

STANDARDS OF CARE

Anaesthesia guidelines for dogs and cats

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The ASAV has prepared these standards to support veterinarians in offering the highest standards of care to their patients. The standards set out in this document detail the ideal standards of anaesthetic care for dogs and cats within a general practice setting. The ASAV believes that owners should be advised of the best available care as set out in these standards. These standards are based on the latest peer-reviewed scientific research, surveys of Australian veterinarians and broad consultation within the veterinary profession. Anaesthesia is a continually evolving discipline, with frequent advances in pharmacology and technology. It is mandatory for all members of the anaesthesia provision team to periodically undergo training to refresh their knowledge. Referral to a board-certified veterinary anaesthesiologist should be considered for cases that are beyond the practitioner's level of expertise or comfort.

These standards will be reviewed and updated based on feedback from veterinarians and the publication of relevant new research.

Pre-anaesthetic clinical evaluation

Signalment

Information pertaining to species, age, breed, neutering status and demeanour should be noted for each patient. An understanding of age and breed characteristics may provide information about additional anaesthetic concerns and prompt further diagnostic tests. Geriatric animals may pose higher anaesthetic risk because of their reduced cardiac, hepatic and renal function, which may not be apparent on routine physical examination. Similarly, certain breed characteristics can lead to greater risks for airway obstruction, increased responsiveness to anaesthetic drugs and delayed recovery, all of which can result in increased anaesthesia-related morbidity and mortality. Individual genetic variability can trigger unexpected and adverse

responses to anaesthetic drugs, which need to be identified by good recordkeeping and consistent patient monitoring. Although genetic differences are typically held responsible for prolonged recoveries and increased drug responsiveness, true genetic sensitivity has been demonstrated in only a handful of breeds, including the Greyhound and the Collie (Table 1). Demeanour should be taken into consideration when planning individual anaesthetic drug protocols, reducing patient perioperative stress and ensuring safety for veterinary personnel.

History and reason for anaesthesia

A detailed, accurate history should be considered an essential part of a pre-anaesthetic evaluation. Previous conditions take on significance when their residual effects compromise the patient while under anaesthesia or become exacerbated as a result of the stress of anaesthesia and recovery. For example, a patient with cardiac disease may be more intolerant of fluid therapy or a brachycephalic breed may have a higher risk of recovery complications because of brachycephalic airway syndrome. The history should include pertinent information regarding prior and concurrent drug therapy and whether the patient has had any adverse reactions or sensitivities to medications or anaesthetic agents. When possible, the anaesthetic record of a patient that has been anaesthetised previously should be retrieved and reviewed thoroughly for any adverse responses during induction, maintenance or recovery from anaesthesia.

Physical examination

A thorough physical examination of all body systems should be performed prior to general anaesthesia and sedation. For further information please refer to 'Standards of Care: Regular Health Check Standards for Dogs and Cats' (www.ava.com.au/sites/default/.../ASAVA_StandardsOfCare_Web.pdf).

Clinical diagnostics

Pre-anaesthetic diagnostics are a consideration to allow detection of underlying disorders that may influence the management of the patient or influence the prognosis associated with any given disorder. The decision on when to perform pre-anaesthetic diagnostics and which tests to include is a decision that needs to be based on the patient's history, as well as physical examination, and addressed individually by each practice on a case-by-case basis. Evaluation of patients at least 1 day prior to an elective procedure can help avoid time conflict between the surgery schedule and the benefit of additional clinical diagnostics. Recommended diagnostic testing for specific conditions is discussed later.

