GUIDELINES FOR PRIVATE PRACTICE VETERINARIANS ON ANAESTHESIA AND PAIN MANAGEMENT IN CATS UNDERGOING DESEXING

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These guidelines provide private practice veterinarians with current evidence-based guidance on anaesthesia and pain management for cats undergoing desexing with a specific focus on pre-pubertal cats (≤16 weeks of age) and unsocialised fractious cats (of any age). The aim of these guidelines is to provide a resource for veterinarians desexing cats and encourage practitioners to develop confidence in anaesthesia of pre-pubertal cats and unsocialised fractious cats.

Note: *not all drugs referred to within these guidelines are licensed for use in cats and not all doses are consistent with the manufacturer's recommendations.*

Animal Anaesthesia
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Executive summary

Given the benefits of desexing cats for individual cat health and population control these guidelines have been developed to help ensure that anaesthesia can be performed safely and with a high standard of patient care. Cats present several considerations for anaesthesia and surgery, but two cohorts of cats warrant special regard: those that present for desexing prior to puberty (≤ 16 weeks of age); and those that are unsocialised. The former group of cats are very small and more likely to experience complications such as hypothermia and prolonged recovery while the latter are difficult to evaluate prior to the administration of drugs. In these cases, an educated guess on the clinical status of the unsocialised cat must be made to ensure the safety of both the cat and personnel. Balanced anaesthesia, including multimodal analgesia, can be achieved with careful planning and preparation of equipment, drugs and personnel. The best approach is to develop an individual plan for each cat based on their clinical presentation, history and signalment. The small size of cats, especially pre-pubertal cats, requires careful attention to safe airway protection, dilution of concentrated drugs like medetomidine, prevention of intra-operative heat loss, minimisation of the duration of surgery and effective monitoring and management of intra-operative physiological complications. During anaesthesia, someone with the appropriate training and skills must be dedicated to continuous monitoring and intermittent recording of various parameters (especially heart rate, blood pressure and temperature) that reflect the physiological status of the animal during the procedure. With a considered approach, careful planning, access to the appropriate drugs and equipment and low stress handling techniques, it is possible to provide effective anaesthesia and analgesia for pre-pubertal and unsocialised cats for desexing safely.

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1. Background

Unwanted cats are a concern in Australia and in many countries around the world [1,2] as the welfare implications for individual cats and the associated social and environmental impacts of cats that cannot be responsibly homed are significant [3]. Desexing cats before they can reproduce is an important part of any strategy to control cat populations [4]. Although owned cats are usually desexed as part of responsible cat ownership, many accidental litters are born, and many unplanned pregnancies occur; therefore, desexing before they can reproduce is an important strategy for reducing the number of unwanted kittens [2,5].

The benefits of desexing before puberty include a decrease in unwanted litters, less inclination to roam and a lower incidence of disease and injury [2]. Conversely, the risks of 'early' desexing are limited and mostly associated with the perceived risk of anaesthesia and surgery in small and immature animals. Prepubertal desexing is commonly performed by veterinarians in shelters and welfare organisations but in private practices there is often reluctance to undertake these procedures [6]. Hence, the RSPCA, the Australian Veterinary Association, and many other veterinary and cat welfare organisations around the world recommend that cats are desexed at or before puberty as normal practice [7,8]. The barriers to this approach have been identified and include veterinarians' concern about safe anaesthesia and analgesia for young cats [7].

Targeted desexing programs have been identified as important in cat management, particularly for unowned and semi-owned cats. Many of these cats are unsocialised, and the management of anaesthesia and analgesia for this cohort of cats is anecdotally a source of concern for veterinarians working outside the shelter or welfare organisation environment [4,9,10].

These guidelines have been developed as a current evidence-based resource to help veterinarians to perform safe and effective anaesthesia of cats; in particular, prepubertal and unsocialised cats.

The guidelines were drafted by a specialist in veterinary anaesthesia and analgesia (GM) and reviewed by other specialists in veterinary anaesthesia and analgesia, veterinarians in practices with a high feline case load, and members of the Australian and New Zealand College of Veterinary Scientists. Wherever possible evidence-based recommendations have been made.

2. Approach to anaesthesia

Anaesthesia is the controlled and reversible intoxication of the central nervous system where the patient neither perceives nor recalls noxious stimuli [11]. The keywords are controlled and reversible, which infers that the state of unconsciousness is monitored and managed, and that complete recovery occurs. Furthermore, there will be no experience of pain.

The aim of anaesthesia is to create a **balance of unconsciousness, analgesia and muscle relaxation** [12]. However, anaesthesia is a complex process, with many critical steps that must be performed in a considered, timely and competent way. The anaesthesia of young cats, and of distressed cats who are difficult to restrain, is no exception, and every effort should be made to address the specific considerations of this cohort of animals in order to plan and perform anaesthesia with due care.

In general terms patient assessment and the development of a plan for anaesthesia must be made with consideration of the approach to restraint; drugs to be administered; monitoring of the animal; equipment that is required; supportive therapies such as intravenous fluids and active warming; analgesia; and oversight of recovery [13].

Cats present a number of considerations for anaesthesia and surgery but two particular cohorts of cats warrant special regard: those that present for desexing prior to puberty (≤ 16 weeks of age [14]); and those that are unsocialised. The first group of cats is young and small (< 1 kg), and the latter is likely to be distressed. Thorough physical examination of unsocialised cats may be difficult, and the history of the animal may not be available. These issues may compromise the ability of the veterinarian to plan anaesthesia and analgesia as carefully as they may otherwise do. Nevertheless, it is possible to anaesthetise these cohorts of cats with confidence and success. These guidelines will assist practitioners to perform balanced anaesthesia of these animals safely and take measures to ensure patient comfort.

Key points are described in detail throughout the text and summarised in Figure 1.

- Prepare equipment ahead of time and check anaesthetic machine and breathing system at the start of each day
- Develop an individual plan for each cat for balanced anaesthesia and multimodal analgesia
- Dilute drugs like medetomidine from 1000 µg/mL to 100 µg/mL for accurate dosing
- Minimise surgery time
- Have a trained person dedicated to monitoring anaesthesia with a focus on heart rate, blood pressure and body temperature
- Assess pain prior to discharge to ensure analgesia is adequate
- Use meloxicam post-operatively 0.1-0.2 mg/kg subcutaneous injection

Figure 1: *Key points for safe anaesthesia of cats.*

3. Pre-anaesthetic assessment

Prepubertal cats

Although the process of maturation varies between species and breeds, for cats the neonatal period extends up until 6 weeks of age and the paediatric period up to 12 weeks of age [15]. Therefore, cats who are older than 12 weeks of age have mature physiological systems: central nervous system, autonomic nervous system, cardiovascular system, respiratory system, haematology, renal function, liver function, thermoregulation and neuromuscular junctions [16, 17]. Nevertheless, these cats will be small and pre-anaesthetic assessment should ensure there is no evidence of immature physiology such as an unexpectedly high heart rate, poor musculature, small stature, abnormal appetite or toileting habits. Prepubertal gonadectomy is defined as castration or ovariohysterectomy of kittens 6 to 16 weeks of age [14, 18]. For cats 12-16 weeks of age the main consideration is size, but for cats < 12 weeks of age lower doses of anaesthetic drugs must be used as renal and hepatic functions are immature [18, 19].

Unsocialised cats

Unsocialised cats can be a challenge to examine, and information acquired prior to the development of an anaesthetic plan may be limited. Observations from a distance may be rewarding if attention is paid to coat quality, body condition, respiratory rate and effort, and demeanour. These observations may be performed by the caregivers when the cat is in a more familiar and less stressful environment. Personnel familiar with the cat's usual behaviour, eating and drinking habits, and disposition can provide veterinarians with insights that are invaluable, and form part of the information normally gathered in a pre-anaesthetic examination.

Anaesthetic risk

Classification of anaesthetic risk can be achieved by using the American Society of Anesthesiologists (ASA) physical status (PS) system which categorises animals into one of five categories based upon their physical status prior to anaesthesia (Table 1) [20]. This system is used in both medical and veterinary contexts and is a simple, practical and valuable prognostic tool to identify animals with an increased risk of death up to 24-72 hours after anaesthesia [20,21]. The determination of physical status of pre-pubertal cats is likely to be straightforward, however unsocialised cats may be more difficult. The challenges of examining these cats can complicate ASA classification and it is worth noting that when these cats are healthy and well, they may not be captured. In the face of injury or disease (and associated increase in ASA PS) these cats may be easier to capture and, consequently, more likely to present.

Anaesthesia related mortality in cats has been reported in only a few studies with the most recent overall mortality rate associated with anaesthesia being 0.24% [20]. However, the risk of anaesthesia is significantly greater in cats with ASA PS ≥ III compared to those with ASA PS I or II [20]. Overall, the relative risk for the published studies showed that cats with ASA PS ≥ III had 4.83 times greater risk of anaesthesia-related mortality compared to cats with ASA PS I or II [20]. These studies include a vast range of cats undergoing anaesthesia for various procedures, so for cats presenting for desexing it is assumed that the ASA PS will be I or II and the risk of carefully planned and executed anaesthesia will be low. In a study of healthy cats undergoing desexing procedures in general practices, the mortality was 0.1% [22]. A single death in the cohort of 1019 cats occurred during recovery soon after the cat became dyspnoeic [22]. Of note, is the risk of endotracheal intubation in cats: a mortality study has shown that intubation increases the odds of anaesthetic related death in cats [23]. Further discussion about airway management is below. (Refer to section 4, page 14)

ASA PS	Definition	Examples
I	Normal, healthy patient	Normal weight, normal size for age, normal body condition
II	Mild systemic disease present	Metritis, mastitis, stomatitis, skin abscess, superficial wounds, pregnancy
III	Severe systemic disease present	Renal failure, severe respiratory disease, pyometra, severe infection
IV	Severe systemic disease that is a constant threat to life present	Cardiac disease, liver failure, advanced renal failure, rodenticide intoxication
V	Moribund with no expectation of survival without the procedure	Massive trauma, diaphragmatic hernia, intussusception

Table 1: *American Society of Anesthesiologists Physical Status (ASA PS) Classification System [21].*

Pre-anaesthetic examination

To optimise the quality and breadth of information obtained during pre-anaesthetic assessment, various components should be evaluated and documented (Table 2). Once it is confirmed that the animal is ASA PS I or II, then these guidelines can be followed. For unsocialised cats where these data cannot be acquired, the balance between safety for personnel and additional distress for the cat associated with physical restraint must be balanced against the risk of inducing profound chemical restraint (heavy sedation or anaesthesia) with a single event of restraint and administration of an injection. Assumptions about the ASA PS status must be made, and review of these assumptions as soon as possible is prudent i.e., physical examination soon after induction of anaesthesia.

