Animal Anesthesia: The Race to Recovery

An Honors Thesis (HONR 499)

by

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Abstract

Animal anesthesiology is a long-lived science that was first recorded in ancient writings. The methods of use have transformed throughout history, but the principle goal of alleviating pain in order to treat and save an animal’s life has never changed. This versatile branch of science allows for veterinarians and professional personnel to care for their patients to the best of their abilities while in a safe environment. I investigated the required preparations, medications, and the proper protocol that are essential when using anesthesia, then compared and contrasted these topics with small animal anesthesia to equine anesthesia. My research greatly increased my knowledge that will benefit my career as a veterinarian.

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Preface

When I was younger, the Animal Planet Network show called “Emergency Vets” captured my full attention. The show constantly showed cases of animals with severe injuries, like two shattered hind limbs, or less severe cases like a puppy getting its first exam. The veterinarians appeared busy, stressed, and concerned, but I admired that. I admired the way they pushed themselves through stress and frustration to save every animal. I remember the way each episode made me feel. The way the veterinarians on the show fought for the animals’ lives inspired me. My constant thought while watching was “I want to do that. That is the job for me. I know I can do that someday.”

This past summer those same thoughts and feelings were reinforced when I helped Dr. Gupta and his technicians resuscitate English bulldog puppies from a caesarian surgery. Dr. Gupta was extremely diligent and focused. He was determined to save all the animals. I remember thinking that I want that same knowledge. When the owners arrived, they were so appreciative and thankful for Dr. Gupta working promptly, efficiently, and updating them during the surgery. He was able to save five lives of five wonderful dogs and give the owners a new, more complete family. That is one of the many things I appreciate about the veterinary field. It allows for opportunity to expand a family and bring happiness to animals and owners. It is one reason why I want to pursue a lifelong career as a veterinarian.

When I worked at Conley & Koontz Equine Hospital, a dystocia case, which is when there is a difficult birth caused by improper positioning of the foal in the uterus, came in on emergency. There was no room for error and everything was fast paced. The doctors were focused and prepared for every option of surgery or clinical care that might need to be done. With the owners waiting outside surgery and sedation lasting only a half hour,
the pressure was evident. The doctors used chains to tie around the foal's front coffin joints, used a crane to lift the mare for gravitational force, and pulled hard on the foal. With minutes to spare in the sedation, the foal was delivered and the mare was unharmed.

Each of these personal experiences taught me a lot about the veterinary medical field and continued to increase my interest in pursuing this lifelong career. During these procedures, I was able to follow the decisions of the veterinarians and could understand the reasons behind them. However, the one common theme that I had difficulty understanding during these types of procedures was anesthesia. I was aware of the importance for prompt and efficient anesthetic drugs, but I did not understand how it was determined what drugs were used or how they were administered. As a result, the spark of interest grew into a flame every time I witnessed a surgical procedure that required anesthesia. The lack of understanding is why I decided to focus my honors thesis topic on the different types of animal anesthesia, its history, preparations, protocol, and importance. The goal of my research was to acquire a better understanding of this unique science, as well as gain important knowledge I can utilize in my future career as a veterinarian.

Introduction

The shot has been fired and the race has begun. The sound of hooves beating the fine dirt into a trampled imprint of the horse's soul resounds in the animal's ear. The focus of the jockey cannot be altered; the heart of the beast cannot be tamed. Within a matter of seconds, time figured out a way to stand still. Like swarming bees to fresh honey, every oxygen molecule rushes to penetrate the lungs of the horse, giving life to the
steaming body that the gunshot ignited. With urgency and haste, the beast flares its nostrils, chomps at the bit, and lengthens its stride. The ground is the hooves’ victim; relentlessly beaten and shaken to its core. The black tunnel engulfing the horse’s eyes continues to narrow as the sensation of victory rushes through its veins. Just when there are only ten strides standing in the way of glory, the seemingly beaten ground fights back. As the horse’s hooves come crashing back to the ground, traction is lost, the animal loses balance, and gravity pulls the animal and its rider to the dirt. The ground has become the new victor. Time stops again, but now for the veterinary medical staff. The shot of injury has been fired and the race to successfully anesthetize the terrified and pain stricken animal has begun. It has now become an entirely new race to win. The risks of anesthesia are the same as they are in a race. Making mistakes, injury, or failing are the dangers that veterinarians have to face every time an animal needs to be put under anesthesia. Since ancient history, this science has drastically changed and enhanced the practice of veterinary medicine. Medications, methods, and the effects of anesthesia differ from equine to small animal species, but there are also many similarities that can link the two contrasting groups. Nevertheless, anesthesia is an art of science used to aid, improve and assist the veterinarians attempting to cure and enhance the animals’ quality of life.

