Monitoring The Anesthetized Patient

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Monitoring anesthetized patients is a big responsibility. The doctors in your facility dpend on you, as a nurse/technician, to monitor their patients while they are performing a procedure. Improving your monitoring skills is invaluable, as it allows the doctor to focus on the procedure and not the monitoring. This will allow them to finish to procedure more quickly. In this presentation I will be discussing which parameters you can measure, as well as the normal ranges for these parameters and how to correct abnormalities.

In this presentation I will be discussing five different parameters that can be measured while monitoring anesthetized patients. These parameters are as follows:

1. Blood pressure/heart rate
2. Electrocardiogram (ECG)
3. Pulse oximetry (SPO2)
4. End-tidal Carbon Dioxide (ETCO2)
5. Temperature

These parameters, when used altogether, allow you to monitor the cardiovascular and respiratory systems. While these monitoring devices are very useful, it is important to understand that there is no monitor out there that will replace your eyes, ears and hands. It is important not to rely only on what the monitor is displaying, but to also take time to physically assess your patient.

Blood Pressure/Heart Rate

In my opinion, blood pressure and heart rate should be monitored in every anesthetized patient. I feel this way because all anesthetics, injectable or inhaled, cause some degree of vasodilation, which can lead to hypotension. Depending on the health of you patient prior to anesthesia, they may already be at risk for becoming hypotensive and anesthesia will definitely put them at an even greater risk. It is much easier, and better for our patients, to prevent hypotension than to treat it.

The normal range for blood pressure is a systolic between 110-160mmHg, a diastolic between 70-90mmHg and a mean arterial pressure (MAP) between 80-110mmHg. The systolic component is determined by the pressure generated when the heart contracts. The diastolic component is determined between contractions (when the heart is filling). The MAP is defined as the average arterial pressure during a single cardiac cycle. The MAP must be greater than 60mmHg in order to adequately perfuse the vital organs. The MAP is calculated as follows:

1/3 systolic + 2/3 diastolic = MAP

When monitoring blood pressure, you must also monitor the patient’s heart rate. It is important to do this because it is possible to have a normal blood pressure, with an abnormal heart rate. The body is quite good at maintaining a normal blood pressure, and when there is a change in the blood pressure, the body will try to compensate. It will compensate by decreasing, or more commonly, increasing the heart rate in order to maintain a normal blood pressure. However, the body can only to this for so long, and unless we intervene, the heart will become exhausted and the patient will crash.

The normal range for heart rate in cats is between 145-200 beats/minute. There is a wide range for the normal heart rate in dogs, depending on the size and age. The normal range for dogs is between 70-180 beats/minute.

Hypotension is quite common in the anesthetized patient however it is not always a crisis. As I mentioned earlier, all anesthetics cause some degree of vasodilation, so we should expect our patient to have a drop in blood pressure after we anesthetize them. It is important to monitor the blood pressure to make sure that the patient's blood pressure is adequate to perfuse the vital organs. The most common causes for hypotension are hypovolemia, peripheral vasodilation, reduced myocardial contractility, excessive anesthetic depth and hypothermia. Treatment for hypotensive includes decreasing the inhalant anesthesia, crystalloid/colloid boluses and external heat support.

Although not as common as hypotension, hypertension can also occur in the anesthetized patient. The most common causes for hypertension in the anesthetized patient are light anesthetic depth and pain. Treatment for hypertension includes increasing the anesthetic depth and/or administering an analgesic.

There are several ways that we can measure blood pressure. It can be measured indirectly, which is most common, or it can be measured directly. I will be focusing mostly on indirect monitoring, namely the Doppler and oscillometric monitors and will only briefly discuss direct monitoring.

