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Anaesthetic emergencies

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ABSTRACT: The key to handling anaesthetic emergencies is being able to identify and manage any problems as they arise and before they present as 'disasters'. This requires careful monitoring, knowing what is normal for your patient and understanding which steps are appropriate to take next. This article will discuss monitoring, normal parameters, drugs, high risk patient and recovery.

Anaesthetics are inherently unsafe, as all drugs affect the cardiovascular and/or respiratory systems. As a result, every anaesthetic requires careful monitoring to ensure that risks are kept to a minimum, harmful trends are recognised and time is allowed for appropriate action. The anaesthetist is the best monitoring tool; while good monitoring technology is available and useful, it should never be a substitute for observation skills and clinical judgement.

Monitoring is continual and should be recorded on a chart to show developing trends; this is important as it may also then be used as a medical and legal document. Therefore, knowing what the normal parameters are for your patient and recording them at the start is essential.

Pre-anaesthetic checks

Thorough assessment prior to premedicating the patient can prove to be invaluable.

Assessment prior to any sedation or general anaesthesia is a fundamental part of making the anaesthetic process as safe as possible.

Physical assessment

Pre-anaesthetic assessment should include – but not be limited to – assessment of the cardiorespiratory system. It is important that both the veterinary surgeon and nurse anaesthetist should auscultate every patient's chest using a stethoscope.

Many patients will not have cardiac or respiratory disease; but being comfortable with 'normal' chest sounds will enable the anaesthetist to identify abnormal sounds and potential problems more readily.

Pulses should be felt to ensure that they are of a good quality and there is no deficit between the pulse and heartbeat.

It is also important to take the patient's temperature.

Knowing what these parameters normally are for the patient will allow the anaesthetist to identify changes and assist him or her in making informed decisions during the anaesthetic and recovery period.

History

A thorough history should be taken. If a patient has received trauma – such as being in a road traffic accident – this can have an effect on the heart and cause arrhythmias and/or complexes which become more apparent once the patient is anaesthetised. It is, therefore, crucial to identify factors that may affect physiological, pathological and drug-related changes before inducing general anaesthesia.

Laboratory assessment

It can be helpful to do pre-anaesthetic blood tests. This may not be necessary in young, healthy, routine cases, but in diseased patients, or those presenting as emergencies, it is crucial.

Routine packed cell volume (PCV), biochemistry and haematology blood tests can provide invaluable information which may change the anaesthetic and/or fluid therapy protocol. It will also provide a baseline of information should further tests be required later on.

Monitoring

The anaesthetic record is not just a legal document; it contains vital information about the anaesthetic and reflects the level of monitoring. It displays trends and patterns which may not otherwise have been easily identified. These trends could include, for example, the steady increase or decrease of heart rate or blood pressure – where between each measurement there is not a significant difference but over a period of time a greater than expected change is revealed, indicating there may be need for intervention.

Monitoring can be continuous or intermittent. Intermittent monitoring includes physical, manual checks of the patient and should be performed every five minutes. Continuous monitoring comes from monitoring equipment, which will allow the user to notice any changes promptly (**Figure 1**).

Monitoring also allows for the assessment of anaesthetic depth. A *sudden* increase in depth is a significant warning sign that problems are on the horizon and action should be taken swiftly to address this. Reflexes provide invaluable information on depth of anaesthesia and can help the anaesthetist determine if the patient is feeling pain or inadequately anaesthetised.

A good analgesia protocol will allow for the anaesthetic maintenance agent to be kept to a minimum. This can be crucial in critical cases. Most anaesthetic-related emergencies will be respiratory or cardiovascular, thus making close monitoring and minimal depression of these systems important.

Identifying problems

Problems during an anaesthetic do not have to be complicated. It is frequently assumed that anaesthetists are monitoring to be able to identify complex difficulties. Recognising minor issues, however, and addressing them at that point, prevents their becoming 'crises'. Having the ability to ascertain the cause – as well as to identify the problem – is an important skill when monitoring any animal under sedation or anaesthesia.

There is a very long list of signs that indicate problems, including pale or brick-red mucous membranes and poor or absent pulses. Bradycardia is a common problem which needs to be addressed. A reduced heart rate, unless caused by hypertension, will result in a decrease in blood pressure and, therefore, in cardiac output.

Peripheral pulses should always be checked while a patient is under general anaesthesia, as this gives an indication of the quality of circulation and will reveal if there are pulse deficits. A normal electrocardiogram (ECG) can be present without pulses as mechanical cardiac activity is the last to go before death; so an ECG should not be relied upon solely.