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Table 1. Selected breed-related anaesthesia concerns

Category	Concerns	Precautions
BRACHYCEPHALIC BREEDS (e.g. Pug, Bulldog, Boxer, Pekingese, Persian cats etc.)	Brachycephalic airway syndrome; increased risk of upper airway obstruction Consideration should be given to delaying the elective procedure until corrective airway surgery has been performed	<ul style="list-style-type: none"> • Preoxygenate • Caution with excessive sedation • Diligent monitoring from admission to discharge • Prepare for difficult intubation • Provide supplemental oxygen until extubation • Extubate ONLY after patient is bright and alert with a gag-reflex present • Monitor breathing pattern and oxygenation status post-extubation • Be prepared to re-anaesthetise and re-intubate the patient in recovery if required
SIGHTHOUNDS (e.g. Greyhound, Whippet, Borzoi, Saluki, Afghan Hound, Irish Wolfhound)	Delayed drug metabolism, possible delayed recovery from drugs such as barbiturates, propofol and acepromazine; lower body fat percentage; hypothermia; stress-induced hyperthermia; myopathy	<ul style="list-style-type: none"> • Use low-dose acepromazine (0.005–0.02 mg/kg IM) • Avoid barbiturates • Administer propofol or alfaxalone SLOWLY to effect • Monitor patient temperature and actively warm as required • Treat stress-/pain-induced hyperthermia with prompt anxiolytics, analgesics, cooling • Provide adequate padding during long procedures
HERDING BREEDS (e.g. Collie, Border Collie, Australian Shepherd, Shetland Sheepdog)	<i>ABCB1</i> (MDR1) mutation causes defect in P-glycoprotein pump, resulting in accumulation of certain drugs in the central nervous system, causing excessively prolonged sedation	<ul style="list-style-type: none"> • Diligent monitoring following sedation • Reduce premedication/sedation dose by at least 25% • Consider using drug that can be reversed/antagonised • Consider genetic screening prior to anaesthesia for elective procedures
TOY BREEDS (e.g. Chihuahua, Pomeranian, Shih Tzu, Brussels Griffon)	Hypothermia because of large body surface area to volume ratio; difficulty monitoring; hypoglycaemia	<ul style="list-style-type: none"> • Active patient warming and diligent monitoring of body temperature • Utilise Doppler blood pressure monitoring device, as well as ECG, pulse oximetry, temperature • Monitor blood glucose concentrations prior to and during anaesthesia as well as recovery; supplement as required
GIANT BREEDS (e.g. Saint Bernard, Newfoundland)	Increased response to sedatives	<ul style="list-style-type: none"> • Dose drugs based on lean body mass or allometric scaling (e.g. α_2-adrenergic agonists)
DOBERMAN PINSCHER	Predilection for dilated cardiomyopathy, von Willebrand disease	<ul style="list-style-type: none"> • Evaluate coagulation status • If von Willebrand disease suspected, administer desmopressin prior to surgery • If NSAIDs are required, administer COX-2-selective drug
BOXER	Acepromazine-induced vagal response, marked hypotension and bradycardia have been reported in Boxer dogs of UK lineage; Boxer cardiomyopathy	<ul style="list-style-type: none"> • Avoid acepromazine in Boxer dogs if possible and reduce acepromazine dose (0.005–0.01 mg/kg IM) if alternative sedation agents are not available • Thorough patient history and physical examination, including ECG analysis prior to anaesthesia

Pre-anaesthetic laboratory evaluation

Pre-anaesthetic diagnostic testing is an adjunct to a detailed patient history and thorough physical examination to aid in the detection of disease. Although there can be no doubt that pre-anaesthetic

biochemical and haematological analyses are valuable for certain patient groups (e.g. geriatrics) and any patient that is clinically unwell, questions have been raised as to whether they are justified for every patient.¹ The use of extensive laboratory screening of patients has not been shown to significantly improve patient

outcomes or prompt changes in anaesthetic technique.² Despite this conclusion, pre-anaesthetic blood analysis was found to have resulted in a reclassification to a higher ASA status (defined in Table 2) in 8% of dogs and additional preoperative treatments in 1.5% of dogs, which would have otherwise not been evident from the patient history or physical examination and should therefore be considered for all patients undergoing anaesthesia.² Given increased understanding of the limitations of population-based reference ranges, there is value in comparing results of pre-anaesthetic biochemical parameters to previous results for that individual to see if there have been significant changes, even if the values remain within the population-based reference ranges.³ Recent publications have shown that significant changes can be detected by diagnostic tests in patients that would have otherwise been considered to be in good health based on history and physical examination alone (6.2% of dogs and 19.2% of cats).⁴ The type and timing of diagnostics should be determined by the veterinarian based on these previously mentioned factors, as well as any changes in patient status or the presence of concurrent disease. There is no evidence to indicate the minimum timeframe prior to anaesthesia within which laboratory analysis should be performed. However, the timing should be such as to best reflect current changes that may affect anaesthetic risk.

