Secrets of Safe Anaesthesia in Rabbits

Study Notes

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Pre-operative advice to owners

Prior to anaesthesia providing the owners with some advice is important. This is possible in cases where an elective procedure is being performed but may not be possible where an emergency procedure has to be performed. As rabbits have a high metabolic rate then they should be fed the usual diet until the owner is ready to transport their rabbit to the clinic. Ideally you should encourage the owners to bring two days worth of the rabbit's usual diet with them. Feeding this diet can help to limit the effects of gastrointestinal slowdown whilst at the vets. Many rabbits will have specific dietary requirements and providing this is important. Even if the procedure is not elective many owners will come back to the clinic with a platter prepared for their pet whilst it is in the clinic. This allows you to evaluate what the owner perceives as important components of the diet. If the owner does not bring in some of the rabbit's usual diet then having some food stocks on standby is required. It is important to have stocks of both foods that you would recommend but also diets that may be less than ideal such as the mixed muesli diets.

Rabbits should be transported at a cool time of day in a secure carrier or box. In addition familiar toys bowls and hides can also help settle in an anxious patient.

Assist feeding is an important part prior to anaesthesia. These patients have a high metabolic rate and so starvation is not beneficial, but of course many rabbits may well be anorexic as part of their condition. If assist feeding is being performed this has to be taken into account when planning anaesthesia. Removal of food should occur at the point of premedication in all rabbits as if heavy sedation occurs they can become sedated with an oropharynx full of food.

A full clinical examination is important as these are prey species and hide disease well. Subtle signs of illness may be missed by their owners. This also allows for baseline parameters to be obtained on that individual. Respiratory and dental diseases are common for example.

Elective procedures may require minimal supportive care as the rabbits are clinically healthy. However sick rabbits will benefit from a period of supportive care prior to anaesthesia and supportive fluid therapy or nutritional support are important. In mild cases supportive care may be instigated at the point of anaesthesia to minimise stress on the patient. Housing prey species away from predators is part of this.

Intensive critical care is important, however in most cases 1 – 2 days is sufficient. By this point the patient should be sufficiently stable to allow anaesthesia. If this is not the case then the empirical supportive care is not being effective and more specific treatment is required. To achieve this, a diagnosis is important, and anaesthesia will be required in most cases. If the patient continues to be unstable euthanasia may well be indicated. Financial limitations can be a problem when treating small mammals and it is very easy to use up all funds on supportive care without making a diagnosis and treating the rabbit specifically for its problem. Antibiotics are often abused in these cases as an alternative for a diagnosis.

Patient size is also an important factor to consider. They have a large surface to volume ratio and hypothermia is a risk. Equally if measures used are highly effective then hyperthermia is also a risk during anaesthesia and surgery. Avoiding hypothermia starts with identifying normothermia for that patient on that day and so baseline parameters are required. Reference ranges for a rabbits' rectal temperature can be wide and having a clearly defined pre anaesthetic temperature which should be maintained during and after anaesthesia is important.

Baseline physiological parameters for rabbits.

	HBR	RR	Temp (^{0}C)	Weight (g)
Rabbit	180 – 300	30 – 60	38.5 – 40	1000 – 10000

It is important to realise that stress and anxiety will influence these parameters. Respiration rate should be taken form observation at a distance and heart rate can often be taken by gently opposing a stethoscope to the side of the patient without physical restraint.

Sick patients and those during and after anaesthesia will be unable to regulate their temperature (for example shivering thermogenesis is lost under anaesthesia) and providing a heat source is important. In many cases focal heat is contraindicated as the patient may be unable to move away or towards a heat source. Providing an even heat source over the entire cage is important and monitor rectal temperature to ensure normothermia is maintained. Rabbits have a poor thermal tolerance and hyperthermia and hypothermia can develop quickly. Most benefit from an even temperature of 26 – 30 degrees centigrade in the recovery period but quickly need to be transferred to lower temperatures once mobile. Continue to monitor the rectal temperature. Continuous recording devices are helpful as the temperature can be recorded remotely with

minimal disturbance of the patient and loss of heat from the incubator for example. Higher humidities can also benefit these patients and reduce the risk of dehydration.

Plant propagators can be used and are readily available at a low cost. They are ideal for recovery and can provide a higher humidity environment, oxygenation and nebulisation during the recovery period. Care has to be taken as larger individuals can dislodge the plastic lid and in some cases this requires weighting down to prevent escape of the patient.