Pre-anaesthetic assessment component	Details
1. Clinical history	• Are there any current health concerns? • Is the cat eating, drinking, urinating and defecating normally? • Has the cat lost any weight lately? • Is there any history of vomiting or regurgitation? • Is there any history of coughing, sneezing or respiratory issues? • Is the cat's activity normal? • Is the cat receiving any medications? • Has the cat been anaesthetised before? Were there any complications?
2. Signalment	• Age • Breed • Sex • Pregnancy status
3. Clinical examination	• Temperament • Cardiovascular system – mucous membrane colour and capillary refill time, skin tent, heart rate, murmur presence and description, and pulse rate and rhythm • Respiratory system – anatomy (brachycephalic), respiratory rate and effort • Neurological system – demeanour and mentation • Size, body condition
4. Procedural considerations	• Predicted duration of procedure • Invasiveness of procedure (laparotomy vs castration) • Suitable surgical instruments for small cats
5. Anaesthetic considerations	• Appropriate selection of anaesthetic and analgesic drugs • Appropriate fluid therapy • Active warming • Airway maintenance • Breathing system
6. Other considerations	• Duration of fasting • Interactions with other medications • Need for diagnostic testing prior to anaesthesia including blood tests or imaging • Owner consent

Table 2: *Components of pre-anaesthetic assessment for consideration prior to the development of an anaesthetic plan.*

4. Equipment

Anaesthetic machine

The anaesthetic machine delivers oxygen, along with other carrier gases such as air, and anaesthetic agent through a breathing system to an animal. Anaesthetic machines have an oxygen supply, a flowmeter for each carrier gas, a vapouriser and a common gas outlet where the breathing system is connected. Anaesthetic machines must be checked at the start of every procedural day to ensure they are functioning safely and effectively. The Association of Veterinary Anaesthetists Anaesthetic Safety Checklist [24] includes the required checks on an anaesthetic machine (Appendix 1).

The carrier gas is usually 100% oxygen but may also be a mix of oxygen with air. The fractional inspired concentration of oxygen should always be > 30%; e.g., if total fresh gas flow is 2 L/min then oxygen should be delivered at no less than 0.6 L/min and the other carrier gas should be delivered at no more than 1.4 L/min.

Breathing systems

For cats, a non-rebreathing system such as a T-piece (Figure 2) or Bain (Figure 3) can be used to deliver oxygen and anaesthetic agent to the animal. A paediatric circle (rebreathing system) can also be used, but non-rebreathing systems are considered safer for small animals such as cats as they offer less resistance to expiration than rebreathing systems [19]. However, rebreathing systems can be used safely and effectively with lower fresh gas flows than non-rebreathing systems. This efficiency translates to less use of oxygen and inhalant anaesthetic and preservation of warmth and humidification of gas within the breathing system, which helps prevent hypothermia and drying of the airways [19]. When the breathing system is attached to the anaesthetic machine it must be checked to ensure there is no leak in the system. Leaks will compromise delivery of the carrier gases and anaesthetic agent to the animal and increase the risk of hypoxaemia and light anaesthesia. Furthermore, a leak in the breathing system will expose personnel to anaesthetic gases, which should be avoided.

Machine and breathing system leak test:

- Connect the breathing system to the common gas outlet of the anaesthetic machine and close the adjustable pressure limiting valve.
- Occlude the end of the breathing system (which connects to the endotracheal tube) with the palm of your hand or a custom occluder (i.e., cap that is sold with the breathing system).
- Fill the system with oxygen or carrier gas. The rebreathing bag should expand and maintain its volume if there is no leak.
- With a Bain breathing system, the integrity of the inner limb must also be confirmed: connect the system to the common gas outlet on the anaesthetic machine and turn the flowmeter on. Carefully occlude just the inner limb at the patient end of the breathing system (with a small finger or pen) and watch the bobbin in the flowmeter dip due to back pressure being created if the inner limb is intact. This test should only be performed momentarily to ensure damage to the flowmeter does not occur.
- Open the adjustable pressure limiting valve.

The rebreathing bag for cats should be 0.5 L in size for cats up to 5 kg. For larger cats the rebreathing bag should be 1 L.

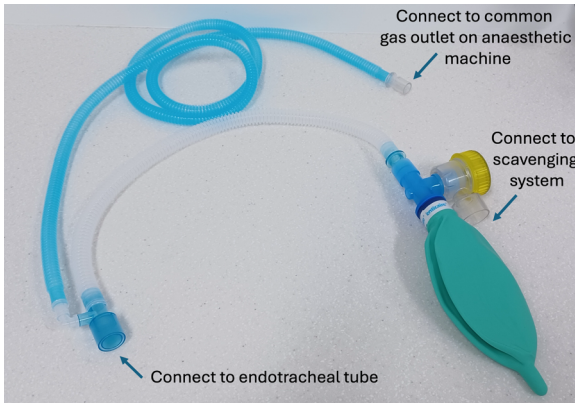


Figure 2: *Ayres T-piece breathing system.*

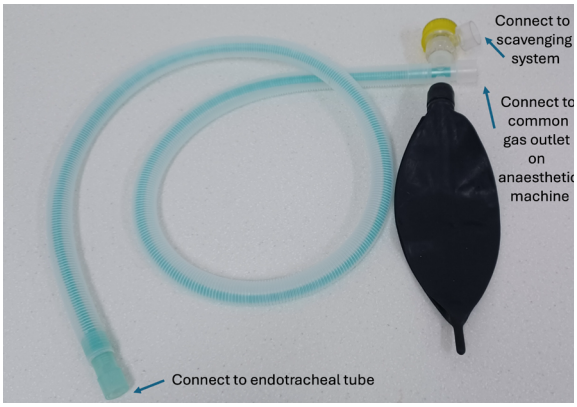


Figure 3: *Bain breathing system – a coaxial system where the inner limb is the inspiratory limb.*

To prevent rebreathing of carbon dioxide, the fresh gas flow must be set appropriately as the rebreathing of carbon dioxide is prevented by the continuous flow of fresh gas through the system (Table 3). However, if a capnograph is being used to monitor the adequacy of ventilation during anaesthesia the waveform (capnogram) can be assessed to ensure that there is no rebreathing of carbon dioxide, i.e., the waveform returns to baseline between each breath. A value for the inspired carbon dioxide concentration may also be provided by this equipment and should be 0-5 mmHg [19]. Non-rebreathing systems are desirable for small animals such as cats because, as mentioned earlier, they provide less resistance to expiration due to the absence of unidirectional flow valves. Non-rebreathing systems also create less equipment dead space (the volume of breathing system between the level of the incisors of the cat and the part of the breathing system where inspiratory and expiratory gases diverge). Excessive dead space (> 20% of the tidal volume of the animal or >2-3 mL) may be problematic in small animals as the effective tidal volume available for gas exchange is decreased and rebreathing of carbon dioxide is increased.

If a capnograph is used, it collects inspired and expired gases at the end of the endotracheal tube. The connector for the capnograph should be as small as possible to ensure it does not contribute to excessive equipment dead space.

The inclusion of a manometer in the breathing system is very useful to ensure that dangerous pressures are not achieved during manual or mechanical intermittent positive pressure ventilation. Some breathing systems have a manometer included or one can be purchased as part of the anaesthetic machine, or separately.

Breathing system	Total Fresh Gas Flow	Minimum Fresh Gas Flow	Example calculation
T-piece	~400 mL/kg/min	1.5 L/min	4 kg cat: 400 x 4 = 1600 mL/min or 1.6 L/min
Bain	~200 mL/kg/min	1 L/min	4 kg cat: 200 x 4 = 800 mL/min or 0.8 L/min therefore set 1 L/min

Table 3: *Fresh gas flow calculations for non-rebreathing systems. Note that the use of capnography enables titration of the fresh gas flow to prevent rebreathing of carbon dioxide. Capnography will reveal whether there is any inspired carbon dioxide and enable setting of the fresh gas flow to ensure that rebreathing does not occur.*

Airway management

After induction of anaesthesia, the breathing system is connected to an endotracheal tube, a feline specific laryngeal mask airway or a facemask.

Airway management in all species, including cats, is important as the maintenance of a patent airway to avoid obstruction, and to maintain oxygenation and ventilation, is vital. This procedure is a fundamental responsibility of personnel responsible for anaesthesia. However, the use of endotracheal tubes in cats is controversial, and as previously mentioned, a mortality study has shown that intubation increases the odds of anaesthetic related death in cats [23]. The need for intermittent positive pressure ventilation also increases this risk of death for cats [25]. Nevertheless, if inhaled anaesthetic agents are to be used for maintenance of anaesthesia, an endotracheal tube or feline-specific laryngeal mask airway must always be used to facilitate delivery of the inhaled agent with the carrier gas (usually 100% oxygen). If the duration of action of injectable agents is long enough for the desexing procedure, then a facemask may be used to deliver oxygen without the need for endotracheal intubation.

The use of endotracheal tubes is the most common approach to protecting the airway during anaesthesia. To perform endotracheal intubation, a laryngoscope and appropriately sized endotracheal tubes are required. The internal diameter and the length of the endotracheal tube must be considered during selection, along with the presence of a cuff. The internal diameter of the tube should be 3 - 5.0 mm for adult cats but sizes between 2 – 5.5 mm should be available (e.g., 1 kg cat trachea can be intubated with a 3 or 3.5 mm tube) [19]. If the internal diameter is too great the risk of laryngeal and tracheal trauma is increased and if it is too small (i.e., substantially less than the diameter of the trachea) the resistance to expiration, and in turn the

work of breathing, is increased. The tube should fit snugly within the trachea. If plain, uncuffed, tubes are used the size of the tube that can be placed atraumatically is bigger than a tube with a cuff. The length of the tube should be checked to ensure it extends from the level of the incisors to the tip of the shoulder (or thoracic inlet). If the tube is too long the risk of endobronchial intubation is increased, isolating parts of the lung. Furthermore, a tube extending beyond the incisors may increase equipment dead space and contribute to rebreathing of carbon dioxide. The risk of using cuffed tubes is referred to below. For small cats especially, uncuffed tubes may be safer than cuffed tubes.

Once the cat is adequately anaesthetised intubation can be performed (Table 4) [19].

Step	Comments
Pre-oxygenate with a face mask or flow by oxygen for 1-2 minutes.	If tolerated by the cat, pre-oxygenation increases the concentration of oxygen in the lungs and delays oxyhaemoglobin desaturation if intubation is difficult. This approach should only be taken if the cat is premedicated and adequately sedated to accept this restraint without distress.
Induce anaesthesia through an intravenous catheter or with intramuscular administration of anaesthetic drugs (unsocialised cats).	Intravenous agents can be titrated to effect to ensure the minimal effective dose is administered. This approach is only suitable for cats who are premedicated and adequately sedated to accept restraint without distress. This may not be practical for unsocialised cats and intramuscular administration of anaesthetic drugs (for induction) may be more appropriate for these cats; see below. Intramuscular agents are administered after calculation of a dose considered to be appropriate – the entire dose is administered in one injection.
Position the cat in sternal recumbency.	Check the depth of anaesthesia is adequate for intubation.
Use a laryngoscope to visualise the larynx.	Do not touch the larynx with the tip of the laryngoscope. The tip of the laryngoscope should depress the base of the tongue to improve the view of and access to the larynx.
Apply local anaesthetic (without adrenaline) to the larynx.	Use a spray formulation ensuring the nozzle does not touch the larynx to administer no more than 2 mg/kg lignocaine OR use a 1 mL syringe to drop 2% lignocaine directly onto the larynx (<0.2 mL).
Wait 60-90 seconds for local anaesthetic to have an effect	Administer oxygen by face mask during this time.
Insert endotracheal tube between arytenoid cartilages during inspiration	If there is any resistance to intubation or coughing, stop and administer more intravenous anaesthetic induction agent.