**History**

Anesthesia has been in existence for an extremely long time. Present in the ancient writings of Sumerians, Babylonians, Egyptians, Greeks, and Romans, anesthetic practices developed during the Middle Ages and continued to mature and modernize. In general, the types of procedures used then are now considered archaic. In the past, humans were the subjects of animal anesthetic practice more so than animals, even when it came to
testing new methods. The ancient people attempted to put someone to sleep with the use of opiates, alcohol, asphyxiation, or compression of the carotid arteries to alleviate pain during surgical intervention. It is easily established today that those methods were not only extremely dangerous, but frequently resulted in death before the surgery even began. These drastic processes continued until 1540, when ether was introduced. Reportedly, this chemical compound had anesthetic effects on birds when it was first tested. This was proof that a safer and more practical method of putting animals to sleep was possible. Unfortunately, this discovery of ether did not avert people away from using the ridiculous methods like asphyxiation or alcohol. If the unorthodox anesthetic methods were still used today, it would be the equivalent of putting a lame horse in a race. There is already a huge probability of being unsuccessful, and with the added stress of the injury, the bigger challenge to reach full recovery is created for the patient ("Anesthesiology" 1).

The ceasing of these extreme, unorthodox practices did not occur until the official discovery of chemistry, carbon dioxide, oxygen, and other essential gases used in life. Although the date of those discoveries is uncertain, it was reported that nitrous oxide has anesthetic properties by Sir Humphrey Davy in the 1800s. This discovery was expanded upon in 1824 when H. H. Hickman discovered how inhaling nitrous oxide and carbon dioxide numbed the pain in dogs during surgery. These gases appeared to enhance the rate and depth of breathing, which allowed the animal to fall into a slumber state that was needed for the operation. As a result, the first non-invasive and less harmful anesthetic was discovered for all to experiment and expand upon ("Anesthesiology" 2).

Although nitrous oxide and carbon dioxide were discovered in 1824, they were not utilized until twenty years later in 1844. The anesthetic properties were first used in
humans rather than animals and proved to be successful throughout the following years. In fact, nitrous oxide is still the primary gas used for human general anesthesia today. The focus shift between man and animal medicine did not occur until 1847. The first to attempt to use gas on animals was a doctor named Dr. C.P. Jackson. Dr. Jackson was a Boston physician who successfully used ether in animals rather than the nitrous oxide. Although this was sufficient enough to subdue the patients, it did not work as well as chloroform. The discovery of chloroform was the key to opening the gateway of research, experimentation, and recognition of how and what should be used in order to safely put animals in a monitored and organized coma for treatment. Chloroform is no longer used today in veterinary science due to the serious side effects that it imposed on the liver and kidneys of patients. However, it still deserves credibility as being the starting "gunshot" of the race that led to advances in veterinary medicine anesthesia ("Anesthesiology" 2).

**Anesthesiology Continues to Expand**

After chemistry and natural gases were discovered and applied to general anesthesia, many scientists explored different avenues of administering the drugs. For example, in 1875 a man by the name of Pierre-Cyprien Ore published his first workings on chloral hydrate and how it can be given as intravenous anesthesia in animals. Shortly after this was explored, Humbert used the same type of drug to anesthetize a horse. The primary distinction between the methods was the administration. Humbert completed his studies by giving the chloral hydrate in the rectum, as well as using inhalation as another source of anesthesia. (Edgar II, Saidman, and Westhorpe 295). These two available options proves that general anesthesia, especially for animals, was continuing to develop into the mid-1800s and on. The improvements continued to evolve throughout this
century. It was not until the end of the nineteenth century when the various ways of giving general anesthesia were officially established. However, the race to perfect the drugs continues to run throughout the course of time, with the safety of each patient remaining at the forefront of every veterinarian and scientist’s mind (“Anesthesiology” 2).

The race of anesthetic expansion continued throughout the nineteenth century and into the twentieth century. Many new developments were still being introduced, however many were producing unfavorable results. For example, cocaine was tested as an aesthetic but it did not work well on the animal patients. As a result, cocaine was not introduced into veterinary medicine. Because of the continuing mix of methods and procedures, general anesthesia was established as a science but was having difficulty gaining a foothold as an adopted profession. It was not until the mid-1900s when the science became more widely trusted and tolerated with the introduction of barbiturates (“Anesthesiology” 3). Barbiturates are drugs that act as a depressant on the central nervous system of a patient. These anesthetics are characterized into four different groups: ultra short, short, intermediate, and long-acting. Their effects can range from mid-sedation to coma (“Barbiturates” 1). Barbiturate drugs were used exclusively for small animals for a short time period. This allowed for anesthesia to make its first footprint into the small animal field. Although these new drugs benefited small animal anesthesia, it did not have that same positive impact for large animal anesthesia.