When faced with financial or technical limitations that prevent extensive pre-anaesthetic biochemical and haematological analyses we recommend the following minimal pre-anaesthetic screening be mandatory: packed cell volume (PCV), total solids (TS), blood glucose, blood urea nitrogen (BUN) and urine specific gravity (USG). Prior to major surgical procedures we also recommend performing a peripheral blood film evaluation to enable prompt identification and characterisation of conditions such as anaemia and thrombocytopenia.

Advanced laboratory evaluation

Von Willebrand disease (vWF). Breeds that have a high incidence, such as Doberman Pinschers, should have a buccal mucosal bleeding time (BMBT) performed prior to anaesthesia for any surgical procedure. A finding of prolonged BMBT indicates further testing for vWF is required.

Platelet counts and coagulation panels. Indicated for patients exhibiting signs of unexplained/easy bruising, petechiae or ecchymosis and for procedures where significant haemorrhage is possible.

Arterial blood gas, acid–base and electrolyte analysis. Indicated for patients with suspected pathophysiological abnormalities that can alter gas exchange or acid–base disturbances. Interpretation of a

Table 2. ASA physical status classification system

1. Normal healthy patient
 2. Patient with mild systemic disease
 3. Patient with severe systemic disease
 4. Patient with severe systemic disease that is a constant threat to life
 5. Moribund patient not expected to survive without the operation
- If the procedure is an emergency, the physical status classification is followed by 'E' (for emergency) e.g. '3E' would be for a patient with severe systemic disease undergoing emergency anaesthesia

blood gas profile should be accompanied by consideration of electrolyte concentrations. This should focus on recognition of acid–base and electrolyte patterns and while this rarely leads to a specific diagnosis, it allows for tailoring of fluid therapy and specific interventions that can be lifesaving (e.g. addition of potassium in hypokalaemic patients).

Diagnostic imaging

Suspected or known conditions requiring diagnostic imaging for the purpose of evaluating anaesthetic risk include:

Cardiac or respiratory disease. Known or clinical suspicion of cardiac or respiratory disease should be investigated by means of thoracic radiography and if indicated echocardiography or electrocardiography prior to anaesthesia.

Anaesthetic risk and physical status

Following completion of a thorough patient history, clinical examination and interpretation of findings from ancillary diagnostics, the American Society of Anesthesiologists (ASA) Physical Status Classification System can be assigned (Table 2). The practice of assigning an ASA Status to a patient provides a framework for clinicians to summarise their pre-anaesthetic evaluation and encourages consideration of the physical status of the patient rather than solely focussing on the procedure itself. It is also a useful standardised method of documenting patient risk from a medicolegal standpoint, as high ASA scores have been shown to be predictive of anaesthetic morbidity and mortality in veterinary patients.⁵

Owner comprehension and informed consent

Prior to anaesthesia, clients should be fully informed of all relevant known risks associated with the planned procedure, including the anaesthesia and associated loco-regional anaesthesia techniques, and signed consent should be obtained. In addition, this discussion should include consented instruction as to what degree of intervention should be performed in the event of a life-threatening emergency such as a cardiac arrest. Use of a colour-coded system has been recommended for clarity within the practice setting (e.g. CODE Red: no resuscitation should be attempted; CODE Amber: resuscitation should be attempted but should be limited to basic life support techniques such as closed chest cardiac compressions – unless the abdomen is open and transdiaphragmatic direct cardiac massage is feasible; CODE Green: all available means of resuscitation should be employed including open-chest direct cardiac massage, when trained personnel capable of performing such techniques are present). Should more patient information be obtained (e.g. from additional diagnostic tests), the risk assessment associated with anaesthesia may change. The owners should be made fully aware of such changes.