The weight of the patient is important. Weight should be taken twice a day on accurate scales and compared to breed ranges and individual records for that patient. It is important to evaluate body condition as well as a patient with marked ascites (for example) may weigh well, but be in poor body condition. This will not only allow for accurate therapeutics but also help in assessing the response of the patient. Owners will very quickly realise the benefit of regular weighing and the first question they will ask when on the phone is ‘what was flopsys’ weight this morning?’ Record the weights on the computer as well for easy access in the consulting room.

Some patients may need to be restrained for weighing, but most rabbits will voluntarily allow themselves to be weighed and owners may even keep accurate daily records at home (particularly if you encourage them). Analgesia is important as the clinical signs of pain may be limited. Non steroids should be used as a routine and opioids are also used commonly. Bear in mind the need to consider any anaesthetic regime and ensure there is no antagonism between opioids utilised.

Fluid therapy is important and it may be impossible to quantify deficits so many patients are assumed to be dehydrated and a standard rate of fluid therapy provided. This is often 10mls/kg/hour with the route depending on the severity of illness. Hyaluronidase can be added to subcutaneous therapy to speed up absorption.

Pre-emptive antibiotic therapy may be indicated if significant infection is suspected or a contaminated procedure is going to be performed. Finances may preclude culture and sensitivity and if this is the case presumptive therapy for the likely pathogens is required. If a culture is going to be taken give antibiotics afterwards. If the sample is taken at surgery (for example from a dental abscess capsule) then intravenous therapy can be provided to provide immediate cover.

Caution is to be advised regarding the risk of dysbiosis and species specific sensitivities. However ensuring all likely pathogens are treated is important. First line antibiotic cover may include covering for aerobic and anaerobic bacteria and gram positive and negative infections (four quadrant cover). Microbial resistance can be high and if a significant infection is likely our choice of therapy may be altered.

The first line choice for rabbits are trimethorpim sulphonamides to avoid dysbiosis. Cephalexin or narrow spectrum penicillins can be used but only parenterally. All of these provide four quadrant cover although resistance is possible. If a significant infection is suspected enrofloxacin (which is licensed) will have good activity against resistant gram negative aerobes but has no activitiy against anaerobes. This can easily be achieved by adding metronidazole to extend the spectrum. The advantage is these can be given orally to patients as well as parenterally. Penicillins and cephalexin are synergistic when used with enrofloxacin in the face of serious infection. When sending cultures away, be mindful of the benefits of local or topical therapy and agents which would not be given systemically such as aminoglycosides or clindamycin which may be utilised in drops, beads or for nebulisation. These should be included on any sensitivity panel.

Preparation is the key to any anaesthetic. As these are higher risk patients minimising the length of any anaesthetic procedure is important and identifying all likely items you will need and preparing these in advance is important. Preparing all the emergency drugs is also important. Simple dosing charts can be created and kept in a crash box patient side as an alternative.
Pre medication of rabbits is often performed and can help with muscle relaxation, analgesia and sedation of the patient (providing all three aspects of the anaesthetic triad). Pre medicants can

cause hypothermia however and cause cardiovascular and respiratory depression and so supportive care measures should be implemented at the point of premedication. Waiting until the patient is in theatre prior to dealing with thermal support is a mistake and patients can quickly become markedly hypothermic. Food should be removed once premedication has occurred to avoid any food being left in the oropharynx. Rabbits are usually placed in a basket and kept in a quiet darkened room and covered with a towel. The time is noted and they are evaluated regularly. They are moved to a heated room to counteract any hypothermia and this avoids subjecting patients who are in the ward being subjected to higher temperatures. Anticholinergics can be used however in rabbits glycopyrrolate has to be used given a large percentage of rabbits have atropinases. Ventilation is depressed under anaesthesia. Elevating the thorax and lying the patient in ventral recumbancy can facilitate ventilation of an anaesthetised patient. Operator fatigue is also a problem and the veterinary surgeon dealing with the patient can lead to inadvertent compression of the patient. Instruments, draping and swabs can also have an effect. Sitting down and resting your forearms on the theatre table reduces the likelihood of this occurring and in addition reduces hand tremor and improves dexterity, facilitating fine surgical intervention.