Unfortunately, the rough and prolonged recovery in large animals is a lot more difficult to overcome when bringing an animal out of anesthesia. For this reason, the welcoming of anesthetic practices in large animals was not completely present until pre-anesthetics were introduced in 1950 (“Anesthesiology” 3). The use of pre-anesthetics,
which are medicines given for a smoother and safer induction of anesthetic drugs, allow for a better recovery in large, powerful animals, as well as a safer recovery time so that the animal can regain its strength and balance.

During the early twentieth century, anesthesiology became an official division of veterinary medicine in the United States. This was solidified by the creation of the American Society of Anesthesiologists, which is the group that creates and implements the standards of safety and ethics for anesthesiologists ("Anesthesiology" 4). By the end of the twentieth century, the race of discovering animal anesthesia appeared to be coming to an end and every scientist that contributed to the cause were its victors.

**Different Types of Anesthesia**

Today, modern anesthesia, which is the "ability to produce controlled, reversible state of unconsciousness, amnesia, and muscle relaxation", has continued as a major platform for all veterinary medical practices ("Anesthesiology" 5). "Anesthesia" is the common term used when discussing the state of insensibility or depressed activity of the body, however it is not the only branch that makes up this science. "Analgesia" refers to pain relief without the loss of consciousness. This is frequently used to refer to the depression of nervous tissues. It is typically activated via the use of drugs that target the peripheral and central nervous systems ("Analgesic" 1). Another term often used is "narcosis". This refers to a state of sleep that is accompanied by analgesia. If an animal is severely injured, it is usually in the animal, owner, and veterinarian's best interest to put the patient in a narcotic state to ensure proper medical care and handling without a bad temperament getting in the way of adequate medical treatment. "Sedation" is defined as a sense of calmness due to a mild degree of depression of the central nervous system, which
usually causes drowsiness. Sedation is an extremely popular form of anesthesia in equine practices. Because horses are usually high-strung, skittish, and terrified largely when they are in a new environment, sedatives are regularly injected to protect the horse and veterinarian from any unnecessary harm ("Anesthesiology" 5).

The three ubiquitous branches in anesthesia are: local anesthesia, regional anesthesia, and general anesthesia. Local is the loss of feeling in a particular area of the body. This method is often used when the doctors need to stitch a small wound or numb a particular area in order to properly perform medical treatment. The sole purpose is to avoid inflicting pain on the patient. Regional anesthesia is referred to as the loss of feeling in a larger targeted area than local, but it is still restricted to the areas of the body. Regional is often used synonymously with local anesthesia. Both methods carry the same principle of focusing on a particular injured area without the veterinarian inflicting pain, or requiring that the animal be completely unconscious. In fact, unconsciousness is usually avoided because of the increasing risk factors for every time a deep sleep is induced ("Anesthesiology" 5-6).

Lastly, general anesthesia is defined as the “state of unconsciousness with the absence of pain sensation over the entire body. It is produced by intoxication of the central nervous system, which in turn diminishes external stimuli and stimulates muscle relaxation” ("General Anesthesia"). General anesthesia is the term that coincides with any patient required to go into a full surgery. It is imperative, when using this method, that all trained professionals are aware, focused, and performing their duties to the best of their abilities. Any time an animal, large or small, is placed under general anesthesia, the risk of side effects or death increases. During any case, the professionals need to be aware of this
and act accordingly. However, that does not mean anesthesia is completely unsafe. The branches used today lead to the best possible chance of recovery or healthy improvements for the patient. All three of these branches, whether it is local, regional, or general anesthesia, are key methods used in order to properly treat any suffering animal.

**General Animal Anesthesia Preparations**

Race day is the time to shine for all the participants. It is the day where all the hard work and frustrations compile into one big bubble of adrenaline that bursts and disappears off of athletes, even if those athletes are horses. But as all good jockeys know, the preparation before the race is pivotal. Without the correct execution or application of knowledge during less stressful times, the chance of correct execution on the highly stressful race day is extremely unlikely. The same concept applies in the medical field, especially in veterinary medicine where the patient's every move can become a guessing game. Preparations are important for all medical procedures, but veterinarians take the preparations for pre-operative anesthesia especially seriously. Local and regional anesthesia do not require as much detailed work as general anesthesia requires. This is due to the smaller areas of focus for those methods, as well as the fact that the patients are not put into complete unconsciousness. Regardless of the type of anesthesia used, it does not matter whether a small animal or large animal is being treated; the requirement for proper preparation and execution is crucial.

The list of tasks involved in order to achieve a successful pre-operative anesthetic procedure is not long, but it is detailed. The first form of action, for the patient and owner's best interest, is to collect a medical history. This history must include any past medical problems, allergies, significant illnesses or injuries, and any general knowledge
about the pet's medical condition (Martinez et al. 1). Even small details can indicate large scale problems that may prevent the veterinarian from using anesthesia. For example, if the patient has a history of poor exercise ability, this could indicate abnormal heart or lung function (Keegan 1). This type of shortcoming is an important consideration because the functionality of all of the major organs is imperative when an animal is in an induced state of unconsciousness.