Table 4: *Steps for endotracheal intubation of a cat.*

Confirm correct placement	See list below.
Inflate the cuff if a cuffed tube has been placed	Inflate the cuff to ensure a seal between the tube and the trachea. Either gently squeeze the rebreathing bag, listen for leakage of fresh gas around the tube and incrementally inflate the cuff until there is no audible leak of gas; or check the manometer (if included as a component of the breathing system) to ensure the pressure within the breathing system reaches 10-15 cm H_2O.
Secure endotracheal tube with a flexible tie around the tube and behind the ears of the cat	Use a quick release knot or bow.

Table 4: *Steps for endotracheal intubation of a cat (continued).*

The complications associated with endotracheal intubation include laryngospasm, laryngeal oedema, bronchospasm, tracheal irritation and rupture, tracheal stricture, and trauma to the arytenoids [26, 27]. Each of these complications is dangerous and, while laryngospasm may be the most common, efforts should always be taken to mitigate the risks:

- Pre-oxygenate by delivering 100% oxygen through a breathing system and facemask for 1-2 minutes if the cat will tolerate this restraint
- **Ensure an adequate depth of anaesthesia prior to attempting endotracheal intubation**
- Use a laryngoscope to visualise the larynx and attempt intubation when the arytenoids are open
- Apply topical lignocaine spray to the larynx at least 45 seconds prior to intubation [28, 29]
- Disconnect the endotracheal tube from the breathing system whenever the recumbency of the cat is changed [27]
- If using a cuffed endotracheal tube, avoid overinflation of the cuff by measuring cuff pressure (and not relying on palpation of the pilot balloon) [27] or consider an endotracheal tube with no cuff (especially for small cats) to allow breathing of room air or the delivery of oxygen with or without isoflurane [30, 31]
- Use a feline specific laryngeal mask airway such as a v-gel (with continuous capnography) to deliver oxygen with or without isoflurane [26]
- Avoid intubation all together for short procedures performed with injectable anaesthetics [32] (except for brachycephalic cats [30])
- Always ensure endotracheal tubes are cleaned, disinfected with non-irritant chemicals and rinsed before reuse

Inadvertent oesophageal intubation is also a risk with the attempt to place an endotracheal tube. To ensure the endotracheal tube or laryngeal mask airway is correctly positioned the following tests can be performed:

- **Use a capnograph to confirm correct placement** by identifying carbon dioxide in expired gas from the lungs, by attaching the capnograph to the endotracheal tube after intubation and before connecting the breathing system
- Without a capnograph
  - **Visualise the endotracheal tube** ***in situ*** **between the arytenoid cartilages**
  - Watch the chest rise when the rebreathing bag is gently squeezed
  - Watch the rebreathing bag move when the cat breathes spontaneously
  - Palpate the neck to ensure an endotracheal tube cannot be palpated outside the trachea

Ultimately, the benefits of intubation must be considered against the risk for cats being desexed. When injectable drug protocols are used (i.e., inhaled anaesthetic agents are not being used to maintain anaesthesia), routine endotracheal intubation is not required [32]. For short procedures, such as castration, endotracheal intubation may not be necessary. However, **the equipment for intubation must always be available in the event of an emergency** [32, 33]. If endotracheal intubation is not performed, then oxygen should be delivered by a facemask during the procedure.

Monitoring equipment

The body systems that should be monitored during anaesthesia include the cardiovascular system, the respiratory system, the thermoregulatory system and the central nervous system. **Basic monitoring can be performed with a stethoscope, thermometer and clinical observations.** More advanced monitoring requires equipment such as a blood pressure measurement device, pulse oximeter, electrocardiograph and capnograph (Table 5) [34].

Body system	Basic monitoring	More advanced monitoring
Cardiovascular	Palpation of an arterial pulse (e.g., femoral artery) • Pulse rate and rhythm • Pulse quality Observation of mucous membrane colour • Perfusion (capillary refill time) Thoracic auscultation • Heart rate and rhythm	Blood pressure measurement • Perfusion of organs and tissues Electrocardiography • Heart rate and rhythm Pulse oximetry • Pulse rate and rhythm • Tissue perfusion Capnography • Perfusion of pulmonary vasculature
Respiratory	Observation of chest wall excursions and/or movement of the rebreathing bag of the breathing system • Respiratory rate and effort	Pulse oximetry • Oxyhaemoglobin saturation Capnography • Respiratory rate • Adequacy of ventilation • Performance of anaesthetic machine and breathing system (to identify rebreathing of carbon dioxide)
Thermoregulatory	Thermometer • Core body temperature	
Central nervous	Subjective assessment of muscle tone, eye position, palpebral reflex • Depth of anaesthesia assessment	

Table 5: *Basic and advanced monitoring equipment for use during anaesthesia.*

Some monitoring equipment gives information about more than one physiological system (Figure 4); e.g., the pulse oximeter provides information about the cardiovascular system (tissue perfusion, pulse rate) and the respiratory system (oxyhaemoglobin saturation).

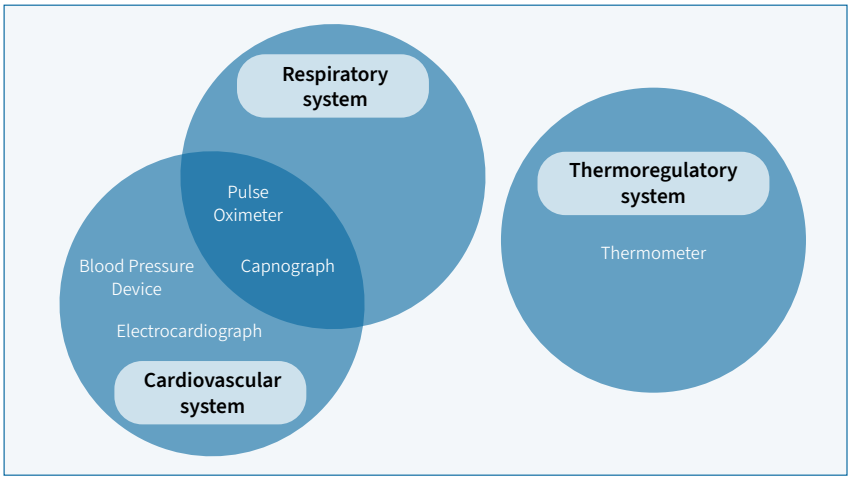


Figure 4: *Monitoring equipment may give information about more than one physiological system.*

The reliability of monitoring equipment in small animals, especially young cats, may be compromised. It is important to understand the limitations of monitoring equipment to ensure that the information is interpreted appropriately (Table 6).

Equipment	Comments on accuracy in cats
Stethoscope	Transthoracic or oesophageal stethoscopes can be used without notable limitations.
Thermometer	Rectal or oesophageal thermometers can be used without notable limitations.
Pulse oximeter	Various factors influence the accuracy of pulse oximetry, which relies upon good perfusion of a non-pigmented, non-hairy part of the body, such as the tongue. When alpha$_2$ adrenoreceptor agonist drugs have been used vasoconstriction may interfere with this perfusion and give artefactually low readings. Hypothermia and ambient light may also may also interfere with pulse oximetry.
Electrocardiograph	Electrocardiography can be performed in cats with few limitations, although the size of the complexes may be small and interfere with the calculations of the heart rate. The uniformity and regularity of the complexes can be evaluated visually.

Table 6: *Notes on the limitations of monitoring equipment used in cats.*

Blood pressure measurement device	The gold standard of blood pressure measurement is invasive measurement involving placement of a catheter in a peripheral artery. Non-invasive methods of blood pressure measurement are more clinically accessible and relevant for desexing procedures. Ultrasonic Doppler equipment can be used to hear peripheral arterial pulsations and measure the systolic blood pressure in cats with a sphygmomanometer [35]. However, this technique is not considered accurate when compared to invasive blood pressure measurement [36]. The relative change in systolic blood pressure (the trend) during anaesthesia can be ascertained with this technique. Doppler equipment is versatile insofar as it can be used on very small animals to hear arterial pulsations or the heartbeat. The skin must be clipped over the area of interest and ultrasound gel must be used to optimise the quality of the signal. Oscillometric blood pressure measurement devices are available and are suitable for use in cats [37, 38]. These devices are most accurate for the mean arterial blood pressure value. Accuracy is improved when the cuff is placed on a limb that is level with the heart and when the width of the cuff is approximately one-third of the circumference of the limb. High definition oscillometric blood pressure measurement devices are relatively new and are useful in anaesthetised cats. These devices do not rely as much on the size of the cuff for accuracy [35]. When alpha$_2$ adrenoreceptor agonist drugs have been used vasoconstriction and bradyarrhythmias may interfere with the accuracy of non-invasive blood pressure measurements.
Capnograph	Capnographs may be mainstream (measurements made in the connector between the endotracheal tube and the breathing system) or sidestream (measurements made in the unit after gas has been collected from the end of the endotracheal tube and moved through the tubing to the unit). Mainstream capnography is generally more accurate but only values for expired carbon dioxide and the respiratory rate are generated. There is no waveform or capnogram. The connector for mainstream capnography may cause drag on the endotracheal tube and contribute to equipment dead space. Sidestream measurements are less likely to cause drag, and the connectors can be small, so equipment dead space is not increased. The measurements can be affected by dilution, especially if the fresh gas flow set on the anaesthetic machine is high. Side stream capnography is more commonly used as values for inspired and expired carbon dioxide, along with a waveform and the respiratory rate are generated.

Table 6: *Notes on the limitations of monitoring equipment used in cats (continued).*

5. Preparation

Following pre-anaesthetic assessment and the development of an appropriate plan for anaesthesia and analgesia the patient should be prepared. For ASA PS I and II cats, pre-anaesthetic stabilisation is unlikely to be required. An accurate weight for the cat should be obtained to ensure that drug calculations can be performed precisely. If unsocialised cats cannot be weighed accurately, an estimate of their weight can be made by weighing the container they are in (cage, trap, carrier) and subtracting the weight of the empty container. Drug doses should be calculated on the lean body weight of the animal as body fat doesn't have a significant effect on the volume of distribution of drugs [39].

Food and water

Water should be provided up until the premedication drugs are administered and the duration of fasting should be determined. There are no clearly proposed evidence based pre-anaesthetic fasting guidelines for cats [40]. The purpose of pre-anaesthetic fasting is to avoid the risk of regurgitation and aspiration of stomach contents, to decrease the risk of gastro-oesophageal reflux and associated oesophagitis and to minimise the risk of a large stomach compromising surgical access and spontaneous ventilation during anaesthesia. However, the advice for cats is empirical and for cats less than 8 weeks of age or less than 2 kg in weight, fasting (following feeding with wet, easily digestible food) should be short (i.e. 1-2 hours) to mitigate the risk of hypoglycaemia [41]. Otherwise, adult cats or those more than 8 weeks of age and more than 2 kg in weight can be fasted for 4-6 hours if they have been fed wet, easily digestible food [39]. If dry food has been fed, the period of fasting should be 8 – 12 hours.