Anaesthetic protocols for rabbits

The initial aim should be a smooth rapid induction with securing an airway quickly. This typically involves the use of injectable agents, possibly with the addition of some gaseous agent. Although there is a wide variety of possible regimes it is important to use agents that the nurses and veterinarians are familiar with. There are a number of ways that rabbit anaesthesia can be made safer without the need to change agents. However if significant problems occur (for example with medetomidine) then being confident with other regimes is important as critical patients will need a different approach.

Most rabbits should receive injectable agents. These provide some sedation, analgesia, muscle relaxation and can reduce anxiety. When ever possible an intravenous line should be placed.
This can be used for IV induction but also for emergency drug therapy (including the use of some reversal agents). Fluid therapy should also be provided to all patients under anaesthesia. IV use allows lower doses to be administered, reduces the lag time so they can be dosed to effect (as opposed to IM or IP use where a set dose is given). If IV induction is achieved immediate intubation is possible.

In some extreme cases gaseous agents alone may be utilised. However these should have an IV line placed and this may remove the need for gaseous induction. Breath holding occurs with isoflurane and sevoflurane and as a result sevoflurane does not lead to quicker induction in rabbits. If this is the chosen option consider providing some analgesia or mild sedation with an opioid prior to mask induction. Restraint must be secure as even if mild sedation is utilised the noxious stimuli from the gaseous agent can lead to struggling. Wrapping the rabbit in a towel is usually required alongside firm restraint. This is stressful for any rabbit and vocalisation (screaming) may occur. Pre oxygenation is required prior to administering the gaseous agent. This is typically performed for a few seconds to a minute. The circuit should be flushed as there may be residual anaesthetic in the circuit/machine. Some authors prefer to incrementally dose the gaseous agent over time. This however does not appear reduce induction time, but may in some cases lead to reduced anxiety and struggling.

Generally subcutaneous administration of agents is sufficient, although IM injections are quicker and more consistent. These agents are used to provide analgesia, reduce anxiety and provide some muscle relaxation and sedation. Combining agents can help as side effects of each are minimised and all will provide some analgesia (pre emptive multimodal analgesia).

One option to consider is **medetomidine** (0.1mg/kg), **ketamine** (10 mg/kg) and **buprenorphine** (0.03mg/kg). If given subcutaneously this will provide suffient sedation for radiography for example. Caution is required as this can (will) cause respiratory depression and vasoconstriction

of peripheral perfusion. This should not be used in sick rabbits. Medetomidine is one of the two main drugs reported to the VMD on the adverse drug reaction forms. Gaseous agents can be given by mask to top up this cocktail to achieve a suitable plane for intubation or surgery. Intravenous use of this cocktail is also an option. This has the advantage of reducing the dose and it can be titrated to effect. Dosages as low as 0.05mg/kg medetomidine, 5mg/kg ketamine and 0.03mg/kg buprenoprhine can facilitate intubation when given intravenously. The advantage of this induction cocktail is it can be reversed using **atipamezole.** The same volume is used for rabbits. In many cases if the intravenous route has been used reversal may not be required.

Fentanyl/fluanisone ('Hypnorm') is another option to consider as this is licensed in the UK. This is commonly given intramuscularly or subcutaneously as a premedicant with intravenous midazolam or diazepam used to facilitate intubation. **Diazepam** and **ketamine** has also been used as a premedicant.

Doses of Hypnorm used do vary. The data sheet recommends 0.5mls per kilo. However lower doses of 0.2 – 0.3mls per kilo are commonly used. These rabbits then require up to 2 mg/kg diazepam or 1 – 2 mg/kg midazolam intravenously. Propofol is another alternative agent that has been used after Hypnorm as an intravenous induction agent. This can still cause marked cyanosis and it is not my personal choice. However some authors have found it to provide smooth inductions and lead to quicker recoveries than using midazolam.

Hypnorm can be reversed using a variety of agents. The fluanisone is not reversed and can lead to prolonged recoveries. However the fentanyl component can be reversed. Naloxone can be used in an emergency but will of course eliminate any analgesia. Doses used vary between 0.01 – 0.1 mg/kg. More commonly buprenorphine is used to partially reverse the fentanyl reducing the sedative effects but continuing to provide analgesia. Doses used are 0.01 – 0.05 mg/kg.