Due to these types of behavioral or physical obstacles in each patient, another process in preparation for anesthesia is a physical examination by the veterinarian. This entails taking the patient's temperature, pulse rate, and respiratory rate. It is also imperative for the veterinarian to evaluate all of the organ systems to indicate whether or not there are any cardiovascular and/or respiratory abnormalities (Martinez et al. 1-2). If there is an indication of either problem, it is important that those are attended to before anesthesia. Unfortunately, sometimes those abnormalities indicate that the patient's body would be unable to properly withstand the anesthetic drugs or overcome any possible side effects, so anesthesia cannot be performed.

Blood tests are also included in physical examinations. Many of the common anesthetic drugs have a tendency to affect blood flow to major organs or are inactivated by the liver. Because of this, the blood tests can be used to test for anemia, kidney, and liver function. The results of the tests aid the veterinarian in deciding what type of anesthetic regimen should be utilized (Keegan 1). Once the patient's medical history has been collected and the physical examination (with blood tests) are concluded, the veterinarian can make the best educated, knowledgeable, and practical decision on what anesthetic techniques should be implemented. This entire preparation procedure is
similar for both small animals, like cats and dogs, and large animals like horses. Any

differences that may occur in these pre-anesthetic steps are the result of anatomical
differences between species, or habits of behavior that is specific to each patient.

**Choosing an Anesthetic Regimen**

Once the anesthetic preparations have been conducted, the next step is for the
veterinarian to decide what regimen is appropriate to use on the patient. This decision is
based upon six different factors. The first factor is the physical status of the animal. This
should be easily evaluated based on the previous preparation steps and tests conducted.
The second factor is the duration of anesthesia that will be required. If the time of
unconsciousness is short, such as a half hour, then the anesthetic drugs do not need to be
very strong. The less the amount of invasiveness and potency of the drug on the body, the
better it is for the patient (Martinez et al. 2).

The third factor is the number of personnel involved in the procedure and their
skill levels. For example, if the patient is a horse that needs to undergo a long surgery, the
regimen would require about six well-trained professionals to be in the surgical area, with
two or more of those individuals being veterinarians. The other professionals usually
include registered veterinary technicians or assistants. If a small dog is undergoing a
minimal surgery, then the requirement would not need to exceed more than two
professionals, with only one of those two being the veterinarian (Martinez et al. 2).

The fourth factor to consider on which anesthetic regimen to utilize is the safety of
the facility or location where the anesthesia will be performed. This includes both the
area of induction with the drugs and the recovery room, but the safety of the recovery
room is pivotal because of how vulnerable the animal is after surgery. In small animal
practices, the cats or dogs are frequently placed back in their holding cages that are heavily padded with towels and soft blankets once the procedure is complete. The patients remain under direct technician and/or veterinarian supervision until they regain consciousness and proper functionality. For horses, the recovery room is a large, enclosed room with padded walls, floors, and doors. When the patient is lowered into the room, all professionals are required to leave and lock the doors when the animal starts to awaken. When a horse begins to regain consciousness, it is dangerous for any personnel to be within a close radius due to the size, power, and initial instability of the animal. Horses thrash and kick when coming out of anesthesia, whereas dogs and cats typically just shake or squirm.

The final fifth and sixth factors parallel one another. The regimen is based on what anesthetic and monitoring equipment is available. There is not much variance in the type or brand of equipment used in small animal practices versus equine. Rather, it is just a matter of what the veterinarian owns and what each machine is specifically designed to do. For example, a vital signs monitor is used in order to track and record the heart rate, blood pressure, and pulse of the patient during surgery. This type of monitor does not vary between small animal and equine medicine. Regardless of any differences, every time an animal goes under anesthesia, it is highly advised to use equipment that will aid in monitoring the animal while unconscious. (Martinez et al. 2).

Recently, the American College of Veterinary Anesthesiologists (ACVA) revised the set of guidelines used for anesthetic monitoring. The ACVA’s goal of these guidelines is to “improve the level of anesthesia care for veterinary patients.” In order to achieve this goal, the ACVA states, “frequent and continuous monitoring and recording of vital signs in
the peri-anesthetic period by trained personnel and the intelligent use of various
monitors are requirements for advancing the quality of anesthesia care of veterinary
patients" ("Recommendations" 1). An example of an improved guideline focuses on
temperature monitoring. The objective is to make sure the patients do not undergo
serious deviations from the normal body temperature. Methods used in order to fulfill
this objective are a rectal thermometer for measurements or an esophageal temperature
probe for continuous measurements. The guidelines also recommend that the
temperature be taken frequently throughout the entire surgical procedure and then
checked for a few hours after completion ("Recommendations" 2). Another example of
improvements to the guidelines is regarding circulation. Several methods used in order to
ensure adequate circulatory functions during anesthesia are: evaluation of the mucous
membrane color and capillary refill time, pulse oximetry to determine the percent
hemoglobin within the blood and continuous monitoring of the heart rate and rhythm
("Recommendations" 1).