Fear, anxiety and stress

To mitigate fear, anxiety and stress for cats, efforts to create a cat-friendly environment are essential. The key principles for creating such an environment includes the management of odours, the use of synthetic feline facial pheromone analog, management of visual and auditory input, dog-free zones and hiding opportunities within cage systems [42, 43]. Familiarising cats, whenever possible, with carriers and car rides, and the veterinary clinic environment may also help alleviate fear, anxiety and stress [44]. Further information on the management of fear, anxiety and stress is available in recent publications, which provide detailed contextualised descriptions of how to minimise distress for cats in a veterinary environment [43, 45].

Cats who are known to be fractious, aggressive, anxious and/or fearful may benefit from the administration of gabapentin prior to admission on the day of desexing [39]. Oral gabapentin (~10 mg/kg) is beneficial to cats in a shelter environment when combined with efforts at behavioural modification [46]. This drug is also reported to be useful when used for distressed cats prior to a veterinary clinic visit to reduce stress and aggression at a dose of 100 mg/cat per os 90 minutes prior to travel to the veterinary clinic [47]. The combination of trazodone and gabapentin has been used in adult cats and provides safe and reliable sedation when administered at 5 mg/kg and 10 mg/kg per os respectively one hour prior to handling [48]. Furthermore, pregabalin has also been shown to be useful to manage anxiety associated with travel and veterinary visits when administered per os (5 mg/kg) 90 minutes prior to the time of required effect [49].

6. Premedication

Premedication is performed to facilitate physical restraint of animals, to ensure a smooth induction of anaesthesia and recovery from anaesthesia, to reduce the dose of other drugs, to provide anxiolysis and to provide pre-emptive analgesia. Premedication can be administered by various routes (e.g. subcutaneous, intramuscular, oral transmucosal) and the timing will depend on the drugs that are used and the route by which they are administered. Following administration of premedication drugs (Table 7), it is best to ensure the animal's immediate environment is quiet, calm and free from stimulation.

The approach to premedication should be based on the information acquired during pre-anaesthetic examination and assessment. Cats who are easy to handle and relaxed may only require light or moderate sedation prior to the induction of anaesthesia while unsocialised cats or young cats that are nervous may benefit from premedication that produces moderate to heavy sedation. Wherever possible premedication should precede the induction of anaesthesia by intravenous injection of drugs that can be titrated to effect.

Antimuscarinic drugs such as atropine and glycopyrrolate are not routinely included in premedication combinations as the increase in heart rate associated with these drugs may be dangerous and may make it more difficult to interpret cardiovascular responses to surgery. The antisialogogue effects of these drugs is not considered justification for their routine use. These drugs may be indicated intra-operatively if opioid induced bradycardia is contributing to hypotension (atropine 0.01 – 0.02 mg/kg or glycopyrrolate 0.005-0.01 mg/kg by intravenous injection). Do not administer these drugs for the bradyarrhythmias induced by alpha$_2$ adrenoreceptor agonist drugs like medetomidine.

For procedures that are likely to cause moderate to severe pain, a full μ opioid receptor agonist such as methadone or morphine is appropriate. Partial μ opioid receptor agonist drugs like buprenorphine are suitable for procedures likely to be associated with mild to moderate pain. Although buprenorphine has been interchanged with morphine or methadone in drug combination protocols for cats (e.g., the QUAD protocol), the analgesic efficacy of this drug seems to be inferior for desexing procedures [31, 50]. As butorphanol is a μ opioid receptor antagonist the analgesic effects of this drug are inferior to buprenorphine [51, 52]. Although butorphanol is a good sedative, it is not included in these guidelines as the pain associated with either castration of ovariohysterectomy is likely to be moderate to severe.

Acepromazine is commonly used for premedication [53] but as a tranquiliser it will not produce heavy sedation even when combined with an opioid. Medetomidine is an alpha$_2$ adrenoreceptor agonist that causes dose dependent sedation and is also commonly used to premedicate cats [25]. The doses in Table 6 are lower than data sheet doses and should create sedation without significant cardiovascular side effects. Medetomidine can be reversed with atipamezole, and this feature may make it a good choice for cats who are difficult to handle but that need to recover promptly after the procedure.

If heavy sedation is required, ketamine can be included in the combination of drugs but the injection of this drug alone or when combined in a syringe with other drugs will sting when administered. Therefore, it is important to be aware of the potential reaction of the cat and to ensure restraint is secure.

Alfaxalone can also be administered by intramuscular injection to cats, but the volume of injection may preclude its feasibility in cats who are difficult to restrain or large in size.

Planned effect	*Cats >6 weeks of age	Unsocialised cats
**Light sedation	Opioid only: • Methadone 0.2-0.4 mg/kg SC or IM 30 minutes prior to induction of anaesthesia **OR** • Morphine 0.2-0.4 mg/kg SC or IM 30 minutes prior to induction of anaesthesia **OR** • Buprenorphine 0.01-0.02 mg/kg SC or IM or OTM 45 minutes prior to induction of anaesthesia	
Moderate sedation	• Acepromazine 0.01-0.03 mg/kg SC or IM 30 minutes prior to induction of anaesthesia **Plus** an opioid as described above **OR** • Medetomidine 10 µg/kg SC or IM or OTM 15-30 minutes prior to induction of anaesthesia **Plus** an opioid as described above **OR** • Acepromazine 0.01-0.02 mg/kg SC or IM **Plus** Medetomidine 5 µg/kg SC or IM with an opioid as above 15-30 minutes prior to induction of anaesthesia	
***Heavy sedation	• Medetomidine 20 -30 µg/kg IM 15 minutes prior to induction of anaesthesia **Plus** an opioid as described above **Plus** Ketamine 1-3 mg/kg IM **OR** ****Alfaxalone only 2.5-10 mg/kg IM [54]	• Medetomidine 50 µg/kg IM 15 minutes prior to induction of anaesthesia **Plus** an opioid as described above **Plus** Ketamine 2-4 mg/kg **OR** ****Alfaxalone only 5-10 mg/kg IM [54]

Table 7: *Premedication regimes for cats. SC = subcutaneous, IM = intramuscular, OTM = oral transmucosal. *Use the lower end of the dose range for cats 6-10 weeks of age. **Light sedation prior to general anaesthesia in healthy cats may require the administration of rescue analgesia during anaesthesia e.g., intravenous fentanyl 1-3 µg/kg [55]. ***In some cases, general anaesthesia may result, and appropriate monitoring (akin to that performed during general anaesthesia) should be performed. ****Alfaxalone alone does not provide analgesia so additional drugs should be administered to ensure a balanced anaesthetic is achieved.*

Subcutaneous or intramuscular injections require restraint of a cat and care to ensure the procedure is not stressful or painful. To reduce injection site pain, use the smallest needle length and size possible to accommodate the viscosity of the drug, use a fresh needle for the injection (i.e., not one that has been used to draw medication from a vial), and ensure the needle does not move around during injection [43]. The onset of action of drugs administered by the subcutaneous route is likely to be longer and less predictable than when the intramuscular route is used.

7. Induction of anaesthesia

Once the cat has been premedicated satisfactorily, an intravenous catheter should be placed for the administration of intravenous anaesthetic induction agent, for the administration of intravenous fluids, or for use in emergencies.

To facilitate intravenous catheter placement, the cat should be adequately sedated (in relation to its temperament) and carefully restrained. The site should be clipped with quiet clippers and prepared with dilute chlorhexidine and/or ethanol. However, alcohol-based skin preparation solutions have a strong scent and can stimulate cats. Topical local anaesthetic cream (e.g., EMLA cream) will help prevent a response to puncture of the skin but should be applied at least 60 minutes prior [56]. Given this timeframe, it may not be appropriate to use EMLA cream in uncooperative cats as it needs to be applied prior to premedication.

Intravenous administration of drugs for induction of anaesthesia is safer insofar as the dose of drugs can be titrated to effect to achieve a depth of anaesthesia that enables endotracheal intubation and/or surgery to proceed (with no gross purposeful movement or autonomic response) (Table 7). If it is expected that the cat won't tolerate restraint for placement of an intravenous catheter when they are sedated, the best approach may be to administer drugs by intramuscular injection to induce anaesthesia (Table 8). With this approach the drugs cannot be titrated to effect so the risk of under or overdosing is possible. In the former scenario additional intramuscular injections may be required, although the timing and doses of drugs can be difficult to determine. In the latter scenario dangerous side effects may threaten the health of the cat.

If premedication has been administered for sedation, intravenous anaesthetic induction agents can be administered (Table 8).

Drug	Dose	Comments
Propofol	4-6 mg/kg IV after light to moderate sedation **OR** 2-4 mg/kg IV after heavy sedation	Slowly titrate to effect ~ 1 mg/kg/10 seconds. Post induction apnoea may occur requiring intermittent positive pressure ventilation ~4x/minute until spontaneous ventilation resumes, or in accordance with capnography to achieve normocapnia. Repeated dosing (over multiple consecutive days) of propofol in cats is reported to cause a rare side effect of Heinz body anaemia [57, 58]. Single doses for isolated procedures like desexing do not pose this risk.
Alfaxalone	1-3 mg/kg IV after light to moderate sedation **OR** 0.5-1 mg/kg IV after heavy sedation	Slowly titrate to effect ~ 0.5 mg/kg/10 seconds. Post induction apnoea may occur requiring intermittent positive pressure ventilation 4x/minute until spontaneous ventilation resumes, or in accordance with capnography to achieve normocapnia.

Table 8: *Drugs for intravenous induction of anaesthesia in cats for desexing procedures. IV = intravenous.*

If the cat is extremely difficult to handle, a combination of drugs can be used to induce anaesthesia by intramuscular injection (Table 8). This approach is common for unsocialised cats and is facilitated by firmly wrapping the cat in a towel or, if there is no other safe option, appropriately using a restraint cage. If oral medications such as gabapentin and/or trazodone can be administered prior to anaesthesia, a restraint cage may not be required, however, the safety of both cats and personnel must be considered [43].

In these cases, premedication *per se* is not administered. Although the drugs used in these protocols have a wide therapeutic margin, the doses must be calculated accurately and based on the measured weight of the cat. Intramuscular 'top-up' doses should be avoided wherever possible as the risk of drug accumulation is greater when drugs are administered by this route. If top-up doses are required, they should be just a proportion of the original dose as judged by the effect of the original dose and the time since the original injection. Alternatively, additional anaesthesia can be provided by the administration of titratable intravenous drugs such as propofol or alfaxalone at low doses such as 0.5-1 mg/kg IV of propofol or 0.25 mg/kg IV of alfaxalone. Equipment for airway management must always be available, if endotracheal intubation has not already been performed.

In Table 9, drug combinations for induction of anaesthesia by intramuscular injection are described. These protocols are included as they represent published data. In some instances, the procedure was specific (e.g., castration only). If the procedure specifies ovariohysterectomy, the same approach can be used for castration but if the converse is specified, the anaesthesia may not be adequate for ovariohysterectomy.

Care must be taken when drawing up small volumes of drugs into syringes. The needle and syringe dead space are a source of inaccuracy when drawing up individual drugs or when combining drugs together in the same syringe. For volumes less than 0.04 mL, large percentage errors are reported, which may lead to accidental over or underdosing. It is recommended that for target volumes < 0.19 mL drugs are diluted to optimise accuracy of dosing [59]. Stock solutions with the correct proportions of drugs by volume may help avoid this potential error. In veterinary medicine it has been shown that neither experience nor qualifications (veterinarian or veterinary nurse) impact on accuracy of drawing up medications in syringes [59].

