. Many animal owners assume that the veterinary anesthetic care and pain management their animals receive are already at a very high level of sophistication, perhaps even comparable to that afforded to human patients. Our obligation to do the best we can for our patients and for our clients requires that we move forward and maintain very high standards in providing anesthesia and analgesia.