Butorphanol generally leads to quicker recoveries but provides less analgesia for a short duration only. Doses used are 0.1 – 0.5 mg/kg. Some authors use butorphanol to facilitate

recovery but provide additional analgesia two hours later with buprenorphine. In painful procedure hypnorm does not require reversal but morphine can be given 2 hours after its administration to provide ongoing analgesia.

This regime can be improved upon. Firstly medetomidine (or dexmedetomidine) can be given intravenously after the hypnorm as a set low dose (0.05 mg/kg) prior to using midzaolam to effect. This provides the advantage of lowering the midazolam (down to 0.2 mg/kg) and then atipamezole can be used to reverse the medetomidine and speed recovery. Equally ketamine could be provided by a low dose to further reduce the midazolam component. Benzodiazepine antagonists such as sarmazenil are available on a special treatment certificate (STC). Low doses can be given intravenously or buccally (0.05mg/kg) to speed recovery although this is not in common use in the UK yet. These provide suitable alternatives to propofol and can reduce recovery times. Hypnorm also has the advantage of peripheral vasodilation so intravenous access is simplified. Thus intravenous catheters can be placed after hypnorm sedation. If an alpha 2 is going to be utilised, it is best to place the intravenous catheter prior to its administration. In addition pulse oximetry works better with hypnorm as peripheral perfusion is better.

Alfaxalone has recenty become available in the UK and has been used alone as an intramuscular agent (at the rate of 5 – 10 mg/kg) or has been used after the administration of medetomidine or xylazine. In this regime 0.25 mg/kg medetomidine was given subcutaneously and 5 mg/kg alfaxalone was given intramuscularly. Intraveous use is preferable as the dose given can be titrated to effect. Buprenorphine has been used as a premedicant at the dose of 0.03 mg/kg with intravenous use of alfaxalone (2 -3 mg/kg) to facilitate intubation. In my experience slightly higher doses mat be required. Alfaxalone works well as an intravenous induction agent following a wide variety of premedicants and works equally well after hynorm. Inductions are smooth and peripheral perfusion is maintained. Catheterisation is easy and intravenous injection does not appear to cause any discomfort. Recovery is usually smooth. The alfaxalone is not reversible however.

Dexmedetomidine is now available and has also been used in rabbits. In medetomidine there is a mixture of the levo and dex isomers. It is the dex isomer that is active providing consistent dose dependant effects. However levomedetomidine is agonistic at lower does but can be antagonistic at higher doses leading to variable effects. Dexmedetomidine is shorter acting the medetomidine and its analgesia lasts longer than its sedative effects (it's the other way around with medetomidine). Low doses of dexmedetomidine can be provided throughout anaesthesia with reduced cardiovascular effects (although you will still see changes in heart and respiratory rate) to provide additional analgesia.

All rabbits should be intubated where possible. Techniques such as nasal intubation have been described but should ideally be abandoned once tracheal intubation is mastered. Direct visualisation of the larynx is best as this reduces the risk of tracheal trauma and allows you to evaluate the oropharynx for food material or foreign bodies. Generally 2- 4 mm endotracheal tubes are utilised. Tracheal trauma is a real risk and repeated attempts to intubate can lead to tracheal and glottal oedema and necrosis. Caution and practice is required. Rabbits have a long narrow mouth with a large fleshy tongue. They are also obligate nasal breathers and so the soft palate will have to be disengaged from the epiglottis prior to intubation. There are laryngoscopes specifically marketed for rabbits (such as the flecknell or a wisconsin blade 0). My preferred instrument is in fact a long otoscope cone. This is solely used for rabbits and if metal can be autoclaved between patients. Perfect restraint is needed although solo intubation is possible with practice. I would suggest that a set time (e.g. five minutes) or number of attempts at intubation (e.g. three trys) before giving up and resorting to masking the rabbit to reduce the risk of tracheal trauma, cyanosis and death.

The head must be held in a straight line with the rest of the body with the tongue extended and held with forceps. The head is then hyperextended. The front end of the rabbit may be elevated off the end of the table as well. The otoscope cone can then be inserted via the other side through the diastema. There are two vascular plexuses either side of the soft palate which can be visualised easily. The epiglottis can be seen as a v shaped silhouette behind the soft palate.