Drug Combination	Reversal agent	Comments
'Quad' protocol: equal volumes of Medetomidine dose 600 µg/m^2 (concentration 1 mg/mL) Ketamine dose 60 mg/m^2 (concentration 100 mg/mL) Midazolam dose 3 mg/m^2 (concentration 5 mg/mL) Buprenorphine dose 180 µg/m2 (concentration 0.3 mg/mL) IM [60]	Atipamezole at 10-50% of the previously administered volume of medetomidine IM no sooner than 20 minutes after induction of anaesthesia [60].	Provides multimodal analgesia, quick induction of anaesthesia and suitable depth of anaesthesia for surgery. To calculate drug volume, body mass is converted to body surface area: body surface area = (K x bodyweight$^{0.67}$)/100 where K = 10.4 for cats. Then body surface area is multiplied by 0.6 to give the volume of each agent e.g. 2 kg cat = body surface area 0.17 m^2. Volume of each drug = 0.17 x 0.6 = 0.1 mL. Total injection volume = 4 x 0.1 = 0.4 mL. *Meloxicam can also be administered after recovery from anaesthesia [31]. See section on NSAIDs (page 35 and table 11).
'Quad' protocol using methadone instead of buprenorphine: equal volumes of Medetomidine dose 600 µg/m^2 (concentration 1 mg/mL) Ketamine dose 60 mg/m^2 (concentration 100 mg/mL) Midazolam dose 3 mg/m^2 (concentration 5 mg/mL) Methadone dose 5 mg/m^2 (concentration 10 mg/mL) IM [31]	Atipamezole at 50% of the previously administered volume of medetomidine IM at the point of extubation [31].	Provides superior post operative analgesia compared to 'Quad' with buprenorphine (above). Drug volume calculation see above. *Meloxicam can also be administered after recovery from anaesthesia [31]. See section on NSAIDs (page 35 and table 11).
'Kitty magic' combination: Dexmedetomidine 22-33 µg/kg **Plus** Butorphanol 0.44-0.66 mg/kg **Plus** Ketamine 4.4-6.6 mg/kg IM Dose at lower end of range for castration and higher end of range for ovariohysterectomy [61]	Atipamezole at same volume of dexmedetomidine can be administered for reversal [61].	Butorphanol is not a good analgesic agent so the approach to multimodal analgesia must be modified to account for the lack of opioid associated analgesia. *Meloxicam can also be administered after recovery from anaesthesia [31]. See section on NSAIDs (page 35 and table 11).

Table 9: *Drugs for intramuscular induction of anaesthesia in cats for desexing procedures. IM = intramuscular, SC = subcutaneous, IP = intraperitoneal (continued).*

Dexmedetomidine 20 µg/kg **Plus** Ketamine 7 mg/kg IM [62]	Atipamezole 25-50 µg/kg IV	Combined with local anaesthesia (2 mg/kg lignocaine intratesticular and SC) this combination is suitable for castration of cats [62].
Dexmedetomidine 40 µg/kg **Plus** Ketamine 4 mg/kg **Plus** Midazolam 0.25 mg/kg IM [63]	Atipamezole 0.4 mg/kg IM	This combination is suitable for ovariohysterectomy of cats between 10 weeks and 6 months of age when combined with meloxicam (0.1 mg/kg SC) and bupivacaine (2 mg/kg IP instilled over right and left ovarian pedicles and caudal aspect of uterine body) [63].

Table 9: *Drugs for intramuscular induction of anaesthesia in cats for desexing procedures. IM = intramuscular, SC = subcutaneous, IP = intraperitoneal (continued).*

Note that dexmedetomidine and medetomidine can be interchanged. Medetomidine is an equal mix of dexmedetomidine and levomedetomidine. As dexmedetomidine is formulated at 0.5 mg/mL and medetomidine is 1 mg/mL, the same volume for injection can be used as the dexmedetomidine dilution has the same potency as medetomidine [61].

Opioid drugs can also be interchanged. The equivalent doses of common opioids are:

morphine 0.2 mg/kg ≈ methadone 0.2 mg/kg (≈ buprenorphine 0.01 mg/kg if pain is only likely to be mild to moderate)

Induction of anaesthesia with inhalant anaesthetic drugs delivered by a facemask or in a chamber is not recommended unless the cat is heavily sedated. This method of induction of anaesthesia has some disadvantages: airway irritation; distress during restraint (unless heavily sedated); and exposure of personnel to anaesthetic gases.

8. Maintenance of anaesthesia

For young cats where anaesthesia has been induced with an intravenous injection of propofol or alfaxalone, anaesthesia can be maintained with an inhalant drug like isoflurane or sevoflurane delivered via the anaesthetic breathing system. The dose of these drugs is expressed as MAC (minimum alveolar concentration) and there is a high degree of variability in the published values for MAC for both isoflurane and sevoflurane in cats [64]. The average MAC for isoflurane is 1.71% and for sevoflurane is 3.08% [64]. These values suggest that the vapouriser should be set at 1.5-2% for isoflurane and 2.5-3.5% for sevoflurane. If post induction apnoea has occurred after the administration of intravenous anaesthetic induction agents it may be appropriate to set the vapouriser at a higher level (0.5-1%) than it is intended to remain on for the maintenance phase.

To ensure the uptake of inhaled anaesthetic occasional intermittent positive pressure ventilation should be applied manually by carefully squeezing the rebreathing bag, with the APL valve of the breathing system closed, to inflate the chest 4-6 times per minute until spontaneous ventilation resumes.

There are multiple factors that decrease MAC: hypothermia, disease, sedative, anaesthetic and analgesic drugs. The vapouriser setting should therefore be considered carefully to avoid anaesthetic overdose considering other drugs that have been administered and the subjective assessment of depth of anaesthesia. Cats who have been anaesthetised with the Quad protocol or Kitty Magic may not require any inhalant anaesthetic drug.

9. Supportive therapies

Various supportive strategies are vital components of cat care during anaesthesia for desexing. Even for short procedures, basic care can make a big difference to the experience for the cat.

Fluid therapy

Most healthy cats undergoing elective surgery such as desexing do not require intravenous fluid therapy if they are euhydrated and euvolaemic prior to the procedure [65]. These cats should however always be offered food and water as soon as possible after recovery. If fluid therapy is administered during anaesthesia, the **fluid rate for cats should be 3-5 mL/kg/h of a balanced isotonic crystalloid** by intravenous infusion [65]. Intravenous fluids are beneficial for supporting cardiovascular function and maintaining intravenous catheter patency.

For cats < 12 weeks of age, hypoglycaemia is a risk because glycogen stores are small. These cats should only be fasted for 1-2 hours and should be offered food as soon as possible after recovery from anaesthesia. Intravenous fluids containing dextrose may be appropriate for longer procedures [18]. Measurement of blood glucose concentration during prolonged procedure or during recovery may be prudent.

Eye care

The eyes should be protected with corneal lubricant, especially if ketamine is used [66]. Lubricant will protect the eyes from accidental abrasion and offset the decrease in tear production caused by anaesthetic drugs such as medetomidine and ketamine [66].

Positioning

The position of the cat during surgery is dictated by the surgical procedure, but whenever possible the cat should be positioned in sternal recumbency with the neck extended. This physiologically normal position supports spontaneous ventilation. When the cat is in dorsal or lateral recumbency, ensure the neck is extended to optimise airflow or to prevent kinking of the endotracheal tube if one is in place. When the position of the cat is changed, the endotracheal tube must be disconnected briefly from the breathing system, so the tube does not rotate within the trachea and cause a tear [27].

Ventilation

Spontaneous ventilation is more efficient when the cat is in sternal recumbency as the position of the diaphragm and abdominal organs does not impede chest excursions and lung inflation during inspiration. When the cat is in dorsal recumbency the risk of hypoventilation is increased, which basic anaesthetic monitoring will detect as a change in respiratory rate, and importantly, respiratory effort. This effect is more pronounced in obese or pregnant cats.

If intermittent positive pressure ventilation is required, it can be delivered either manually or mechanically. Ventilation must be performed carefully to ensure neither excessive pressure (15 cm H_2O should be the maximum pressure generated) nor excessive volume (10 mL/kg should be the maximum tidal volume) is delivered to the lungs. A capnograph is extremely useful in these situations to guide ventilation to normocapnia (expired carbon dioxide 35-45 mmHg). The sampling rate of some capnographs will dilute the sample from cats so the reading may be artefactually low for cats. Being familiar with the equipment is important to understand the normal range for a cat. For sidestream capnographs that sample the expired gases at 150-200 mL/min, the normal expired carbon dioxide level reading is 25-30 mmHg even though the arterial level is normal. Furthermore, the fresh gas flow may also dilute the partial pressure of expired carbon dioxide. This effect can be minimised by ensuring the fresh gas flow is just adequate to prevent rebreathing of carbon dioxide.

Intermittent positive pressure ventilation is indicated when the cat is apnoeic or hypoventilating and when controlled delivery of inhaled anaesthetic is required to ensure balanced anaesthesia.

Temperature control

Monitoring and support of normal body temperature is part of good anaesthetic management. Hypothermia is the most common complication associated with anaesthesia, especially in small animals like cats. Hypothermia may be classified as mild (36.7-37.7 °C), moderate (35.5-36.7°C), severe (33-35.5°C) and critical (< 33°C) [67]. The consequences of hypothermia associated with anaesthesia relate primarily to prolonged recovery due to delayed drug metabolism, accidental overdose of anaesthetic drugs (especially inhaled drugs), cardiac dysfunction, impaired tissue perfusion, respiratory compromise, increased risk of post-operative infection and coagulopathy [39, 64]. Body temperature should be monitored during anaesthesia to ensure that neither hypothermia nor hyperthermia (from overzealous active warming) occurs. The most effective methods for active warming are circulating warm-water blankets and warm air circulation systems [39]. Furthermore, heated breathing systems have a significant positive effect on body temperature during anaesthesia by minimising evaporative heat loss and can easily be integrated into an anaesthetic machine [68]. In addition, every effort should be made to minimise the area of skin that is clipped and prepared for surgery and to avoid excessive wetting of the skin and surrounding fur. If a cat is shivering in recovery, continue to deliver oxygen until body temperature and shivering is controlled. With any active warming device, especially with heat pads and circulating warm water blankets, it is vital that measures are taken to avoid burn injuries by ensuring that direct contact of the animal's skin with the device is avoided and that the temperature of the device is appropriate.

A major contributor to the development of hypothermia in cats is the duration of anaesthesia. For all cats, but especially pre-pubertal cats and unsocialised cats with unknown comorbidities, the duration of anaesthesia and surgery should be minimised. Efficiency of surgery site preparation and surgery is paramount. To keep surgery time as short as possible, high quality surgical equipment and experienced nursing and surgical personnel should be involved in these cases.

10. Monitoring

The most important aspect of monitoring during anaesthesia is having **a person dedicated to the role of monitoring** and recording the physiological status of the animal and any events related to the safe conduct of anaesthesia [34, 69]. This person should be appropriately skilled and trained or working under the direct supervision of someone who is appropriately skilled and trained. This person should not be the clinician performing the procedure. Monitoring of the cardiovascular, respiratory and thermoregulatory systems along with subjective assessment of depth of anaesthesia infers central nervous system depression (which cannot itself be accurately and directly measured in animals in a clinical context). Basic monitoring can be performed with a stethoscope, thermometer and clinical observations. More advanced monitoring requires equipment such as a blood pressure measurement device, pulse oximeter, electrocardiograph and capnography (Table 5). Where possible the Australian and New Zealand College of Veterinary Scientists (ANZCVS) Position Statement on "Monitoring of Anaesthetised dogs and cats" should be followed (Figure 5) [34].