Indirect blood pressure monitoring is noninvasive and quite simple. There are two types of indirect blood pressure monitors available and they are the Doppler and oscillometric monitors. The Doppler is a very useful monitor. It not only allows us to monitor blood pressure, but it also gives us an audible tone so that we can monitor heart rate and rhythm. The Doppler is easy to use and because there are several cuff sizes available, can be used on all patients. The Doppler allows us to monitor blood pressure on small patients and is more accurate than the oscillometric monitors during a hypotensive event. The downside to the Doppler is that it is somewhat labor intensive. In order to get a reading you need to manually squeeze the sphygmomanometer, but this is a small price to pay to know that your patient is maintaining a normal blood pressure. Also, unless you have a very keen ear, the Doppler only allows us to monitor the systolic blood pressure. The oscillometric monitor is the other option for indirect, or noninvasive, blood pressure monitoring. The oscillometric monitor is beneficial because it allows us to monitor heart rate, systolic blood pressure, diastolic blood pressure and MAP. This type of monitor automatically measures and displays the blood pressure and heart rate at the preset frequency. This type of monitor is beneficial in that it is automatic however the oscillometric monitor is not accurate in small patients and during hypotension. With both the Doppler and oscillometric monitors, cuff size and placement is important, as inappropriate cuff size and/or placement can lead to an inaccurate reading. The cuff should be about 40% of the circumference of the limb on which it is placed and the cuff should be placed below the joint, if possible. Using a cuff that is too small will result in a falsely high reading and a cuff that is too big will result in a falsely low reading.

Direct blood pressure monitoring is the most accurate way to monitor blood pressure however this type of monitoring is invasive, technically difficult and expensive. Direct blood pressure monitoring requires the placement of an indwelling arterial catheter. Arterial catheter placement is more difficult than placing a venous catheter. This type of monitoring also requires more expensive equipment. In order to monitor direct blood pressure, you not only need the monitor, but also transducers that connect the arterial catheter to the monitor. Although this technique is very accurate, the expense and technical difficulty often prohibits its use in the general practice.

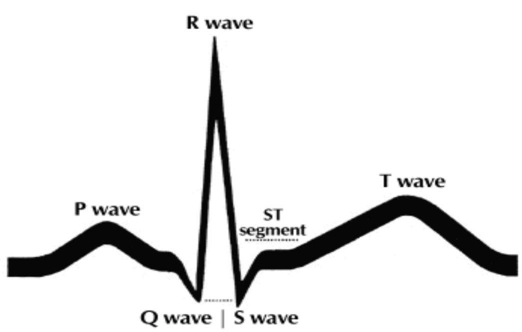
Electrocardiogram (ECG)

Monitoring the ECG can give can give you some very valuable information regarding your patient's status. The ECG records the electrical potential of the heart muscle. The ECG can be used to monitor the heart rate and rhythm to allow detection of any abnormalities however the ECG does not give any information about heart function. The ECG in non-invasive and is simple to connect. There are several ways to connect the ECG. The most common way is by attaching alligator clips to the patient. This method is frustrating at times because the leads can fall off and when the patient is underneath the drapes it is difficult to reconnect them. You can also use the snap leads to connect the patient to the ECG. This method requires shaving a small patch on each of the limbs that will have a lead and taping on a pad that allows the lead to snap on. This method can also result in the leads falling off if they are not attached firmly. The final method, which is the one that I prefer, is the esophageal probe. This method involves placing a special probe down the esophagus. The leads are then connected to the end of the probe. This method is preferable because it eliminates trying to reattach leads under the drapes and there is less interference from movement.

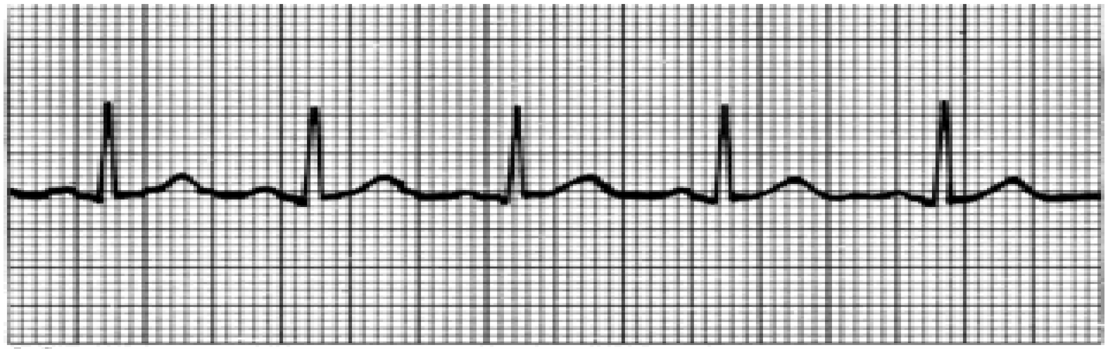
There are many abnormal rhythms that can show up on the ECG. I am not going to focus on these today, but what I want to stress is that it is important for you to be able to identify what a normal rhythm looks like, so that you can alert the doctor to an arrhythmia. Having a normal ECG rhythm can give a false sense of security. A patient who has a normal ECG rhythm is not necessarily a stable patient. The ECG is just a small piece of the puzzle. A patient with a heart murmur can have a normal ECG rhythm, but be at risk of becoming fluid overloaded. Just as a patient can be severely hypotensive while having a completely normal ECG rhythm. This is why it is important to not rely solely on one monitor, but to physically assess you patient to identify any abnormalities (crackles in the chest, poor pulses, etc.).