Flipping the soft palate up with the endotracheal tube will lead to breathing sounds being heard up the otoscope and the glottis can be directly visualised. Local anaesthetic spray can be applied and trickled down the otoscope onto the glottis. The otoscope can be removed and the rabbit oxygenated whilst this takes effect. Cyanosis is common after the soft palate has been displaced so speed is important as in oxygenation of the rabbit between attempts. The otoscope can be reinserted and the endotracheal tube passed into the glottis (remove the connector though!). Some rabbits may be quite light and the otoscope cone can be used as a mouth gag. A few breaths of inhalant usually allow the rabbit to deepen sufficiently to remove the otoscope cone. Once this is performed the endotracheal tube can be secured in place.

Alternatives to this include laryngeal mask or VGELs are being developed to engage over the glottis. These are not commercially available. They do provide a secure airway, minimise the risk of tracheal or glottal trauma, IPPV is possible with them, capnography can be used to confirm placement and they are easy to apply. However tongue compression can be a problem with some swelling and cyanosis possible and it is a blind technique.

Intubation rapidly reverses any cyanosis and capnography can be used to confirm correct placement. Condensation can also be visualised in the endotracheal tube or on a glass slide.
Bronchial intubation is a possible complication and the tube length must be accurately measured. Using an otoscope cone necessitates a longer tube to be used. They must be secured to the head using surgical tape of bandage.

Other clinicians prefer to use an introducer passed into the glottis. The otoscope or laryngoscope is then removed and a premeasured endotracheal tube is passed over the introducer into the glottis. Suitable introducers can include urinary catheters (8 – 10 french usually). This reduces the dead space compared to other techniques and reduces the risk of bronchial intubation. This does add in an extra stage however.

Endoscopic intubation can also be performed an essentially the endotracheal tube is passed over the endoscope and then proximal tracheoscopy is performed with the endotracheal tube then slid off the endoscope.

Blind intubation is also commonly performed. This technique can work well if the veterinarian is skilled in this procedure. Listening to breathing noises cf gurging swallowing noises guides the clinician to where the tube should be placed. However visualisation is not possible and foreign bodies or trauma is possible. It is also difficult to ensure that local anaesthesia has been applied to the larynx.

IPPV is indicated in all rabbits that have been intubated. This increases SPO_2 levels (oxygenation) and facilitates removal of carbon dioxide from the lungs $ETCO_2$ (ventilation). Whilst IPPV can be performed by a veterinary nurse, this can be difficult to achieve. In order to achieve effective ventilation the nurse should be focused on this task otherwise there is increased risk of ventilation perfusion mismatching as the pressure and volume and frequency of ventilation is altered markedly. Mechanical ventilators are available and one such unit is an inexpensive pressure cycling ventilator. This can replace a T piece and can be set for IPPV or normal ventilation. This allows IPPV to be instigated and stopped at any point during procedures depending on the requirements of the patient. This unit measures pressure at the end of the ET tube and a value allows a unidirectional flow of gas until the pressure is reached. Pressure and expiratory time can be set. Increasing pressure increases lung volume (based on lung compliance). The aim is to achieve normal chest movements for the rabbit. It is best to start at lower pressure and observe chest movements of the patient and increase pressure to achieve normal chest movements. Expiration time can be set to provide the normal respiratory rate for the species. Bear in mind that the respiration rate recorded from this patient may be elevated. Recoil of the patient's thoracic cavity facilitates expiration. After a set time period the value closes and inspiration occurs. As the pressure is recorded at the end of the ET tube caution is required for patients with small ET tubes. In these cases if a high flow rate is used pressure can build up and the value is opened, before the patient is sufficiently inflated. This can be corrected by

lowering the pressure, then the flow rate and slowing increasing the pressure again. It is important not to alter flow rate whilst the patient has a high pressure setting as hyperventilation is possible. This problem usually occurs with patients with endotracheal tubes of less than 2mm in diameter. Ideally the flow rate should be geared to keep inspiration within 1 – 2 seconds and expiration time depends on the normal respiratory rate you would expect. IPPV when used appropriate facilitates and stabilises anaesthesia, ensures inhalational agent delivery to the lungs, oxygenation of the lungs and removal of carbon dioxide from the alveoli.

Monitoring patients under anaesthesia is important and is typically performed by the veterinary nurse. However, particularly if IPPV is used, the outward parameters to monitor anaesthesia can be limited in small mammal patients and using monitoring devices can help to reduce both morbidity and mortality under anaesthesia.

Reflexes typically monitored to evaluate the plane of anaesthesia include toe pinch/withdrawal reflex, heart and respiratory rate and rhythm, eye position, mucous membrane colour and refill time, voluntary movement and response to surgical anticipation. Ideally the last two should be pre empted and the plane altered accordingly to the level of surgical stimulation.

