**Anaesthetic Emergencies**

The key to handling anaesthetic emergencies is being able to identify and manage any problems as they arise 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 patients, 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 risks are kept to a minimum, harmful trends are recognised and to allow time for appropriate action. The anaesthetist is the best monitoring tool, while good monitoring technology is available and useful, it should not be a substitute for observation skills and clinical judgement.

Monitoring is continual and should be recorded on a chart to show developing trends but also as a medical and legal document. Therefore knowing what the normal parameters are for your patient and recording them at the start is essential. Thorough assessment prior to pre-medicating the patient can prove to be invaluable.

**Pre-anaesthetic Checks**

Assessment prior to any sedation or general anaesthesia is a fundamental part of making the anaesthesia process as safe as possible. This should include, but not be limited to, auscultating the patient’s chest. Listening to the heart and respiratory sounds with a stethoscope by both veterinary surgeon and nurse anaesthetist is important. Many patients will not have cardiac or respiratory disease but being comfortable with ‘normal’ chest sounds will enable the anaesthetist to more readily identify abnormal sounds and potential problems. Pulses should be felt to ensure they are of a good quality and there is no deficit between the pulse and heartbeat. It is important to take a temperature as well. Knowing what these parameters are normally for the patient will allow the anaesthetist to identify changes and assist them in making informed decisions during the anaesthetic and recovery period.

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

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 emergency cases 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 have otherwise been easily identified. This could be 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 include 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 instantly notice any changes.

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 painful 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
Complications within an anaesthetic do not have to be complicated. It is frequently assumed that anaesthetists are monitoring to be able to identify complex difficulties. This is not true, and recognising minor issues and addressing them at that point, prevents them from becoming a crisis. Having the ability to ascertain the cause as well as identify the problem is an important skill when monitoring any an animal under sedation or anaesthesia.

Many anaesthetists allow a change of 20% increase or decrease in heart rate before they feel the need to take action (ie further analgesia). A decision on when to ventilate an animal should be based on the patient’s ability to ventilate themselves sufficiently. If the end-tidal carbon dioxide (ETCO2) level is known, then this point would be when the patient’s ETCO2 is above 60mmHg or below 30mmHg. 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. Patient’s with brick red mucous membranes have high levels of carbon dioxide and should be carefully ventilated to get rid of this.

There is potentially a very long list of signs which 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 decrease in blood pressure and therefore cardiac output. Peripheral pulses should always be checked whilst a patient is under general anaesthesia as this gives an indication of quality of circulation and 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 solely be relied upon. Loss of pulses can be a sign of poor cardiac output and severe vasoconstriction which may be due to hypothermia, hypotension or drug induced.

**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 60mmHg. This is due to the fact that at 50mmHg perfusion to the kidneys is lost. The kidneys are the organ furthest away from the heart, second is the brain. 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.

**What to do next**

Blood pressure can be calculated as follows;

\[
\text{Blood pressure} = \text{cardiac output} \times \text{systemic vascular resistance}
\]

Cardiac output is calculated by heart rate \(\times\) stroke volume

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

Firstly lower the volatile agent.

1) **Lower volatile agent** ie isoflurane

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

2) **Lower the respiratory rate or pressure if providing IPPV**

When ventilating a positive pressure is applied to the thorax but this produces resistance for venous return to the heart therefore reducing cardiac filling and resulting in a decreased amount of blood being pumped around the body resulting in 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. First crystalloids - check the rate and increase it if possible (5-10mls/kg/hour if there is no cardiac disease)
- fluid bolus - ie 5-10mls/kg over 10-15minutes
- remember 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.
Second colloids - these have a long term effect and are often given as a bolus. (2-4mls/kg over 15mins)

4) **Drugs**
   **Cronotropic drugs**
   These are drugs affecting your heart rate. They include atropine and glycopralate. These drugs should be used if the patient is bradycardia or if there is hypotension corresponding with a low and/or decreasing heart rate.

   **Inotrophic drugs**
   These are drugs increase the contractility of the heart (affect the stroke volume) such as dopamine & 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 which will affect the systemic vascular resistance such as medetomidine or adrenaline. 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 depending upon their condition.

**Heart rate and rhythm**
A patient’s heart rate may easily alter during the period of anaesthesia, it is the degree of change which needs to be identified and dealt with. Bradycardia can often be drug induced but may also but due hypertension, depth of anaesthesia, hypothermia or a combination of these. Tachycardia is most often due to pain but can be a result of haemorrhage and decreasing blood pressure. These are complications which can usually be quickly identified and rectified; however, more serious problems such as arrhythmias require an ECG to diagnose.

Bradyarrhythmias often present with second degree atrio-ventricular block and are caused by either drugs or vagal stimulation which can be from compression of the vagal nerve with
inflation of the stomach or due to surgical handling. They can be treated by antagonising drugs, if that is the suspected cause, relieving the stimulus, or giving atropine or glycopyrolate to increase the heart rate.

AV block

Heart rate

Tacharrhythmias have a number of potential 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.

VPCs

Respiratory complications
Respiratory emergencies should be minimal under general anaesthesia as an airway should be maintained with the use of an endo-tracheal (ET) tube. However, some cases 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 and the patient intubated with oxygen supplied if this is the case.

Some intubated patients may have their ET tube occluded by positioning, the surgeon or mucous, pus or blood from within the chest occluding the ET tube. Obstruction of the airway is not always quickly observed, particularly when the patient is hidden underneath surgical drapes but this can certainly be seen on a capnograph. Nonetheless, good nurse anaesthetists will be monitoring all their patients closely and should spot that the patient has become apnoeic and will feel increased pressure in the reservoir bag when a breath is manually provided. A sudden increase in heart rate is often seen alongside apnoea as the heart is working harder to get oxygenated blood around the body.

It should also be remembered that just because a patient has a respiratory rate, does not necessarily mean that it is acceptable. If the rate is too fast or slow this can affect the CO₂ 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 to keep it anaesthetised or oxygen. If the 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 important than that. Anaesthetised animals are not able to maintain their body temperature so it is essential that this is done for them. Hypothermia is any temperature below 37.8 degrees Celcius in dogs. The metabolic rate of an animal decreases by approximately 10% 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 there is the potential for drug overdose to occur by not reducing the amount of drug being administered. Most commonly this would be anaesthetic inhalation agent 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 does not respond. Emergency drugs are more likely to be required in hypothermic patients as hypothermia can cause electrophysiological changes. Most frequently this is seen as bradycardia which is unresponsive to anti-cholinergics. Cell activity is reduced and this can result in electrolyte abnormalities. It will also mean a prolonged recovery. There are many methods of keeping patients warm during anaesthesia and even bubble wrapping their paws can reduce heat loss. Maintaining a patients temperature is a significant part of ensuring the anaesthetic is as safe as possible and the inability to do this may turn a stable case into a much more critical one.

**Cardiopulmonary arrest**

This is when the patient suddenly and unexpectedly 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). This includes;

- 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 metabolic acidosis developing quickly, organ damage or failure and irreversible neurological damage within three minutes.

Complications under anaesthesia should be more promptly identified (compared to a conscious animal) 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 a CPA as there is a greater chance of it being identified earlier and the anaesthetist should already have both intravenous access and an patent airway maintained. It needs to be considered why the patient is in CPA (anaesthesia related, surgical complication such as a bleed, or due to disease) in order to help the animal through this time and upon reflection if resuscitation is unsuccessful.

**Emergency Drugs**

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

*(Courtesy of R. Robinson BVSC MRCVS, 2013)*

**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 to monitor patients and highlight changes to 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 promptly identify approaching problems and proceed accordingly.