Pre-Anesthetic Drugs

After each of the six factors have been evaluated and taken into consideration by
the veterinarian, the regimen can adequately be determined for the patient needing
general anesthesia. Before the anesthetic drugs are administered, however, it is very
common for pre-operative medicines to be used in order to calm the patient down. They
are transmitted in the form of a sedative or tranquilizer. This is an important component
of the procedure because if the animal is in an excited state, they may be predisposed to
developing an irregular heart rhythm. The excitement also calls for a higher dose of the
general anesthesia, which veterinarians generally attempt to avoid, minimizing the impact of the strong drugs on the body (Keegan 1).

There are also other advantages to using the pre-anesthetic drug agents. First, the drugs ensure both safety for the animal and the professionals. They also provide insurance that the animal is in the best possible state of health before being put in an induced state of unconsciousness. Also, with the animal in a calm state, the induction and recovery from general anesthesia usually flows smoothly and minimizes any additional struggling. The sedative also keeps the airways free from saliva, mucus, and bronchial secretions because of the lack of activity and stress on the body’s metabolism. Lastly, reduction of gastric or intestinal motility is a common advantage, which eliminates the chance of vomiting (“Anesthesiology” 16).

There are many categories and types of pre-anesthetic drugs that can be administered to all different species. The common categories of pre-anesthetic drugs are: anticholinergies, tranquilizers, opioids, alpha2-adrenergic agonists, alpha2-adrenergic antagonists, and tranquilizer-opioid combinations (“Anesthesiology” 16). Anticholinergies are used to reduce bronchi-salivary and mucous gland secretions, reduce motility of the G.I. tract, dilate the pupils, and stabilize the heart to prevent cardiac arrest. An example of this type of drug would be Atropine Sulfate. Anticholinergies are usually administered to tachycardia patients, which means they have an abnormal, rapid heart rate (“Tachycardia” 1). Tranquilizers are used in order to produce calmness for easier control of the animal, reduce the expected dose of general anesthesia, and provide an anesthetic effect of unawareness without causing drowsiness. Diazepam is a commonly used tranquilizer. Opioid drugs are used to decrease the body temperature, suppress any cough
residing in the patient, decrease excessive salivation, and reduce sweating. An example that would fall into this category would be the drug Morphine Sulfate. The tranquilizer-opioid combinations are simply combining two drugs from each of those categories in order to achieve multiple effects that each produce. Etorphine-Acepromazine is one type that is classified as a tranquilizer-opioid drug. Lastly, the alpha₂ agonists and antagonists are used to frequently sedate vicious animals or induce muscle relaxation, which results in relaxation of the entire body. Xylazine and Tolazoline are two popular pre-anesthetics that are used under these categories ("Anesthesiology" 18-25). Each particular category of pre-anesthetic drug provides different functions that are ideal for specific cases.

Veterinarians are well-trained professionals that are able to deduce which drug would produce the best, healthiest, and most efficient outcome for the patient before undergoing general anesthesia. As is every step of the preparation, choosing the correct regimen and type of drug to use are vital phases of the anesthetic process. These drugs are the equivalent of consuming and maintaining the proper diet before a big race is conducted. If the horse does not obtain adequate nutrition before the gunshot resounds in the track, then the rest of the event will be ill preformed and yield poor results. If the incorrect preoperative drugs are chosen, the more likely the rest of the medical procedure will also yield poor results.

**Animal Anesthesia Protocol**

Once the cocktail of pre-anesthetic drugs has been chosen, it is proper protocol to administer an intravenous (I.V.) catheter in the vein of the front or hind limb of small animals and the neck of large animals, specifically horses. This catheter is considered to be the patient’s lifeline while it is undergoing general anesthesia. It makes it easier for the
veterinarians, or registered veterinary technicians, to add additional anesthetic drugs, antibiotics, anti-pain medications, or fluids to keep the patient's body hydrated (Keegan 1). Before implanting the I.V. catheter, it is crucial to make sure the surrounding fur is shaved and the area is scrubbed with anti-bacterial surgical disinfectant. This will help aid in preventing life-threatening bacterial infections.

Once the catheter has been placed and the drugs administered, the next step in the general anesthetic process is inserting the endotracheal tube. It is a soft, plastic tube that is inserted into the windpipe of the animal. Once correctly in place, it is immediately attached to the anesthetic machine. The utilization of the endotracheal tube allows for the veterinarian to control and monitor the breathing during unconsciousness. A principal element to this task is using the proper size of tube, which will prevent inhalation of stomach contents into the lungs or airways (Keegan 2). The endotracheal tube remains inserted into the patient until anesthesia is turned off and the animal regains its swallowing reflexes. Once the reflexes resume, it is a key sign that the patient is regaining consciousness and is on its way to recovery.