There are several components of the ECG waveform. Each tracing on the ECG must have a P wave, QRS complex and a T wave. Each of these components gives us information about each heart beat. The information given is as follows:

- P wave = Atrial depolarization
- QRS complex = Ventricular depolarization
- T wave = Ventricular repolarization



As I stated earlier, being able to identify a normal rhythm is just as important as being able to identify an abnormal rhythm. A normal rhythm requires a normal heart rate for that patient. Each beat must also have a P wave, QRS complex and T wave. And finally, each beat must be equally spaced. Any alteration in these requirements is abnormal, and the doctor must be notified. Treatment for an abnormal ECG will depend on the cause of the abnormality. The treatment can range from increasing the anesthetic depth or administering an analgesic to treat tachycardia caused by pain, to administering an anticholinergic to treat bradycardia or heart block. An example of a normal ECG is as follows:



There are many options for ECG monitors, most of which are also capable of monitoring other parameters. When purchasing an ECG monitor, it's important that it have printing capability. This way, if there is an abnormality, you can print off a strip to show the doctor and also to put in the patient's record.

Pulse-oximetry (SPO2)

The pulse-oximeter is a way to measure how the patient is oxygenating. The pulse-oximeter measures the oxygen saturation in circulating red blood cells. The pulse-oximeter probe emits both infrared and red wavelengths. The saturated hemoglobin absorbs more infrared light and the desaturated hemoglobin absorbs more red light. The saturated hemoglobin is displayed as a percentage of total hemoglobin. The normal range for the SPO2 is greater than 96%. When a patient is breathing room air (21% oxygen), this correlates to a partial pressure of arterial oxygen (PaO2) of 90-100 mmHg. The PaO2 is what we use to determine if the patient is oxygenating properly when we perform an arterial blood gas measurement. The PaO2 should be about 5 times the inspired oxygen (FiO2). An anesthetized patient, who is intubated and on gas anesthesia, is inspiring 100% oxygen. Therefore, we would expect their PaO2 to be around 500mmHg. The pulse oximeter cannot detect a change in arterial oxygenation until a significant change has occurred. The SPO2 will remain near 100% until the PaO2 has dropped to below 60-70mmHg, at which time the patient may be nearing a crisis. Cyanosis is a very late sign.

The pulse oximeter, like other monitors, is not without disadvantages. The pulse oximeter can give a false sense of security when used on patients breathing 100% oxygen. It may be of greater benefit to patients who are breathing room air, as the monitor will show a decrease in SPO2 sooner (the PaO2 starts off at about 100mmHg, as compared to 500mmHg). The pulse oximeter can also give a falsely low reading due to several variables. These variables include inadequate tissue perfusion, tissue thickness, pigmentation, movement, fluorescent lighting and abnormal hemoglobin. As with other monitors, it's important to evaluate the patient and not just rely on the monitoring equipment.

There are many handheld pulse oximeters available, as well as those that are part of a multiparameter monitor. The handheld monitors are very convenient because they are compact and easy to use. When purchasing a pulse oximeter, I would recommend that you purchase a monitor that displays the SPO2 and heart rate, as well as the waveform. The waveform correlates with the heart rate and helps you to distinguish if the reading is accurate. If the waveform is irregular, and/or the heart rate does not match the patient's actual heart rate, the SPO2 is not accurate. The pulse oximeter can be a valuable tool when used along with other parameters.