An anaesthetic record (Appendix 2) must be used for every case to document the details of the animal, the pre-anaesthetic findings, the dose, route, time and effect of drugs that have been administered and at least the data from basic monitoring (respiratory rate, heart rate, body temperature, depth of anaesthesia subjective assessment).

POSITION STATEMENT:

During anaesthesia of healthy dogs and cats there must be a person dedicated to the role of monitoring and recording the physiological status of the animal and any events related to the safe conduct of anaesthesia. This person must be appropriately trained and experienced or must work under direct supervision of someone who is appropriately trained and experienced.

In addition to clinical observations of the animal (palpation of a peripheral pulse, measurement of pulse rate and respiratory rate, observation of mucous membrane colour/ capillary refill time and subjective assessment of depth of anaesthesia), monitoring of anaesthesia should be complimented by the use of equipment including a pulse oximeter, capnograph, blood pressure monitor, and thermometer. A record of anaesthesia must be created in every case. Animals must always be observed from the time that drugs are first administered to the time that adequate recovery from the procedure has been confirmed.

Figure 5: *Australian and New Zealand College of Veterinary Scientists Position Statement on monitoring of anaesthetised dogs and cats [34].*

Adverse events during anaesthesia

Various changes occur as a direct result of the administration of sedative, anaesthetic and analgesic drugs. In addition, changes may occur because of the procedure being performed e.g., autonomic response to nociceptive stimuli. These changes must be identified, tracked, and potentially treated. Monitoring physiological variables enables assessment of the response to anaesthesia and the procedure. Changes over time, or instability in a certain parameter, reflect suboptimal management of anaesthesia. **Once an abnormality or change is detected it must be determined whether the issue is significant and requires treatment.** The short duration of desexing procedures means there is less time for adverse events to occur, but if there is a complication with the surgery (e.g., haemorrhage), the procedure may take longer.

Some of the common physiological complications, their causes and treatment are summarised in Table 10. For paediatric cats, the maintenance of arterial blood pressure (and cardiac output) is more reliant on heart rate than stroke volume [18]. Remembering that:

arterial blood pressure = cardiac output x total peripheral resistance

hence

arterial blood pressure = heart rate x stroke volume x total peripheral resistance

It follows that maintenance of the heart rate in paediatric cats (<12 weeks of age) is vital. To determine the cause of a change, information from observations made during monitoring and measurements from monitoring equipment are essential e.g., quantitative data on heart rate, blood pressure, oxyhaemoglobin saturation, expired carbon dioxide and body temperature.

Parameter	Change	Potential causes	Treatment
Heart rate	Increase or instability	Inadequate depth of anaesthesia	Assess depth of anaesthesia and increase if required
		Inadequate level of analgesia	Administer more analgesia
		Early hypoxaemia	Increase inspired oxygen concentration and manually or mechanically ventilate
		Hypercapnia	Increase minute volume i.e., increase the respiratory rate and/or tidal volume by commencing manual or mechanical intermittent positive pressure ventilation or altering the existing settings
		Hypotension	Assess depth of anaesthesia, fluid therapy, vasopressors, inotropes
		Hypovolaemia	Fluid therapy
		Drugs e.g., atropine	Administer sympatholytic agent if appropriate e.g., fentanyl
		Disease e.g., cardiac	Manage on case-by-case basis
		Hyperthermia	Active cooling
		Idiopathic	Administer sympatholytic agent if appropriate e.g., intravenous fentanyl
	Decrease	Excessive depth of anaesthesia	Assess depth of anaesthesia & decrease if required.
		Excessive analgesia e.g., opioid	Nil if blood pressure is okay
		Moderate to severe hypoxaemia	Increase inspired oxygen concentration and manually or mechanically ventilate
		Hypertension	Vasodilation, negative chronotrope
		Hypervolaemia	Vasodilation, diuresis
		Drugs e.g., alpha$_2$ adrenoreceptor agonist	Consider reversal
		Diseases e.g., hypothyroidism	Manage on case-by-case basis
		Hypothermia	Active warming
		Idiopathic	Administer positive chronotrope e.g. atropine or glycopyrrolate

Table 10: *Common physiological complications of anaesthesia, their causes and management options.*

Blood pressure	High or unstable	High heart rate	See above: treatment for high heart rate
		High stroke volume: high preload, high contractility, low afterload	Decrease intravenous fluid therapy Increase depth of anaesthesia Increase analgesia
		High afterload: vasoconstriction	Vasodilation e.g., acepromazine or isoflurane
	Low (mean arterial blood pressure < 60 mmHg)	Low heart rate	See above: treatment for low heart rate
		Low stroke volume: low preload, low contractility, high afterload	Increase intravenous fluid therapy Use inotrope e.g., ephedrine or dobutamine
		Low afterload: vasodilation	Use vasopressor, e.g., norepinephrine
Minute ventilation (respiratory rate x tidal volume)	Increase (expired carbon dioxide < 35 mmHg) = hyperventilation	Inadequate depth of anaesthesia	Increase delivery of anaesthetic agent if appropriate
		Inadequate analgesia	Administer more analgesia if necessary
		Hyperthermia	Active cooling
		Hypoxaemia	See below: treatment for hypoxaemia
	Decrease (expired carbon dioxide > 45 mmHg) = hypoventilation	Excessive depth of anaesthesia	Decrease depth of anaesthesia if possible
		Excessive analgesia such as opioids	Manual or mechanical intermittent positive pressure ventilation
		High body condition	Manual or mechanical intermittent positive pressure ventilation
		Dorsal recumbency	Manual or mechanical intermittent positive pressure ventilation
Oxygenation	Hypoxaemia	Low inspired oxygen concentration	Increase inspired oxygen concentration
		Hypoventilation	Manual or mechanical intermittent positive pressure ventilation
		Ventilation and perfusion mismatch	Recruitment of alveoli if possible, i.e., expand collapsed lung

Table 10: *Common physiological complications of anaesthesia, their causes and management options (continued).*

Oxygenation	Hypoxaemia	Diffusion impairment	Increase inspired oxygen concentration and manual or mechanical intermittent positive pressure ventilation
		Right to left shunting	Alveolar recruitment
Body temperature	Hypothermia	Anaesthesia	Avoid excessive depth of anaesthesia
		Cold environment	Maintain warm ambient temperature
		Small body size	Active warming with circulating warm air blanket
		Low body condition	Active warming with circulating warm air blanket
	Hyperthermia	Reaction to drugs	Stop administration of drug, e.g., inhaled agent
		Excessive active warming	Remove active warming device and consider active cooling
Central nervous system	Excessive depth of anaesthesia	Overdose of anaesthetic agent	Decrease delivery of anaesthetic agent
		Synergistic effects of anaesthetic and analgesic agents	Reversal of agent if possible, e.g., naloxone, atipamezole, flumazenil
		Hypothermia	Active warming
	Inadequate depth of anaesthesia	Post induction apnoea delaying uptake of inhaled anaesthetic agent after induction with injectable drug	Manual intermittent positive pressure ventilation every 15 seconds until the return of spontaneous ventilation
		Failure of delivery of anaesthetic	Check vapouriser, breathing system, infusion pump
		Inadequate dose of anaesthetic agent	Check dose and concentration of agents and administer more to effect

Table 10: *Common physiological complications of anaesthesia, their causes and management options (continued).*

The most common complications in healthy cats undergoing desexing in general practice have been documented as hypotension (22.6% of cats – associated with acepromazine, high isoflurane dose, longer duration of anaesthesia and lower body weight), bradycardia (16.7% of cats – associated with medetomidine, longer duration of anaesthesia and higher body weight), and hypothermia (13.8% of cats – associated with high isoflurane dose, longer duration of anaesthesia and lower body weight) [22].

This study from the U.K. documented the incidence of perioperative anaesthetic complications in 1019 cats and concluded that monitoring during anaesthesia should prioritise the measurement of heart rate, blood pressure and body temperature [22]. The study revealed that half of the cats experienced at least one complication during anaesthesia and that minimising the duration of surgery was important to decrease the risk of complications [22].

11. Recovery

Monitoring should continue into the recovery period to ensure that any crises can be managed. For cats, the biggest risk for anaesthetic-related death occurs in the first 6 hours after extubation (Figure 5) [25]. Cats have a high incidence of complications during anaesthesia which are likely to contribute to anaesthetic-related death in this critical period after extubation: hypothermia, hypotension, hypoventilation, hypoxia, and pain [23, 25]. These complications are more likely in young and small cats [23]. Furthermore, airway obstruction after extubation may occur due to laryngospasm, laryngeal oedema, or fluid in the airway.

Extubation should occur when the cat is able to swallow and protect their own airway. This procedure should be performed in the operating area or an area where emergency interventions can be made if required, i.e., re-intubation and/or administration of oxygen and/or other life support measures. Once the trachea is extubated and there is no evidence of post-extubation laryngospasm, laryngeal oedema, or obstruction, the cat can be moved to a quieter area for ongoing observation. Signs of upper respiratory tract complications include dyspnoea or apnoea, increased respiratory effort and noise, and cyanosis.

To mitigate the risks associated with recovery from unconsciousness, various observations should be made continuously and recorded every 15 minutes until the cat is able to promptly and strongly right themself:

- Observe respiratory rate and effort
- Observe mucous membrane colour and capillary refill time
- Palpate arterial pulse
- Monitor and manage body temperature
- Assess pain (see below)

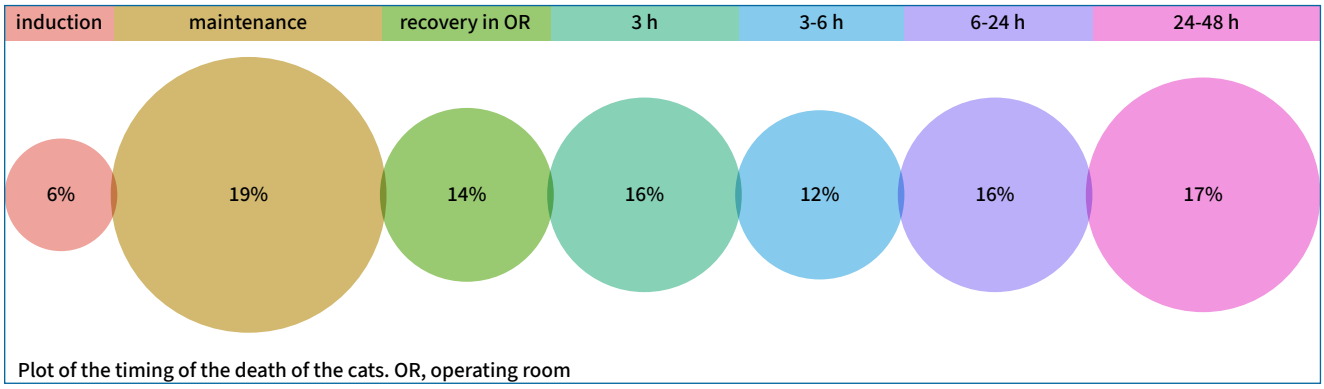


Figure 6: Anaesthesia-related deaths in cats. Post-operative deaths are those after extubation in the operating room (OR), from transfer to hospitalisation within the first 48 hours after extubation. Adapted from Redondo et al 2024 [25].