Loss of pulses is a sign of severe vasoconstriction which may be the result of hypothermia, hypotension or poor cardiac output. It may also be drug induced.

Figure 1. Monitoring equipment allows the user to notice any changes promptly

When to ventilate

Many anaesthetists allow a change of 20 per cent increase or decrease in heart rate before they feel the need to take action (i.e. further analgesia). A decision on when to ventilate an animal should be based on the patient's ability to ventilate independently. If the end tidal carbon dioxide ($ETCO_2$) level is known, then this point would be when the patient's $ETCO_2$ is above 60 mmHg or below 30 mmHg.

If this information is not available, then the anaesthetist should be providing assisted or controlled ventilation when the patient is tachypnoeic, bradypnoeic or unable to achieve an adequate tidal volume. Long-term tachypnoea and bradypnoea result in abnormal carbon dioxide levels in arterial blood and, therefore, pH changes. Patients with brick-red mucous membranes have high levels of carbon dioxide and should be ventilated carefully to eliminate this.

What can go wrong?

Hypotension

Hypotension is a complication in almost all anaesthetics and there are a number of actions which can be taken prior to requiring intervention with drugs.

Action should be taken to prevent the mean blood pressure from dropping below 60 mmHg. This is because at 50 mmHg perfusion to the kidneys is lost. The kidneys are the organ furthest away from the heart, while the brain is second. Low blood pressure can have detrimental effects in patients who already have renal disease if perfusion to the kidneys during the anaesthetic cannot be maintained. This makes detecting hypotension fundamental to a safe anaesthetic and recovery.

Blood pressure can be calculated as follows:

Blood pressure = cardiac output x systemic vascular resistance

Cardiac output = heart rate x stroke volume

This means that heart rate is not the only factor which will affect blood pressure. Nearly every drug used in anaesthesia causes vasodilatation, resulting in a drop in blood pressure. There are four steps which can be followed to increase and maintain blood pressure within normal limits:

1. Lower the volatile agent

Anaesthetic gases cause a significant amount of vasodilatation and some patients are more sensitive to them than others. Reducing the volatile agent should be done with caution to ensure that the patient does not recover from anaesthesia early. Further analgesia may be required to allow for a reduction in volatile agent.

2. Lower the respiratory rate or pressure if providing intermittent positive pressure ventilation (IPPV)

When ventilating, positive pressure is applied to the thorax, but this produces resistance for venous return to the heart, which reduces cardiac filling and results in a decreased amount of blood being pumped around the body. This causes a fall in blood pressure.

Restricting the amount of pressure applied with each breath will limit the resistance against venous blood flow and improve cardiac filling and output.

Reducing the respiratory rate will allow more time between breaths when there is no pressure on the chest and consequently less resistance for venous return. This results in increased cardiac filling and thus cardiac output.

3. Fluids

If the patient is not already receiving fluid therapy, start it, beginning with crystalloids:

- check the rate and increase it if possible (5-10 ml/kg/hour if there is no cardiac disease)
- fluid bolus (5-10 ml/kg over 10-15 minutes)

Remember that crystalloids remain in the vascular space for a shorter period of time compared to colloids and may not solve the problem, particularly if the cause is not dehydration. If this is the case, follow with colloids. These have a long-term effect and are often given as a bolus (2-4 ml/kg over 15 minutes).

4. Drugs (Table 1)

Chronotropic drugs: Chronotropic drugs are those affecting heart rate. They include atropine and glycopyrrolate. These drugs should be used if the patient is bradycardic or if there is hypotension corresponding with a low and/or decreasing heart rate.

Inotropic drugs: These are drugs that increase the contractility of the heart (affect the stroke volume) and include dopamine and dobutamine. These should be used when the heart rate is normal but the patient remains hypotensive despite having tried the first three steps mentioned above.

Vasoconstrictors: These are drugs such as medetomidine or adrenaline that will affect systemic vascular resistance. The use of these should be considered carefully before use. Alpha-2-agonists can provide analgesia as well, allowing the user to increase blood pressure, provide analgesia and sedation and thus decrease the volatile agent. However, alpha-2-agonists are not appropriate for use in all patients.

Heart rate and rhythm

A patient's heart rate may readily alter during the period of anaesthesia – so remember it is the degree of change which needs to be identified and dealt with. Bradycardia can often be drug induced but may also be caused by hypertension, depth of anaesthesia, hypothermia, or a combination of these. Tachycardia is most often the consequence of pain, but can be a result of haemorrhage and decreasing blood pressure.

These are complications that can usually be identified quickly and rectified; however, more serious problems – such as arrhythmias – require an ECG to diagnose.