End-Tidal Carbon Dioxide (ETCO2)

The ETCO2 is a way to measure how the patient is ventilating. All patient's hypoventilate to some degree when anesthetized. The ETCO2 is a non-invasive way of measuring arterial carbon dioxide pressure (PaCO2). In order to directly measure the PaCO2, you would need to draw an arterial sample and put it through a blood gas machine. This is both technically difficult, time consuming and requires costly equipment. The ETCO2 monitor allows you to monitor the patient's ventilation status quickly and easily. When interpreting the ETCO2, it's important to keep in mind that the ETCO2 is approximately 4-5 mmHg lower than the PaCO2.

The normal range for ETCO2 is between 35-45mmHg. Hypercapnea (increased ETCO2), is commonly encountered in anesthetized patients. This is due to the fact that all patients will hypoventilate to some degree while anesthetized. Hypoventilation is the most common cause of hypercapnea, however, hypercapnea can also be caused by rebreathing of carbon dioxide. Hypercapnea caused by hypoventilation can be resolved by decreasing anesthetic depth, increasing oxygen flow and by administering intermittent positive pressure ventilation (IPPV). Hypercapnea caused by rebreathing of carbon dioxide can be remedied by changing the sodazorb granules and by placing the patient on a non-rebreathing circuit. Although less common, hypocapnea (decreased ETCO2) can also occur. Hyperventilation is the most common cause of hypocapnea. Treatment of hypocapnea includes increasing anesthetic depth, decreasing oxygen flow rate and decreasing the frequency if IPPV.

The ETCO2 monitor is very simple to use. There is an adaptor that is placed between the patient's endotracheal tube and the breathing circuit. The monitor displays the patient's ETCO2, as well as the respiratory rate. Some monitors also display a waveform. There are many options available when looking to purchase an ETCO2 monitor. They range from a compact unit that only displays the ETCO2 and respiratory rate, to more complex (and costly) units that measure multiple parameters.

Although the ETCO2 monitors are very useful and give valuable information regarding the ventilator status of our patients, not having one is not the end of the world. When monitoring an anesthetized patient, it's important to remember that even though the patient may be taking breaths at a normal rate and appears to be ventilating adequately, there is a really good chance that they are hypoventilating and are quite possibly hypercapnic. Therefore, it is your responsibility to give them several nice deep breaths several times a minute. By doing this you are helping your patient, because even though you don't have a machine giving you a number, you are helping your patient ventilate better than they were on their own.

Temperature

Patients must be able to maintain a normal temperature in order to maintain normal body functions. The normal temperature for cats and dogs is 100-102.5F. Anesthetizes patients are at a much greater risk of becoming hypothermic, especially those that are small and those undergoing lengthy procedures. Also, anesthetized patients undergoing surgery are likely to become hypothermic due to open body cavities and if the irrigation fluid is not warm. Hypothermia can cause decreased respiration rate and depth, bradycardia, hypotension, decreased absorption of drugs and delayed recovery from anesthesia. There are many ways that you can help minimize hypothermia, including circulating water blankets, warm water bottles, warm IV fluids, IV fluid warmer, Bair hugger and warm lavage fluids. Hyperthermia, although less common in the anesthetized patient, can also occur. Hyperthermia can cause acid-base and electrolyte abnormalities, convulsions, brain damage and death. Overheating due to external heat support, using the Bair hugger, for example, is the most common cause of hyperthermia in the anesthetized patient. Therefore, it is very important that the patient's temperature is monitored while they are under anesthesia to determine of more external heat support is necessary and to prevent the patient from overheating.

You can monitor your patient's temperature rectally with a simple digital thermometer, but this method can be difficult when your patient is covered in drapes. There are other thermometers available that have esophageal probes and also rectal probes that are longer and flexible, allowing you to easily monitor your patient's temperature throughout their entire procedure.

Summary

There are many parameters that we can monitor on our anesthetized patients. Some of them can be monitored simply, without much cost, while others require costly equipment and advanced technical skill. Proper anesthetic monitoring can be accomplished without fancy monitors, as long as you are making good use of you eyes, ears and hands. Because - there isn't a monitor out there that can replace an observant nurse!

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