If medetomidine has been used for induction of anaesthesia, it may be reversed with atipamezole. The decision to allow recovery from medetomidine without reversal may be made if a low dose of medetomidine was used and spontaneous recovery is apparent or if a slower recovery is desirable based on the temperament of the cat. Atipamezole can be administered at any time after the administration of medetomidine but if ketamine is included in the injectable drug combination, atipamezole should not be administered until 20 minutes after the administration of the induction drugs [70, 71]. The dose of atipemazole (5 mg/mL solution for IM injection) is determined by the original dose and route of administration of medetomidine – generally half the volume is given i.e., if medetomidine (1 mg/mL) was administered at 40 µg/kg IM (= 0.04 mL/kg) then atipamezole is administered at 0.02 mL/kg IM (= 100 µg/kg) [71].

The recovery area should be quiet and warm and enable ongoing oversight of the cat. A recovery cage with blankets or towels and a place for cats to hide once mobile is desirable. For unsocialised cats, an approach to management of this critical period of anaesthesia is to return the cat to their carrier after extubation. The cat is positioned in sternal recumbency with their head facing out the open door so visual observation is convenient. Once the cat can hold their head up the door can be closed, and the carrier can then be moved to a recovery ward or area that is quieter. The intravenous catheter should be removed once the cat has convincingly recovered from anaesthesia. For unsocialised cats the intravenous catheter may be removed sooner to avoid further handling and stress associated with its removal.

12. Analgesia

Pain is defined as "An unpleasant sensory and emotional experience associated with or resembling that associated with actual or potential tissue damage" in humans and animals [72]. The definition refers to the sensory – nociceptive – component of pain, and the emotional – how it makes one feel – component. During anaesthesia, the sensory component of pain may occur, but the emotional component can only be experienced when an animal is conscious. If there is a response (autonomic or movement) to a stimulus during anaesthesia, it must be determined whether the cat is inadequately anaesthetised or inadequately analgesed. Assessment of depth of anaesthesia and relating the observed response to a stimulus will help determine whether more anaesthetic or more analgesia is required. Sometimes both will be required. However, simply increasing the depth of anaesthesia may not always be the best approach as nociceptive pathway stimulation because of surgery will translate to pain in the post-operative period. If the cat seems adequately anaesthetised (relaxed muscles, no palpebral reflex, eye position rotated downwards) and there has been a response to a surgical stimulus, then more analgesia is likely required (Table 10).

If surgery is performed by an experienced surgeon there is a lower requirement for post-operative analgesia than there is for cats that have had surgery performed by an inexperienced surgeon [73]. The experience of the surgeon will influence intraoperative parameters such as heart rate, respiratory rate and blood pressure (more stable with experienced surgeons), along with the duration of surgery (shorter for experienced surgeons) and the requirement for intraoperative rescue analgesia such as intravenous fentanyl (lower for experienced surgeons) [73]. Therefore, during surgical training particular attention must be paid to the adequacy of analgesia during and after surgery.

Pain assessment

Pain assessment in cats must be performed to recognise, describe and treat pain. The Glasgow Feline Composite Measure Pain Scale (CMPS-F) has been validated in cats [74] and is considered easy to use and efficacious [75]. The tool includes observation and assessment of facial expression [76] and defines an intervention level for the administration of analgesia [77]. Both spontaneous and evoked behaviours are included in the 7 questions. The scores range from 0 to 20 and analgesic intervention is at a score of ≥ 5 [75] (Appendix 3). The Feline Grimace Scale phone app is also available to assess pain in cats as an easy and practical real-time acute pain assessment tool [78]. This scale has recently been assessed for its utility in kittens (10 weeks to 6 months of age) and is both a valid and responsive acute pain scoring instrument for this cohort of cats [79]. Through observation and scoring of the position of the ears, the degree of eye opening, the shape of the muzzle, the position of the whiskers and the alignment of the head and shoulders, a score of between 0 and 10 can be derived. This score is higher in cats after ovariohysterectomy compared to the pre-operative baseline and is lower after the administration of rescue analgesia [79].

Pain should be assessed soon after recovery from anaesthesia and prior to discharge. Rescue, or additional analgesia, should be administered if necessary. It is most likely that an opioid (Table 9) will be administered in this instance, so it may be necessary to delay discharge of the cat until the effects and side effects of additional analgesia are appreciated.

Pain management

The management of pain is essential from an ethical perspective and contributes significantly to the welfare of cats in the peri-operative period. If a cat experiences pain after desexing, a protective emotional bias may become associated with the clinic, which may cause the cat to respond negatively (protectively) on future visits [43]. Good pain management will ensure that the experience in the both the immediate and delayed post-operative period will enhance a positive emotional bias. For unsocialised cats this approach is particularly relevant as fear and anxiety can alter the perception of pain and make it more significant for the individual, and vice versa [43].

Every effort should be made to ensure that analgesia is multimodal, preventive and administered for an adequate duration [80]. In addition, the clinic environment should be made as comfortable and cat friendly as possible with warm and quiet areas where good nursing can be supported to ensure the cat can be treated with respect and empathy. Many anaesthetic drugs, especially those included in an injectable anaesthesia protocol, have significant analgesic effects, e.g., medetomidine and ketamine. Note that acepromazine, midazolam, isoflurane, propofol and alfaxalone do not have analgesic effects.

Multimodal analgesia refers to the administration of analgesic drugs from different classes, with different mechanisms of action. This approach ensures that both the sensory and emotional components of pain are treated, i.e. the nociceptive pathways (transduction, transmission, modulation) are affected as well as perception of pain. **For cats undergoing desexing, an opioid and a non-steroidal anti-inflammatory drug must be the minimum approach to multimodal analgesia. Whenever possible, a local anaesthetic agent and drugs with analgesic effects such as medetomidine and ketamine should also be considered.**

Preventive analgesia is the administration of analgesic agents pre-emptively (prior to tissue damage), during surgery and for hours to days afterwards [81]. Successful preventive analgesia reduces or ablates pain for hours, days and weeks following surgery.

Adequate duration of treatment with analgesic agents is important to ensure that chronic pain does not develop. Some analgesic agents, such as non-steroidal anti-inflammatory drugs will provide analgesia for 24-48 hours while opioids such as methadone and morphine will provide analgesia for 4-6 hours. Local anaesthetics such as lignocaine have a short duration of effect (1-2 hours).

Analgesic options for cats are provided in Table 11 [80]. Most studies evaluating post-operative pain in cats following desexing are focused on the acute post-operative period and do not extend to the days after surgery. It is generally accepted that pain associated with castration or ovariohysterectomy will last for 1-2 days after surgery. Hence, the use of an opioid in the premedication combination of drugs, local anaesthesia and a non-steroidal anti-inflammatory drug may be sufficient. Additional post-operative doses of opioids and/or non-steroidal anti-inflammatory drugs may be useful for some cats. The timing and dose of non-steroidal anti-inflammatory drugs (NSAIDs) is controversial in cats [82]. There is a strong argument to administer NSAIDs (and other analgesics) preventively but to err on the side of caution and to mitigate the risk of undesirable side effects it is likely to be safer to administer NSAIDs after the procedure when it is clear that blood pressure and perfusion have been maintained. However, NSAIDs may be administered pre-operatively if blood pressure is monitored and cats are normovolaemic prior to anaesthesia. Nevertheless, in an abundance of caution these guidelines refer to the post-operative administration of NSAIDs.

Otherwise, the NSAID can be administered after recovery with the exact dose and timing influenced by the physical status of the cat, the age of the cat, and the physiological responses to anaesthesia and surgery [84]. Meloxicam and robenacoxib are the most used drugs from this analgesic class [80]. However, for pre-pubertal cats the timing and dose of administration of meloxicam or robenacoxib is controversial and more evidence is required to ensure these drugs can be administered safely, while maintaining efficacy (see Table 11 for multimodal analgesia options). For cats who are dehydrated, these drugs should not be administered until after the procedure and after rehydration [32].

Although meloxicam is licensed for use in cats from 6 weeks of age at a dose of 0.3 mg/kg SC, the clinical recommendation, when peri-operative meloxicam is indicated, is to administer a single dose of 0.2 mg/kg SC or 0.1 mg/kg PO [85] after the procedure if blood pressure has been monitored and managed, and hydration is normal. If analgesia is required in the days after surgery veterinarians may choose to administer meloxicam off-label at 0.05 mg/kg PO once daily for up to 4 days, starting 24 hours after the initial injectable dose, in accordance with the 2022 ISFM guidelines for acute pain management in cats [80].

Furthermore, post-operative meloxicam at these doses should be used in cats > 10 weeks of age, when their capacity to metabolise and eliminate drugs is greater [15]. For younger cats (6-10 weeks of age) a lower dose is suggested i.e., 0.1 mg/kg SC or 0.05 mg/kg PO post operatively. These aberrations from the licensed dose are based upon a balance between ensuring safety and efficacy of this class of drugs.

Recent literature describes the use of the anti-inflammatory drug grapiprant in cats undergoing ovariohysterectomy. This study compared robenacoxib (1 mg/kg PO) and grapiprant (2 mg/kg PO) administered 2 hours prior to anaesthesia and surgery and found that grapiprant was non- inferior to robenacoxib for 24 hours [86]. While this study holds promise that alternative anti- inflammatory drugs (i.e., not NSAIDs) may be both safe and efficacious for cats undergoing desexing procedures, further research is required to support the use of unlicensed drugs in cats.

Local anaesthetic drugs are extremely versatile and efficacious. If the doses are calculated carefully, these drugs are also safe. Their use is detailed in Table 11. Furthermore, local anaesthetic drugs can be used at the surgical site (incision site) by infiltration of the subcutaneous tissues as a ‘line block’ either before the first incision or immediately after closure of the site, prior to recovery from anaesthesia.