Bradyarrhythmias often present with second-degree atrioventricular block and are caused either by drugs or by vagal stimulation, which can be from compression of the vagal nerve with inflation of the stomach or a consequence of surgical handling. They can be treated by antagonising drugs, relieving

Table 1. Emergency drugs (Courtesy R. Robinson BVSc MRCVS, 2013)

Drug	Dose	Comments
Adrenaline	0.01-0.02 mg/kg 0.005-1 µg/kg/min	Causes vasoconstriction, which can be severe with an increase in oxygen consumption and sensitivity to hypoxia Increases cardiac contractility Causes bronchodilatation. The use of this drug is generally reserved for CPCR
Dopamine (low dose)	1-4 µg/kg/min	Causes splanchnic vasodilatation, natriuresis and diuresis
Dopamine (medium dose)	5-10 µg/kg/min	Can cause arrhythmias with tachycardia
Dopamine (high dose)	10-20 µg/kg/min	As above
Dobutamine	2-20 µg/kg/min (dogs) 1-5 µg/kg/min (cats)	Increases cardiac contractility with minimal changes to heart rate Can cause arrhythmias, tachycardia and vasodilatation with seizures in cats
Noradrenaline	0.05-2 µg/kg/min	Causes vasoconstriction with little increase in heart rate Increases blood flow to the heart and kidneys without causing tissue ischemia
Phenylephrine	0.15 mg/kg 1-3 µg/kg/min	Causes vasoconstriction with reflex bradycardia Increased coronary blood flow but decreased splanchnic blood flow
Vasopressin	0.4-0.8 IU/kg (dogs) 1-4 mU/kg/min (dogs) No published dose in cats	Causes vasoconstriction (more potent than phenylephrine or noradrenaline) Low doses will cause vasodilatation in cerebral, renal, pulmonary and mesenteric vessels Increases water permeability in renal collecting ducts to maintain normovolaemia and stimulates aggregation of platelets and ACTH release

Figure 2. Ventricular premature contractions (VPCs)

the stimulus, or giving atropine or glycopyrrolate to increase the heart rate.

Tachyarrhythmias have a number of possible causes. These include heart disease, acidosis, pain, myocardial hypoxia, sepsis and splenic disease. Treating the cause of such arrhythmias is not always available as an option, so drugs are required.

Ventricular premature contractions are not uncommon and can be treated with lidocaine if more than 10-15 per minute are occurring **(Figure 2)**.

Respiratory complications

Respiratory emergencies should be minimal under general anaesthesia, as an airway should be maintained with the use of an endotracheal (ET) tube. However, some procedures, such as bronchoalveolar lavage (BAL), will not always allow for the placement of an ET tube. These patients often fail to saturate oxygen properly and the procedure should be stopped, the patient intubated and oxygen supplied if this is the case.

An ET tube may become occluded by positioning, the surgeon or mucus, pus or blood from within the chest. Obstruction of the airway is not always quickly observed, particularly when the patient is hidden beneath surgical drapes, but this can certainly be seen on a capnograph.

Good nurse anaesthetists will be monitoring their patients closely and should spot that the patient has become apnoeic. They will feel increased pressure in the reservoir bag when a breath is manually provided. A sudden increase is often seen alongside apnoea as the heart is working harder to pump oxygenated blood around the body.

It should also be remembered that just because a patient has a respiratory rate, it does not necessarily mean that it is acceptable. If the rate is too fast or too slow this can affect the CO_2 levels and therefore the pH of the blood. The patient may not be taking adequate breath sizes and, therefore, not getting adequate gaseous exchange of either volatile agent or oxygen.

If respiration is not normal, ventilation should be considered. Ventilation does not have to be reserved for emergency situations and deciding to provide IPPV may prevent complications later on.

Temperature

Keeping the patient warm during the anaesthetic may seem simple and minor; but it is, in fact, much more complicated and important than might be thought. Anaesthetised animals are not able to maintain their own body temperature, so it is essential that this is done for them.

There are many methods of keeping patients warm during anaesthesia, and even bubble wrapping their paws can reduce heat loss. Maintaining a patient's temperature is a significant part of ensuring that the anaesthetic is as safe as possible, and the inability to do this may turn a stable case into a much more critical one.

Hypothermia is defined as any temperature below 37.8°C in dogs. The metabolic rate of an animal decreases by approximately 10 per cent for every one degree decrease in core body temperature. This means that elimination of drugs is slowed, resulting in a reduction of drug requirement.

Consequently, if the amount of drug being administered is not reduced, there is the potential for drug overdose to occur. Most commonly this would be the anaesthetic gas, as the minimum alveolar concentration (MAC) becomes reduced.