Preparation for anaesthesia

Individual patient plan

An individualised anaesthetic and analgesic plan should be constructed for the management of each patient based on risks identified in the pre-anaesthetic evaluation and incorporating the staffing, equipment and drug resources available. Contingencies should be

made for potential adverse events and emergency drugs should be available and doses calculated.

Stabilisation

Where possible, concurrent disease or conditions that may contribute to an elevated anaesthetic risk should be addressed prior to anaesthesia. Elective procedures should not proceed while concomitant and untreated risk factors exist. Patients requiring emergency procedures should receive optimal stabilisation prior to anaesthesia.

Fasting

It is recommended that healthy dogs and cats are fasted for at least 6 h prior to being anaesthetised, whenever possible, to reduce the risk of regurgitation and aspiration pneumonia.⁶ Water should not be restricted until just prior to anaesthesia at the time of premedication.⁶ Exceptions to this would include patients undergoing gastric surgery and those with megaesophagus. Dogs and cats aged less than 8 weeks or weighing < 2 kg are at greater risk of hypoglycaemia and should not be fasted for > 1–2 h.⁶

Premedication and analgesia plan

The importance of a well-planned premedication and analgesic plan cannot be understated. The choice of premedication will be influenced by signalment, temperament, concurrent disease, the procedure to be performed, drug availability, personal familiarity and preference. The appropriate choice of premedication drugs should aim to achieve the characteristics outlined below. No individual drug possesses all of the following properties and as such, various combinations of agents are used to best achieve these characteristics:

Sedation and stress reduction. Calm or immobilise a patient to enable minor procedures (e.g. catheterisation, clipping etc.), reduce stress and decrease anaesthetic drug requirement during induction of anaesthesia and reduce adverse arrhythmogenic autonomic activity.⁶

Safe handling. Facilitate safe patient handling and pre-anaesthetic preparation (e.g. catheterisation, clipping etc.) for both the animal and personnel.

Analgesia. Analgesia is a key component of well-balanced anaesthesia for all surgical and potentially painful procedures. It is also important to note that appropriate pre-anaesthetic stabilisation of a patient should involve the treatment of any pre-existing pain. Experimental studies have shown a reduced requirement for postoperative analgesia when analgesics are administered 'pre-emptively'.⁷ Typically, an opioid forms the analgesic component of the premedication for surgical procedures. The selection of the particular opioid and initial dose rate should be made on the basis of:

- expected intensity of the pain
- duration of action required
- desired speed of onset
- relevant side effects of the particular drug.

For a detailed and practical resource designed to assist practitioners in recognising, assessing, and treating pain please refer to the 'WSAVA Global Pain Council Guidelines' (<http://www.wsava.org/guidelines/global-pain-council-guidelines>).

Balanced anaesthesia. By providing analgesia and sedation the premedication should also facilitate a dose reduction of other potentially more physiologically compromising drugs (e.g. inhalational agents) used to induce anaesthesia.

Calm recovery. Both the analgesic and sedative components of the premedication drug combination should be present at the time of emergence from anaesthesia to promote a calm recovery. If the duration of therapeutic effect of the individual agents is not sufficient to achieve this, redosing of one or both components may be required prior to the conclusion of the anaesthetic procedure.

Premedications are typically administered intramuscularly (IM) or subcutaneously (SC) 15–45 min prior to induction of anaesthesia. Whenever permissible by drug labelling guidelines, premedicants should be administered IM, as this route affords more reliable drug absorption, compared with SC administration.⁸

Venous catheterisation

An intravenous (IV) catheter is the patient's lifeline while under the effects of general anaesthesia and sedation. IV access allows for direct administration and rapid uptake of anaesthetic, analgesic and emergency drugs as required perioperatively. Various indwelling catheters placed using an 'over-the-needle' technique are appropriate for peripheral veins and the catheter choice depends on animal's size and personal preference. To reduce resistance-to-flow and clot formation, the largest possible gauge catheter appropriate for the vessel to be catheterised should be selected. The catheter type and size, along with the time, date and site of insertion, should be noted in the anaesthetic/medical record.