The entire process of pre-anesthetic procedures leads to finally delivering the anesthetic inhalant. Similarly to the pre-anesthetic drugs, there are many options for specific types of inhalants to be administered. The most commonly used gas in veterinary medicine is isoflurane (Posner 4). This gas has many advantages compared to other inhalants that may be used. First, isoflurane is less likely to aggravate a pre-existing abnormal heart rhythm. Second, it has the ability to induce a faster recovery with minimal side effects. Also, the pricing is affordable, especially for smaller practices. Veterinarians particularly like isoflurane because it has been proven to be a safe inhalant for older and
sicker patients. Most importantly, the gas enters and exits the brain rapidly, which also supports a faster recovery ("Result Filters" 1).

**A Common Anesthesia Misconception**

A common misconception about anesthesia is that it is a relaxing sleep. On the contrary, although the animal is in a state of unconsciousness, anesthesia is actually a period of exercise due to the heart considerations. The heart functions are usually slowed down by the general anesthesia. However, if the animal is young and healthy, they usually have a more stable cardiovascular reserve and can tolerate the effects of the drugs. The older or more debilitated the animal becomes, the less tolerance it has for general anesthesia because of the decrease in cardiovascular functionality (Keegan 2). Although this misconception is more accurate and usually more frightening to the owner, older patients are still able to fully recover from general anesthesia although the time period for recovery may take longer to complete. The older the patient, the higher the risk is for any type of surgery. The same principles apply to the race metaphor. If an older horse runs in the competition, there is a higher risk of injury or poor side effects than there would be for a young, healthy horse. However, the risks do not outweigh the benefits and an older horse can still run in the race, just as an older patient can still withstand anesthesia.

**Post-Anesthesia: Recovery and Safety**

When the procedure is completed and the patient is taken off of the inhalant anesthetic drug, there is a protocol to follow in order to ensure safety and a fast recovery. In general, animals are not able to retain body temperature as easily as they normally would. The reason for this is because many anesthetics cause the blood vessels in the skin to dilate, which promotes heat loss. The animals' cooling mechanisms are also altered due
to the drugs. Thus, regulating the environment’s temperature as well as the patient’s body temperature becomes increasingly difficult (Keegan 2). In summary, it is important that the patient is properly covered with warm towels, blankets, and/or placed in a warm room. Once the patient has been placed in a secluded area at a comfortable temperature, it is important for either the veterinarian or technician to watch the animal as it is awakening and recovering.

The first function regained will be the animal’s swallowing reflex. When it begins to swallow, the endotracheal tube must be promptly removed so that the animal can breathe on its own. From that point on, the rest of the recovery is primarily observation. It is key to make sure that the animal is not in an environment where it can injury itself further as it attempts to regain its balance. This is especially important for horses because of their large stature and fragile legs. During the post-anesthetic period, it is common for animals to have behavioral changes and issues. Though it is extremely common in all types of species, it is still important to maintain awareness of the animal’s whereabouts and not leave it alone with any children. The family pet is always well trusted by the owners, however there have been instances where the family dog has bitten a child because it was left alone with the child during the post-anesthesia time period. Although caution should always be taken in these situations, it is nothing for the owner to stress about. Usually the animal’s behavior goes back to normal, on its own, within a couple of days (Keegan 2).

**Importance of Anesthesia**

The entire process of anesthetic preparation, administration of pre-anesthetic drugs, general anesthesia, and post-anesthesia protocol are all fundamental steps taken to
aid the veterinarian in creating the best opportunity possible of enhancing every animal's quality of life. The main purpose of anesthesia, which ties together with analgesia, is to treat animals that are in pain and attempt to relieve that pain for the remainder of their lives. For veterinarians, it is more than just acting humanely. The pain relief has been proven to decrease morbidity and mortality. The scientific use of anesthesia is allowing the patients to return to normal function and every-day life more quickly than they could with more reserved treatments. Without the proper anesthesia, the animal would not be able to undergo safe and adequate surgeries, which aid in a fast recovery to continue life; the same applies to analgesia.

**Harmful Effects of Pain**

Research has shown that there is a physiological response to pain in animals. Although the responses are varied based on the amount, location, and severity, veterinarians are educated in the signs and harmful effects that pain can cause.

The first harmful effect is a significant increase in myocardial work accompanied with increased respiratory work. Secondly, there is a decrease in intestinal and urinary movement, as well as an increase in stress-induced hormones (Posner 5). These harmful effects in the body ultimately result in a slower healing time for the patient's injuries. The positive uses of anesthesia and analgesia are prevalent by eliminating these side effects with the drugs' abilities to numb nervous systems and force a state of unconsciousness, where the patient does not have to endure the pain. Without the help of anesthetic drugs and procedures, an immense amount of pain can accumulate to produce infection, depression, and negative behavioral changes within the victim. Unfortunately, struggling animals have a greater morbidity and mortality rate than humans. As a result, they need
to be hospitalized longer and they die more often (Posner 5). These reasons are why anesthesia is so important to use in the veterinary medical world. Veterinarians already have a difficult time fighting off the powerful pain force, so without any aid from anesthesia and analgesic drugs, the fight would turn into a losing war for all patients, clients, and professionals. The risks with anesthesia are important, but the greatest risk is death if effective and rapid forms of anesthetic treatment are not promptly given.