A decreased metabolism also means reduced response to drugs. This can be very dangerous when emergency drugs have to be used, as the patient may not respond. Emergency drugs are more likely to be required in hypothermic patients, as hypothermia can cause electrophysiological changes **(Table 1)**.

Most frequently this is seen as bradycardia, which is unresponsive to anticholinergics. Cell activity is reduced and this can result in electrolyte abnormalities. It will also mean a prolonged recovery.

Cardiopulmonary arrest

This is when the patient suddenly ceases to have systemic perfusion and functional ventilation. Usually, respiratory arrest occurs first; and if it is not treated rapidly and effectively, cardiac arrest will follow. As a nurse anaesthetist, it is important to be able to recognise the signs of approaching cardiopulmonary arrest (CPA).

These signs include:

- weakening pulses
- decreasing end tidal carbon dioxide
- hypotension
- pale mucous membranes
- bradycardia
- sudden tachycardia
- sudden increase in depth of anaesthesia

Signs of CPA include:

- loss of pulses
- flat pulse oximeter trace

- absence of ventilation
- unable to auscultate heart sounds
- fixed dilated pupils

The consequences of CPA include:

- decreased oxygen delivery
- decreased carbon dioxide removal resulting in quickly developing metabolic acidosis
- organ damage or failure
- irreversible neurological damage within three minutes

Cardiopulmonary resuscitation

Complications in an anaesthetised animal – compared with a conscious animal – should be more promptly identified and dealt with before they develop into a more critical situation, such as CPA. However, this is not always possible.

The goals of cardiopulmonary resuscitation are to restore effective ventilation, cardiac rhythm and cerebral perfusion, and to prevent irreversible neurological damage and damage to the organs.

Anaesthetised patients have a greater chance of surviving CPA as there is a greater chance of it being identified earlier. In addition, the anaesthetist should already have both intravenous access and a patent airway maintained.

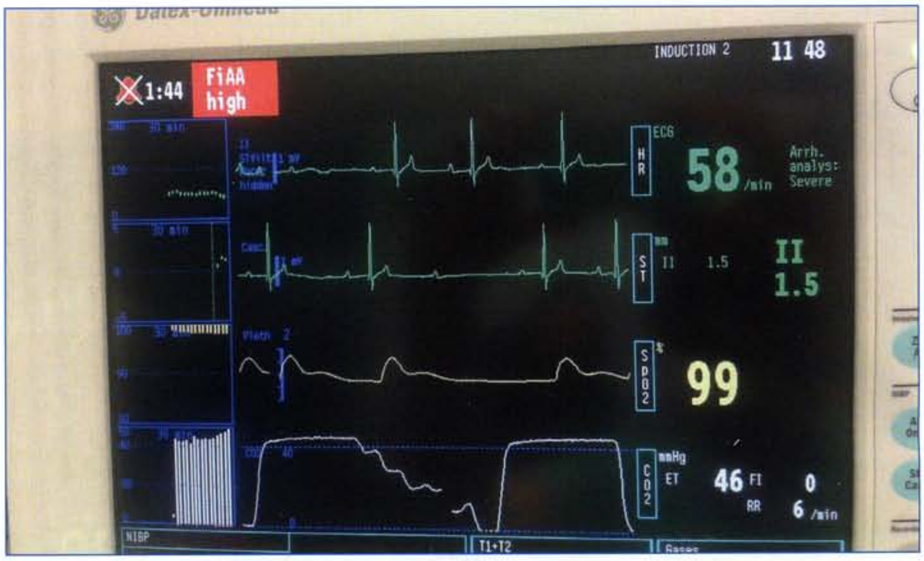

Figure 3. An ECG showing an AV block

The reason why the patient is in CPA needs to be considered – anaesthesia related, surgical complication such as a bleed, or the result of disease – in order to help the animal through this time. It is equally important to determine why it has failed if resuscitation is unsuccessful.

Recovery

The most important aspect of recovering a patient who has required emergency drugs under general anaesthesia is close monitoring for any changes. The animal needs to be observed until it is able to maintain heart rate, oxygen saturation in room air, blood pressure and temperature within normal limits. Ideally these should be recorded on a recovery or kennel sheet.

Conclusion

There are many potential complications with any anaesthetic; and it is the important role of the veterinary nurse anaesthetist not only to monitor patients and to bring any changes to the attention of the veterinary surgeon, but also to have an understanding of the drugs being used.

Careful monitoring of the patient during anaesthesia will allow the nurse anaesthetist to identify approaching problems promptly and proceed accordingly **(Figures 3 & 4)**.

Figure 4. A sinus arrthymia on a pulse oximeter trace