The cephalic vein of the thoracic limbs or the lateral and medial saphenous veins of the pelvic limbs are the most common peripheral veins catheterised. With placement of catheters, strict asepsis is important. Appropriate clipping of the area and aseptic preparation of the skin (with a 1–2% iodine tincture, iodophors, chlorhexidine or 70% alcohol solution) are necessary. Appropriate hand hygiene must be applied and, ideally, sterile gloves worn, particularly for long-stay catheters.

Topical anaesthetic agents (e.g. Emla® cream) may be applied 45–60 min prior to cannulation to reduce stress and facilitate catheter placement in anxious or hyperaesthetic patients. Cover the topical anaesthetic with an occlusive dressing after application to ensure it is not ingested. Constant supervision is advised.

To decrease the risk of catheter-related complications, sterile placement, daily inspection and rewrapping of the catheter site is advised. Whenever possible, administration of irritating or hypertonic solutions into a peripheral vein should be avoided. Regular inspection enables early identification of complications including, but not limited to:

- phlebitis or inflammation of the vessel
- thrombosis or formation of a thrombus on the catheter or vessel wall
- embolism
- catheter breakage
- subcutaneous fluid infiltration.

Tight taping or bandaging, leading to swelling distal to the catheter, may contribute to resistance to the flow of fluids and/or drugs being given via the IV catheter. There is little evidence from human patients that the type of dressing significantly reduces the incidence of catheter infection compared with catheters left exposed and kept clean and dry.⁹ Furthermore, transparent 'breathable' dressings have not been shown to offer significant advantage for human patients over gauze dressings, unless impregnated with chlorhexidine (e.g. 3M™ Tegaderm™ CHG Chlorhexidine Gluconate I.V. Securement Dressing), and do not adhere effectively to animal skin.^{10,11}

Although peripheral IV catheters are typically removed after 72 h in human patients, there is no evidence in veterinary medicine that this is necessary if there are no identified complications.¹² Venous catheters should be flushed and inspected every 6 h and rewrapped every 12 h. If the catheter site becomes wet or soiled, the catheter should be removed and another placed aseptically. While monitoring an indwelling catheter, record the date, catheter site and type, and comments daily. Catheters used for continuous fluid therapy do not need to be flushed routinely. Unused IV catheters should either be removed or flushed every 6 h to maintain patency. This should be done using 0.9% sodium chloride with or without heparin. There is little evidence to support the use of heparinised saline over normal saline to maintain patency of intravenous or arterial catheters.^{13,14}

Equipment preparation

In order to reduce the risks of anaesthesia, foreseeable problems must be prevented. Patient-related problems will be identified by the pre-anaesthetic evaluation. Checking equipment will help to identify and prevent problems caused by technical faults or errors (Table 3). It is critical that all members of the anaesthetic team (both veterinarians and nursing personnel) are familiar with the anaesthetic machine, monitoring systems and related equipment. All members of the team should be able to troubleshoot common equipment dysfunctions.

Selecting breathing systems and fresh gas flow rates

Anaesthetic gas exits the anaesthesia machine (via the common gas outlet) and then enters a breathing circuit. The function of the circuit is to deliver oxygen and anaesthetic gases to the patient and to eliminate carbon dioxide. The carbon dioxide may be eliminated by gas inflow (non-rebreathing systems) or by soda lime absorption (rebreathing systems).