Pulse oximetry measures the oxygenation of the patient by the oxygen saturation of the haemoglobin molecules (SpO_2). This correlates well with the arterial oxygen (PaO_2) levels. The machines are based on the human oxygen haemoglobin dissociation curve. Normal values should be 96% or more. Probes can be difficult to attach to some of the smaller patients. Caution is to be advised if alpha two agonists are utilised as poor peripheral perfusion can lead to improper functioning of the unit. Pulse oximetry does not provide information on blood flow of the oxygenation of the rabbit's tissues (which is in fact the important objective). Many machines are manufactured for human use and are unable to detect heart rates over 250 BPM. There are machines on the market which can record rates up to 350 BPM which can still be exceeded by rabbits and smaller mammals. This however is unusual in the clinical setting. Pulse oximetry does not tell us anything about the effective ventilation of the patient. They are also quite insensitive.

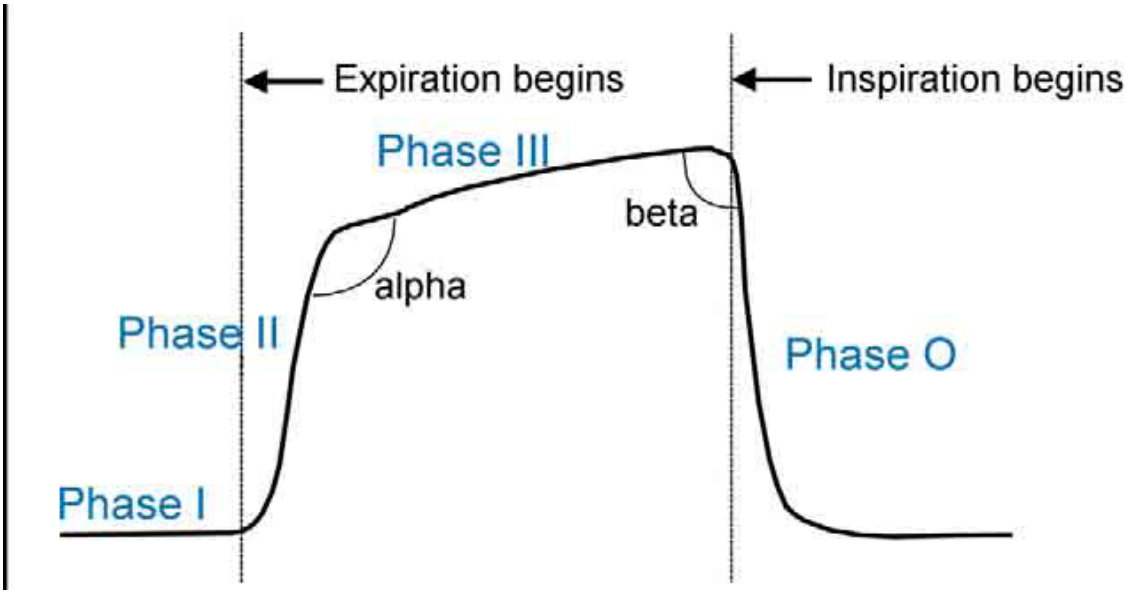
An example helps to identify the short comings of pulse oximetry. If you had a pulse oximeter attached to your finger and then held your breath it is likely you would become hypercapnic and have to breathe again prior to the pulse oximeter detecting a fall in SPO2 levels. A capnograph for example would have immediately detected the breath holding and the subsequent hypercapnia as a result. For this reason capnography is my preferred option for anaesthetic monitoring.