**Differences between Small Animal and Equine Anesthesia**

The process of anesthesia may vary slightly from species to species for small and large animals alike, but the purpose of preventing pain and allowing the veterinarians to treat a patient to the best of their abilities is not altered. In equine medicine, anesthetic practices and protocols are dependent upon a safe and dependable environment (Seahorn 1). A wide variety of challenges become evident due to different temperaments, situations, sizes, and injuries of the horse. For small animals, the working field is a lot simpler and easier to maintain because of their size, calmer demeanor, and the fact that most are not as fragile. Ironically, the larger the animal the more fragile their bodies become, especially when it is induced with anesthetic drugs.

The next difference between small animal and equine medicine involves some of the detailed steps in anesthetic preparation. For horses, there is a high emphasis on cardiovascular and respiratory system function because of the greater amount of work they need to perform in order to sustain the body. Although, horses commonly need an intravenous catheter to administer the pre-anesthetic drugs, it is not always essential (Seahorn 1). On the contrary, in small animals, typically the intravenous catheter is required before every type of surgery. The catheter is much easier to administer and
maintain in small animals rather than in horses. In animals like a dog or cat, they are easier to restrain and the catheter is placed in the leg. Typically, all the professionals need to do is use body weight in order to counteract the force of an aggressive dog or cat. In horses, the catheter can only be placed in the jugular vein of the neck, which has a large probability of irritating the horse and cause it to thrash and buck to avoid contact. Restraining such a large animal requires a lot more strength and multiple professionals, and produces a lot more risk to the workers than a small animal would. Power and brute strength becomes a horse’s strongest ally and the veterinarian’s biggest danger when needles are involved.

Another difference in the preparation steps is the running of blood work. For horses, studies have shown that is not necessarily feasible or beneficial to run the tests. It is typically encouraged, especially for more high-risk patients like a foal or geriatric horse, however it is not always required. For small animals, blood work is mandatory in almost all clinics. In general, the blood work is taken before any pre-medications are given. The tests are used to detect any possible underlying disorders that may influence the treatment of the patient ("Small Animal Anesthesia Guide"). Whether blood work is completed or not, the awareness of the patient’s medical history and past diseases are extremely important to consider before administering any form of anesthesia.

One of the major differences between equine and small animal anesthesia is the use of the drug called Propofol. It is widely used in veterinary practices, however its use has been limited to small animal practices. It is a drug that allows for a quick recovery time and can be used in patients of any age. The most beneficial component is its tendency to be a short-acting anesthetic. It has a rapid onset of unconsciousness and muscle
relaxation, with a rapid clearance for recovery after the procedures. For this reason alone, however, propofol is not used in equine medicine. As a single agent, the drug is not suitable for horses because of its short time periods of sedation. If higher doses are given to lengthen that time, it can cause excessive stumbling, muscle weakness, and the possibility of induced excitement (Rosenthal 1). Those are all negative effects that hurt the veterinarian's ability to treat rather than help them. Although Propofol is not used in horses today, the development of methodology to integrate it into anesthetic regimens is a goal in the veterinary medical field (Rosenthal 2). The many benefits of the drug are too significant to not attempt to implement its use in equine medicine. However, rather than using Propofol, Detomidine is frequently the anesthetic injection drug used for horses. According to Dr. Swanson, who is the associate professor of anesthesia at the University of Pennsylvania College of Veterinary Medicine, Detomidine is a good anesthetic and a good analgesic (Biggs 1). This means that the drug has the combined effect of sedation and pain control. In conclusion, even though Propofol has many desirable characteristics to be used on horses undergoing general anesthesia, there are still good alternatives that can adequately meet all of the needs and requirements for the veterinarian and patient.

On the contrary, propofol is widely used and favored throughout almost all small animal practices. The rapid onset after only 75-120 seconds of injection allows for quick operation by trained professionals. The maintenance of anesthesia lasts approximately 20 minutes, but with the pairing of an inhalant anesthetic drug, the overall general anesthesia time can be adapted to meet the amount of time needed by the veterinarian for a surgical procedure. Within approximately 20 minutes of ceasing anesthesia, the patient is able to stand and resume normal function (“PropoFlo”). These properties, plus an easy
transmission into the patient, are all reasons as to why Propofol is one of the most widely used anesthetic drugs in veterinary medicine.