Breathing systems have been classified using various schemes without consensus and uniformity (i.e. open, semi-open and semi-closed). This inconsistency in nomenclature found within the literature and teaching institutions is a source of confusion and inconsistency. For this reason, it has been suggested that these terms be abandoned. For clarity it is easiest to classify the breathing system into one of two groups: those designed for rebreathing of exhaled gases (rebreathing systems) and those designed to be used under circumstances of minimal to no rebreathing (non-rebreathing systems).¹⁶ It has also been suggested that in addition to describing the design of the breathing system, the fresh gas flow (in mL/kg/min) needed to prevent or enable rebreathing to occur should be stated to fully describe how the system is being used.¹⁷

The amount of rebreathing that occurs with any particular anaesthetic breathing system depends on four factors: the design of the individual breathing circuit, the mode of ventilation (spontaneous or controlled), the fresh gas flow rate and the patient's respiratory pattern. Circuits may eliminate rebreathing either by ensuring an adequate flow of fresh gas, which flushes the circuit clear of expired alveolar gas, or additionally, in the case of a circle system, by the use of soda lime, which absorbs the carbon dioxide so that lower fresh gas flows may be used.

Rebreathing systems. A rebreathing system allows for the rebreathing of the exhaled gases. The expired carbon dioxide is removed and the fresh gas mixture, together with inhalant anaesthetic vapour, is continually added. The components of a rebreathing system include: the fresh gas inlet; absorber circuit; manometer; rebreathing bag; hoses; Y-piece; unidirectional valves (inspiration and expiration); adjustable pressure limiting (APL) valve; and a scavenger system. These components increase the resistance to the movement of the gas mixture in the system, as well as the total volume of the system comparative to a non-rebreathing system. Human adult size rebreathing circuits are typically used for patients weighing > 10 kg. It is advisable that patients in the weight range of 2.5–10 kg be placed on paediatric rebreathing systems with a reduced circuit diameter. There is no minimum patient size for using a rebreathing system accepted among anaesthesiologists; however, the minimum patient size is generally suggested as not ≥ 2.5 kg when using a modern anaesthesia machine with lightweight unidirectional valves. Recommendations for selecting fresh gas flow rates in rebreathing systems are outlined as follows.

Following induction (with an injectable agent)

For patients induced with an injectable anaesthetic agent and subsequently intubated and connected to an anaesthetic machine with a rebreathing system, the initial flow rates should be relatively high (**50–100 mL/kg/min**) to facilitate rapid inspired concentration increases in anaesthetic agent within the system and to replace the anaesthetic vapour that is dissolving into patient tissues during the initial uptake period of anaesthetic delivery (e.g. the first 10–20 min following induction).¹⁵

During maintenance

Once the patient has reached a satisfactory depth of anaesthesia, the flow rate may be reduced to a maintenance level. Rebreathing systems require relatively lower flow rates compared with non-rebreathing systems during the anaesthetic maintenance period because carbon dioxide is removed from the expired gases, which are then returned to the patient. Provided there are no leaks in the system and the carbon dioxide absorber is functional, the carrier gas and anaesthetic can be recycled continuously, with only a small amount of additional fresh gas requirement. Following the initial uptake period of anaesthetic delivery (e.g. the first 10–20 min following induction) flow rates are reduced.

Lower flow rates are beneficial in conserving moisture and heat. During this period, flow rates of **20–50 mL/kg/min** are recommended for small animal patients.¹⁵

Flow rates when making changes in anaesthetic depth – higher fresh gas flow rates (**50–100 mL/kg/min**) are also recommended to