Drug	Dose and route of administration	Duration of analgesia	Comments
Opioids			
Morphine	0.2-0.4 mg/kg SC or IM **OR** 0.1-0.2 mg/kg IV	4-6 hours	Vomiting may occur when administered SC or IM. Risk of histamine release when administered IV.
Methadone	0.2-0.4 mg/kg SC or IM **OR** 0.1-0.2 mg/kg IV **OR** 0.2-0.6 mg/kg OTM	4-6 hours	Has additional NMDA receptor antagonist effects.
Fentanyl	1-3 µg/kg IV	20 minutes	Will cause a dose dependent decrease in heart rate, respiratory depression and MAC sparing effect.
Buprenorphine	0.01-0.02 mg/kg SC, IM, IV or OTM	Up to 8 hours	
Non-steroidal anti-inflammatory drugs (NSAIDs)*			
In cats who are dehydrated, these drugs should not be administered until after rehydration. **Contraindications to NSAIDs include gastrointestinal irritation or haemorrhage, impaired hepatic, cardiac or renal function and haemorrhagic disorders.** Although meloxicam is licensed for use from 6 weeks of age it is recommended in these guidelines to administer lower doses to cats 6- 10 weeks of age i.e., 0.1 mg/kg SC or 0.05 mg/kg PO post-operatively.			
Meloxicam [80]	0.1 - 0.2 mg/kg SC once	See text on page 35 if pain management is required for more than 24 h	For post-desexing pain 0.1 mg/kg SC is recommended in cats 6 - 10 weeks of age and 0.2 mg/kg SC for cats >10 weeks of age.
	OR 0.1 mg/kg PO day 1 then 0.05 mg/kg PO q 24 h	Oral dosing can be administered indefinitely	Oral dosing is usually utilised for the management of chronic pain associated with painful diseases but can also be used to manage post-operative or acute pain.
	OR 0.3 mg/kg SC once		This dose is the licensed dose, but lower doses are recommended.
Robenacoxib	2 mg/kg SC	Can be given once daily for 3 days	

Table 11: *Analgesic options for cats [80]. SC = subcutaneous, IM = intramuscular, IV = intravenous, PO = per os, OTM = oral transmucosal. If analgesic drugs such as opioids have been incorporated into the premedication combination of drugs additional doses of these drugs may not be required unless post-operative pain is identified.*

Local anaesthetics			
Lignocaine	Up to 5 mg/kg intratesticular and SC	Onset 1-2 minutes Duration 1-2 hours	Can be given intratesticular and SC for castration 2 mg/kg [62, 87]
Bupivacaine	1-2 mg/kg intraperitoneal	4-6 hours	Can be aseptically instilled over the right and left ovarian pedicles and the caudal aspect of the uterine body in three equal parts for ovariohysterectomy [63, 88, 89]
Eutectic mixture of local anaesthetic (EMLA) cream with lignocaine and prilocaine	1 g = 1 mL / 2-5 cm area of shaved skin and covered with occlusive dressing	Peak effect may take 60 minutes	May facilitate intravenous access in premedicated cats [56]

Table 11: *Analgesic options for cats [80]. SC = subcutaneous, IM = intramuscular, IV = intravenous, PO = per os, OTM = oral transmucosal. If analgesic drugs such as opioids have been incorporated into the premedication combination of drugs additional doses of these drugs may not be required unless post-operative pain is identified. (continued)*

13. Conclusion

The provision of appropriate anaesthesia and analgesia for cats undergoing desexing can be a challenge. However, by understanding the particular considerations that prepubertal and unsocialised cats present, an anaesthetic and analgesic plan can be developed that is safe for both the cats and personnel working with them. Careful planning, preparation of equipment, drugs and personnel, and ensuring the cats are handled carefully without undue stress will optimise conditions for success. The benefits of early desexing far outweigh the risks of appropriate anaesthesia and analgesia that is carefully performed by veterinarians and veterinary nurses.

14. Appendices

Appendix 1: Association of Veterinary Anaesthetists Safety Checklist

Appendix 2: Association of Veterinary Anaesthetists Anaesthesia Record

Appendix 3: Glasgow Feline Composite Measure Pain Scale

Anaesthetic Safety Checklist

ASSOCIATION OF VETERINARY ANAESTHETISTS

Pre-Induction

- [ ] Patient NAME, owner CONSENT & PROCEDURE confirmed
- [ ] IV CANNULA placed & patent
- [ ] AIRWAY EQUIPMENT available & functioning
- [ ] Endotracheal tube CUFFS checked
- [ ] ANAESTHETIC MACHINE checked today
- [ ] Adequate OXYGEN for proposed procedure
- [ ] BREATHING SYSTEM connected, leak free & APL VALVE OPEN
- [ ] Person assigned to MONITOR patient
- [ ] RISKS identified & COMMUNICATED
- [ ] EMERGENCY INTERVENTIONS available

Pre-Procedure — Time Out

- [ ] Patient NAME & PROCEDURE confirmed
- [ ] DEPTH of anaesthesia appropriate
- [ ] SAFETY CONCERNS COMMUNICATED

Recovery

- [ ] SAFETY CONCERNS COMMUNICATED
  Airway, Breathing, Circulation (fluid balance), Body Temperature, Pain
- [ ] ASSESSMENT & INTERVENTION PLAN confirmed
- [ ] ANALGESIC PLAN confirmed
- [ ] Person assigned to MONITOR patient

This checklist was written by the AVA with design and distribution support from Jurox

Recommended Procedures

ASSOCIATION OF VETERINARY ANAESTHETISTS

Pre-Anaesthesia

★ Has anything significant been identified in the history and/or clinical examination?

★ Do any abnormalities warrant further investigation?

★ Can any abnormalities be stabilised prior to anaesthesia?

★ What complications are anticipated during anaesthesia?

★ How can these complications be managed?

★ Would the patient benefit from premedication?

★ How will any pain associated with the procedure be managed?

★ How will anaesthesia be induced & maintained?

★ How will the patient be monitored?

★ How will the patient's body temperature be maintained?

★ How will the patient be managed in the post-anaesthetic period?

★ Are the required facilities, personnel & drugs available?

Anaesthetic Machine

- ☐ PRIMARY OXYGEN source checked
- ☐ BACK-UP OXYGEN available
- ☐ OXYGEN ALARM working (if present)
- ☐ FLOWMETERS working
- ☐ VAPORISER attached and full
- ☐ Anaesthetic machine passes LEAK TEST
- ☐ SCAVENGING checked
- ☐ Available MONITORING equipment functioning
- ☐ EMERGENCY equipment and drugs checked

Drugs / Equipment

- Endotracheal tubes (cuffs checked)
- Airway aids (e.g. laryngoscope, urinary catheter, lidocaine spray, suction, guide-wire/stylet)
- Self-inflating bag (or demand valve for equine anaesthetics)
- Epinephrine/adrenaline
- Atropine
- Antagonists (e.g. atipamezole, naloxone/butorphanol)
- Intravenous cannulae
- Isotonic crystalloid solution
- Fluid administration set

Drug charts & CPR algorithm (http://www.acvecc-recover.org/)

This checklist was written by the AVA with design and distribution support from Jurox

Appendix 2

Click here to add logo

Anaesthesia record

Date:

ASSOCIATION OF VETERINARY ANAESTHETISTS

Name:	History:	Temperament:	ASA classification
Owner:		HR: RR:	I No organic disease
Breed:		Pulse quality:	II Mild systemic disease
Age: Sex:	Clinical findings/results/medications:	MM: CRT:	III Severe systemic disease (not incapacitating)
Weight:		Thoracic auscultation:	IV Severe disease (constant threat to life)
Anaesthetist:			V Moribund (life expectancy < 24 h)
Clinician:		Temperature: °C	Add 'E' for emergencies
			ASA Grade:

Procedure(s):

Anticipated problems:

Pre-GA medication	Dose	Route	Time
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....

Anaesthetic Safety Checklist completed ☐ (see overleaf)

Induction agent(s)	Dose	Route	Time
.....	.....	.....	.....
.....	.....	.....	.....

☐ IV catheter Position: Size:

ET tube / LMA / Mask	Cuffed / Uncuffed	Size:

Breathing system: ☐ Eye(s) lubricated

Fluids/Drugs/Monitoring Time

Patient position	
Patient warming	
Throat pack	Placed ☐ Removed ☐
Swabs	In: Out:
Sharps	In: Out:

Notes

220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

Iso / Sevo	%
O_2 / N_2O / Air	L/min
SpO_2	%
Jaw tone	-/+/++
Palpebral	-/+
Eye position	↓ / →

Symbols

- ● HR
- o RR ø IPPV
- ᵛ SAP – MAP ^ DAP
- Ⓥ Doppler

RECOVERY instructions:

	T+0	T+15	T+30	T+45
Time				
Heart rate				
Resp. rate				
MM & CRT				
Temp.				
Pain score				

IV catheter care: ☐ Remove once recovered ☐ Maintain & flush

Glasgow Composite Measure Pain Scale: CMPS - Feline

Guidance for use

The Glasgow Feline Composite Measure Pain Scale (CMPS-Feline), which can be applied quickly and reliably in a clinical setting, has been designed as a clinical decision making tool for use in cats in acute pain. It includes 28 descriptor options within 7 behavioral categories. Within each category, the descriptors are ranked numerically according to their associated pain severity and the person carrying out the assessment chooses the descriptor within each category which best fits the cat's behavior/condition. It is important to carry out the assessment procedure as described on the questionnaire, following the protocol closely. The pain score is the sum of the rank scores. The maximum score for the 7 categories is 20. The total CMPS-Feline score has been shown to be a useful indicator of analgesic requirement and the recommended analgesic intervention level is 5/20.

Glasgow Feline Composite Measure Pain Scale: CMPS - Feline

Choose the most appropriate expression from each section and total the scores to calculate the pain score for the cat. If more than one expression applies choose the higher score

LOOK AT THE CAT IN ITS CAGE:

Is it?

Question 1

Silent / purring / meowing	0
Crying/growling / groaning	1

Question 2

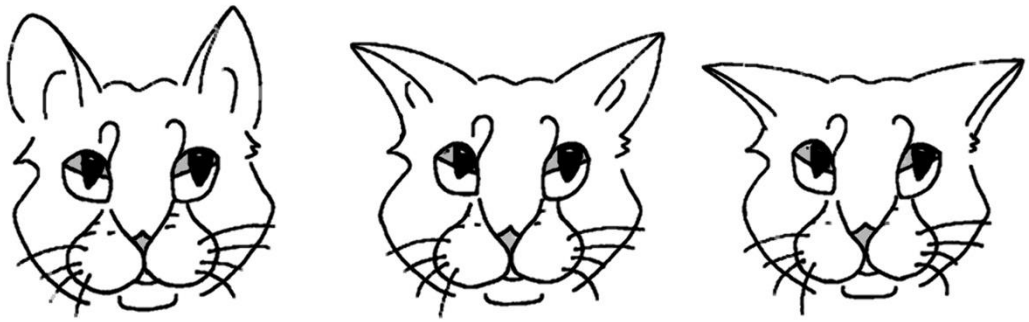
Relaxed	0
Licking lips	1
Restless/cowering at back of cage	2
Tense/crouched	3
Rigid/hunched	4

Question 3

Ignoring any wound or painful area	0
Attention to wound	1

Question 4

a) Look at the following caricatures. Circle the drawing which best depicts the cat's ear position?



0 1 2

b) Look at the shape of the muzzle in the following caricatures. Circle the drawing which appears most like that of the cat?

0 1 2

APPROACH THE CAGE, CALL THE CAT BY NAME & STROKE ALONG ITS BACK FROM HEAD TO TAIL

Question 5

Does it?

Respond to stroking	0

Is it?

Unresponsive	1
Aggressive	2

IF IT HAS A WOUND OR PAINFUL AREA, APPLY GENTLE PRESSURE 5 CM AROUND THE SITE. IN THE ABSENCE OF ANY PAINFUL AREA APPLY SIMILAR PRESSURE AROUND THE HIND LEG ABOVE THE KNEE

Question 6

Does it?

Do nothing	0
Swish tail/flatten ears	1
Cry/hiss	2
Growl	3
Bite/lash out	4

Question 7

General impression

Is the cat?

Happy and content	0
Disinterested/quiet	1
Anxious/fearful	2
Dull	3
Depressed/grumpy	4

Pain Score … / **20**

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