Capnography measures effective ventilation of the patient and ventilatory failure is the most common cause of morbidity and mortality under anaesthesia. Capnography is highly sensitive and reacts far quicker than pulse oximetry in an emergency situation. Capnography measure the end tidal CO_2 levels. It depends on the rapid exchange of gases between the lungs and the circulation and $ETCO_2$ correlates well with $PaCO_2$. As this is a real time monitor and is highly sensitive. The only delay is the time taken for the expired air to reach the monitor. A capnograph provides consistent reliable real time values. They can be used on anaesthetised and conscious patients (to help in the clinical assessment of hypercapnia for example as mucous membrane colour is unreliable) and all species have similar $ETCO_2$ values. The display is simple to use and interpret. Side stream units are most commonly used (as opposed to mainstream units which are more costly) it is important to ensure these have a low flow rate to avoid interrupting the gas flow for small patients. Small adapters can be utilised to minimise dead space. Respiratory rates up to 120 breaths per minute can be recorded. A capnograph and a capnogram are different. A capnogram provides a record of $ETCO_2$ which is calculated by the difference between peak and trough values. A capnograph displays a real time waveform of the level of CO_2 in the gas flow allowing the clinician to evaluate underlying pathology, the respiratory rate and the $ETCO_2$. Capnograms calculate the ETCO2 based on the difference between peak and trough values so a patient that is hyperventilating and re breathing will have incorrect results displayed.

The normal capnograph display consists of a number of phases:

- Phase I = expiration of air from dead space.

- Phase II = Expiration of air from dead space and air in contact with respiratory surfaces.
- Phase III = Expiration of air in contact with respiratory membranes. The plateau is the $ETCO_2$.
- Phase 0 = Inspiration with zero CO_2.



Evaluation of the waveform depends on the following:

Frequency = respiratory rate.

Rhythm = consistent breaths in terms of frequency and depth.

Height = $ETCO_2$ level.

Baseline = Zero for no inspired CO_2.

Shape = signs of hyper or hypoventilation. Should be a plateau.

Capnography can be used to verify intubation (will be CO_2), rebreathing of CO_2 due to hyperventilation (elevated baseline), airway obstruction (no CO_2), hypoventilation (ascending plateau), hyperventilation (descending plateau) or leakage of gas from the system (varying plateau and $ETCO_2$). $ETCO_2$ should be 4.5 – 5.9% (34 – 45 mmHg) in most cases. Artificial ventilation should be tailored to maintain these levels. Clinical assessment of hypercapnia is unreliable and using a capnograph in the conscious rabbit can help quantify the level of respiratory compromise and is additional oxygenation would be of benefit. Obligate nasal breathers (such as rabbits) can have the inlet port placed in front of their nostrils or a tight fitting mask placed over the head and the capnography attached. Alveolar dead space, ventilation perfusion mismatches, an embolism reducing blood flow to the lungs or reduced CO_2 transport to the lungs will all interfere with gas exchange and lead to poor correlation between $ETCO_2$ and $PaCO_2$. Pulse oximetry can detect poor oxygenation which may indicate poor gas exchange, but it gives no indication as to why. PAO_2 can also fall markedly prior to a drop in SPO_2 as well. Pulse oximetry also requires secure attachment to a well perfused, unpigmented area and other lighting can interfere with readings and covering the probe can help improve readings. However, capnography does require intubation and this can limit its usefulness in small rodents. Adequate oxygenation does not equal adequate ventilation and in addition adequate ventilation does not equate to adequate oxygenation either. However failure to provide adequate ventilation is far more likely than oxygenation. There is a lot to be said for using both modalities where possible.

Doppler flow monitors are also very useful. These have become increasingly available in clinical practice for blood pressure monitoring. They are easy to apply and can be used to obtain an audible continuous readout of the heart rate and blood flow. The rhythm and rate can be assessed. These can be taped in place over a peripheral vessel. Flat probes are best for these purposes although a pen style of probe can be used for intermittent evaluation. The heart rate can be calculated or the anaesthetist can concentrate on the rhythm and pick up on subtle changes in rate in real time. The second advantage of these units is for indirect blood pressure monitoring. All anaesthetic agents will create some hypotension during anaesthesia (due to reduced baroreceptor reflex and vasodilation). Measuring blood pressure will allow fluid therapy

(particularly if colloids are utilised) to be titrated. Usually values of the mean arterial pressure range between 70 – 170 mmHg. In rabbits we typically use the fore leg. The cuff is placed high up on the limb with the doppler probe below. Blood flow is detected and the cuff inflated until sounds are lost. The cuff is then slowly deflated until the flow is audible again. This is repeated three times and the average taken as the mean arterial pressure (MAP). Cuff size is important to obtain consistent results.

ECG recording can also be performed. This is more time consuming and difficult to get consistency, particularly if electrical items are being used (such as radiosurgery) can lead to electrical interference and so this is less commonly used as a monitoring tool. However specific patients, based on their presentation, may well require ECG recording as part of a safe anaesthetic regime.