Table 3. Anaesthetic equipment checklist

Equipment	Checklist
Anaesthetic machine	<ul style="list-style-type: none"> For piped gases – connect the oxygen, nitrous oxide or medical air to the correct gas pipelines and perform a ‘tug test’ (pull to check the integrity of the connection to the anaesthetic machine). Check and ensure that there is a second supply of oxygen for emergencies (a full oxygen cylinder safely secured near the anaesthetic machine). For oxygen cylinders – check there are two oxygen cylinders accessible, one ‘in use’ cylinder and one ‘full’ reserve cylinder. Turn the oxygen flowmeter on to maximum and off again, check the ball/bobbin is, respectively, rising/rotating freely. Repeat this step for nitrous oxide and medical air if required. Check the machine for leaks – turn on the oxygen to 4 L/min. Occlude the fresh gas outlet and check that the oxygen flowmeter bobbin/ball drops. This should be performed with the vaporiser you wish to use in place on the back bar and repeated if a different vaporiser is placed on the anaesthetic machine. Note: Please refer to anaesthesia machine’s documentation for specific leak-checking procedures applicable to each machine. Operate the emergency oxygen bypass control (flush). Ensure flow occurs and ceases when control is released. Switch the oxygen off.
Vaporiser^a	<ul style="list-style-type: none"> Check that the vaporiser(s) for the required volatile agent(s) is sitting correctly on the back bar of the anaesthetic machine and locked in place. Check that the dial turns fully through the full range. Turn dial off. Check that the vaporiser(s) is adequately, but not over, filled and that the filling port is tightly closed.
Scavenging	<ul style="list-style-type: none"> For active scavenging systems – check that the scavenging pipe is connected to the scavenging system outlet. Ensure that the active scavenging system is turned on. Ensure that the end of the scavenging system is correctly attached to the breathing system. For passive scavenging systems – ensure that the scavenging hose is connected to a charcoal absorber. The charcoal absorber should be weighed weekly to assess the degree of absorption and replaced when the maximum weight is reached (as recommended by the manufacturer).
Breathing system	<ul style="list-style-type: none"> Select the appropriate breathing system (see ‘Selecting Breathing Systems and Fresh Gas Flow Rates’) and check that the reservoir bag is an appropriate volume for the patient (tidal volume [10–20 mL/kg] × 5). Connect the breathing circuit to the fresh gas outlet, ensuring all connections are secured tightly. Connect the scavenging tube to the circuit. Perform a leak test by closing the APL (adjustable pressure limiting/‘pop-off’) scavenging valve and turning on the oxygen flowmeter. Occlude the ‘to the patient’ end of the circuit with your hand. Let the reservoir bag fill completely with oxygen. Turn off the flowmeter when the pressure gauge registers 30 cmH₂O or when the reservoir bag is fully inflated and slightly distended if the anaesthetic machine does not have a pressure gauge. If the pressure holds steady the system is leak-free, but if the pressure drops (or the bag deflates when squeezed) the system will need to be checked for leaks. Open the APL valve to depressurise the system prior to removing your hand from the patient-end of the breathing system. When using a rebreathing circuit, the soda lime should be checked for signs of exhaustion (according to manufacturer’s recommendations) and the unidirectional valves checked to ensure they are moving freely. When using a non-rebreathing circuit (e.g. Bain), check the integrity of the inner tube by performing an occlusion test of the inner tube. Occlusion of the inner tube while oxygen is flowing should cause the flowmeter bobbin/ball to drop temporarily. <p>All circuits with adjustable scavenging valves should be checked to ensure the valves open and close; then leave the valve open prior to use.</p>
Ventilator	<ul style="list-style-type: none"> Check that the ventilator is configured correctly for its intended use. Ensure that the ventilator tubing is securely attached. Set the controls for use and ensure that adequate pressure is generated during the inspiratory phase. Check that alarms are working and correctly configured. Check that the pressure relief valve functions correctly at the set pressure. Two-bag test – a two-bag test should be performed after the breathing system, vaporisers and ventilator have been checked individually. <ol style="list-style-type: none"> Attach the patient-end of the breathing system (including angle piece and filter) to a test lung or rebreathing bag. Set the fresh gas flow to 5 L/min and ventilate manually. Check the whole breathing system is patent and the unidirectional valves are moving (if present). Check the function of the APL valve by squeezing both bags. Turn on the ventilator to ventilate the test lung. Turn off the fresh gas flow or reduce to a minimum. Open and close each vaporizer in turn. There should be no loss of volume in the system