**Similarities between Small Animal and Equine Anesthesia**

Despite the small differences between equine and small animal medical protocols, there are still many similarities in anesthesia practices for both. The first main similarity is the unanimous use of isoflurane as the primary inhalant drug. This clear, colorless, non-flammable substance has the ability to depress the central nervous system and prompt the state of unconsciousness for the patient. Based on the levels given, the patient can remain under unconsciousness for however long the procedure calls for. The recovery is rapid when using isoflurane because of the quick turnover of the gas within the lungs. When general anesthesia is terminated, the gas exits the lungs and the concentration in the body rapidly becomes zero ("Isoflurane" 1-2). Isoflurane also has little cardiovascular effects. It increases the heart rate, which is commonly seen in all anesthetic drugs, but it does not affect the rate of blood pumped throughout the body by the heart ("Medical Pharmacology"). Other advantages of the gas include: the depth of anesthesia can be easily maintained and controlled, there is no hepatic or renal toxicity to the drug, there is limited effect on the pulse or respiration, and the relaxation of muscles it causes is ideal for surgical procedures ("Medical Pharmacology"). All of these benefits and advantages are readily seen throughout equine and small animal medical procedures. Because of its dependency, potency, and safety, isoflurane is considered the most widely used inhalant agent in anesthesia.

The other major common theme between equine and small animal anesthesia is the immense importance placed on keeping anesthetic records. An ample amount of
research supports how crucial it is that every single step in the anesthetic preparation and process is written down and recorded for possible future use. The areas to be documented include: temperature, heart rate, respiration rate, blood pressure, mucous membrane color, and capillary refill time. The main focus of record keeping is to “enhance any recognition of significant trends or unusual values for physiologic parameters and allow assessment of the response to intervention” (“Recommendations” 3). Every drug administered to the patient during the anesthetic period should be transcribed with the date, time, and dose dually noted. Any adverse reaction to a drug or a combination of drugs is also important to note for future treatment. The specific type of anesthetic regimen, the procedure performed, animal’s identification, comments or concerns observed before, during, and after the procedure, and the patient’s vital signs throughout the entire process should all be registered as well. Every bit of information that is taken can possibly be used for research, experimentation, or to visualize specific trends whenever anesthetic complications can arise (“Principles of Anesthesia”).

The last noteworthy reason for record keeping is legal obligations. If complications occur or there are misunderstandings between the medical practice and client, documentation provides sufficient evidence to either support or deny claims made against either party.

Despite the small differences mentioned between equine and small animal practices, the main outline of the protocol remains the same for horses and dogs (or cats) alike. The anesthetic inhalant, isoflurane, and importance of anesthesia record keeping are only a couple similarities mentioned out of many. Those two were highlighted because of their significant role they play within the anesthetic process. Nevertheless,
every single step in anesthesia, whether alike or different, are crucial requirements needed for proper preparation and execution in all medical procedures. Not every horse in the race is the same, however their goal to make it to the finish line as the victor is their only focus. The same applies to veterinary medicine. The regimen, drug choice, or timeframe may be slightly different, but the primary purpose of treating the animal humanely, quickly, and safely in order to ensure a fast recovery for a better, healthier quality of life is the main goal for every veterinarian.

**Conclusion**

In conclusion, the shot of injury was fired and the race to successfully anesthetize the terrified and pain stricken animal began as a result of one, split-second misstep. First taught by the ancient Sumerians, Greeks, Babylonians, and Romans, the medical anesthetic practices have transformed from unorthodox to reliable and strong. The discoveries made by the renowned scientists Sir Humphrey Davy, Dr. Jackson, Humbert, and others built the cornerstones to one of the most powerful, useful, and artistic forms of science the veterinary medical world has been able to continuously utilize throughout the years. Many types of anesthesia have been created over the years, but every method used requires the same amount of proper preparation and execution in order to ensure the patient’s best chance of survival. Every detailed step in the process leads to the end result of a healthy, recovered, and improved animal than it had been before. Although styles and steps may vary according to the species, like in small animal to equine medicine, the primary goal of creating a higher quality of life is the biggest focus for every veterinarian, technician, and professional involved. Whether it will require Propofol for a dog, Detomidine for a horse, or Isoflurane for both, the anesthetic drugs and inhalants used are
properly matched to the patient and its injury. Where there are medical procedures and an induced state of unconsciousness, there will be risk factors. Nevertheless, the benefit of terminating any pain or discomfort and instead curing a life-threatening injury heavily outweighs the possible risks of behavioral issues or body temperature fluctuations that can accompany anesthesia.

The shot has been fired and the race has begun. The sound of hooves beating the fine dirt into a trampled imprint of the horse’s soul resounds in the animal’s ear. The focus of the jockey cannot be altered; the heart of the beast cannot be tamed. The animal that once claimed defeat against the ground has regained its strength, its health, and its determination to become the victor of yet another race. With the help of anesthesia, the horse already defeated its first opponent of injury and won the race of life.
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