The recovery period is a critical part of the regime. Once gaseous agents are turned off continued respiratory support is indicated as respiratory compromise is common during recovery. Providing continues oxygen and IPPV may be indicated. Reversal agents can be administered to speed recovery, but this has to be balanced with the analgesic effects of agent such as the alpha two agonists, opioids or ketamine for example, which may be beneficial in the immediate post operative period. If low doses have been used reversal may not hasten return to mobility and feeding.

Atipamezole is regularly used for reversal of alpha two agonists. There is no need to wait for 45 minutes. Subcutaneous therapy is often used, although intravenous therapy is indicted if there are complications with anaesthesia. It is always best to provide some atipamazole via the subcutaneous route to avoid resedation during the recovery period. Naloxone should be available to completely reverse any opioids. This will reverse any analgesia and is usually reserved for an inadvertent overdose or where complications have occurred. Butorphanol (a mixed agonist/antagonist) reverses pure mu opioids quickly but only offers short lived analgesia (for 2 hours) and some clinicians will use butorphanol to speed recovery but switch to other

agents subsequently. Buprenorphine is a partial mu agonist can be used to speed recovery. Its advantage is greater analgesia of a longer duration. In other cases, if fentanyl has been used for example in combination with fluanisone reversal may not occur and opioid therapy continued with products such as morphine where painful procedures have been carried out.

Sarmazenil is not licensed in the UK. This is a benzodiazepine reversal agent. This can be used to reverse diazepam or midazolam where these have been used. Typically these are used for IV induction agents in rabbits. This can be given via the IV route or buccally to speed recovery and has lead to quicker recoveries in our clinic. A Special treatment certificate (STC) is required to import the product for use. Doses as low as 0.05mg/kg can be given.

Jaw tone and movements is an indication recovery is imminent and the endotracheal tube can be removed. In many cases the tube stimulates the patient and once removed many patients will tolerate further oxygen by mask. The return of shivering thermogenesis is also an indication of recovery. It is important to plan for recoveries and have a warmed recovery cage prepared. This may be an incubator, propagator or a cage in a warmed room. It is important to continue to monitor respiration, heart rate and rectal temperature throughout this period. All measures used to maintain normothermia during the anaesthetic should be maintained during the initial phase of recovery.

Once moved into the brooder or cage it is more difficult to apply many of the techniques. However continuous monitoring is still possible along side the use of towels, blankets, heat mats (caution advised as they can get damaged through claws or bites) or extra substrate to bury in. Hypothermia is a risk but as the rabbits ability to regulate its own temperature has returned then hyperthermia is a risk. Close observation is required here and a gradual reduction in thermal support is indicated. Rectal temperature monitoring should be provided throughout this period. It is important to ensure a rabbit is capable of maintaining its rectal temperature without thermal support. At this point the rabbit can be transported to the usual wards. Rectal temperature will require further monitoring. Some species will not tolerate a rectal temperature being taken well

and the distress caused vs the benefit of leaving the patient to rest should be considered. Food and water should be available once the rabbit is coordinated (be aware that some will get wet if bowls are provided which can chill the patient). It is important to provide hide boxes, towels, blankets and nesting material where appropriate to allow these rabbits to hide. The ward temperature could be elevated slightly in the initial period or maintained overnight. Digital fan heaters are available with a thermostat which can be used to keep a ward at an even overnight temperature. Feeding, drinking, faecal and urine output should be monitored post anaesthesia. Fluid therapy and analgesia will need to be continued during this period. Nutritional support is important for those species with a high metabolic rate. Gastrointestinal stimulating drugs should also be continued. Improving motility will reduce pain (from gas formation and ileus) and analgesics will also reduce pain (the benefits of this outweighs any effect on bowel motility). Antibiotic usage also must be tailored to the species and need based on clinical presentation. Ranititidine is used as standard as a prokinetic in rabbits and for its protective function against gastric ulceration (1 – 2 mg/kg TID. This is continued until the rabbit is eating well and passing normal faecal pellets. Assist feeding with high fibre diets also stimulates motility.

Emergency drug therapy

Agent	Dose
Atropine	0.04 – 0.1 mg/kg (up to 3 mg/kg rabbit)
Glycopyrolate	0.01 – 0.02 mg/kg
Doxapram	2 – 10 mg/kg
Adrenaline	1:10,000 give 0.5 ml
Dexamethasone	0.5 – 2 mg/kg