Table 3. Continued

Equipment	Checklist
What if a leak occurs?	<p>Breathing systems should be protected with a test lung or rebreathing bag when not in use to prevent intrusion of foreign bodies. Conduct a check before every procedure.</p> <ul style="list-style-type: none"> • Reservoir bag – replace reservoir bag • Breathing circuit – install new breathing circuit or obstruct inhalation/exhalation openings to determine if leak originates from the breathing circuit • Vaporiser fittings – verify fittings and tubing are securely attached • Absorber canister gaskets – check for loose absorbent grains between canister housing gaskets and verify that the canister is seated properly • APL valve – remove valve and obstruct opening to determine if leak originates from the APL valve.
Ancillary equipment	<p><i>Endotracheal tubes</i></p> <ul style="list-style-type: none"> • Select the appropriate size (diameter and length) and type of tube. Prepare three tubes of different sizes for each patient. • Check the cuffs for leaks. Inflate the cuff and leave it inflated for a few minutes to detect leaks. Deflate cuffs. • Ensure that the lumen of the tube is clean and free of debris. <p><i>Laryngoscope</i></p> <ul style="list-style-type: none"> • Attach the appropriate length and type of blade to the handle. Typically, a Miller-style straight blade is most appropriate for small animal patients. • Open/engage the blade to ensure that the light source is working properly. • Laryngoscope blades should be washed between patients. <p><i>Monitoring equipment</i></p> <ul style="list-style-type: none"> • Check that the monitor is switched on and in the correct 'work' mode, rather than in standby. • Check the required monitoring cables are correctly connected. • Check that the available monitoring probe types and sizes are suitable for your patient.
Cleaning and reuse of anaesthetic equipment	<p>Currently, there are no official guidelines for veterinary anaesthesia related to the cleaning and reusing of anaesthesia breathing circuits, ET tubes and ancillary equipment between patients, with the cost–benefit ratio of using sterilised breathing systems or filters remaining questionable. We recommend that all anaesthesia equipment that has direct patient contact (e.g. ET tubes, laryngoscope blades, pulse oximeter clips, oesophageal stethoscope, thermometer etc.) should be thoroughly cleaned in mild soap and water, rinsed thoroughly, dried and disinfected between patients.</p> <ul style="list-style-type: none"> • Anaesthetic circuits and ET tubes should be routinely changed, ideally between individual patients, but at a minimum on a daily basis. If visibly contaminated, circuits, ET tubes and ancillary equipment should be changed and thoroughly cleaned between patients. Circuits and ET tubes used for highly infectious cases should be safely discarded. • Regular culturing of breathing circuits, absorbent canisters and rebreathing bags should be performed for both bacterial and fungal contaminants.

These checks should be carried out prior to each anaesthetic procedure. Servicing of anaesthesia delivery systems should be performed regularly, at specified intervals in accordance with the manufacturer's documented service requirements. Servicing requirements should be noted on a label and displayed on the equipment in a prominent position. The label should list the date of the most recent service and the due date for the next service.

^aVaporiser in circuit (VIC) systems. Most modern vaporisers are agent-specific, concentration-calibrated, out of the circuit and high-resistance vaporisers that are compensated for temperature, flow and back-pressure. Non-precision, VIC systems are still occasionally found in veterinary practice, but without proper, specific training and inhalant anaesthetic agent monitoring these vaporisers pose unnecessary risks during anaesthesia and should not be used.¹⁵ All vaporisers mentioned within this document will, unless otherwise stated, refer to vaporiser agent-specific, concentration-calibrated, temperature-compensated, out of the circuit (VOC) systems.

facilitate more rapid equilibration of anaesthetic concentration within the breathing circuit, and ultimately the patient's depth if the patient is judged as being too 'deep' or too 'light', and the vaporiser dial setting has been adjusted accordingly.

Low-flow anaesthesia – the minimum safe fresh gas flow during maintenance supplies enough oxygen to satisfy the patient's metabolic oxygen consumption. To economise on gas use and waste during the maintenance period, the oxygen flow rate can be reduced to equal the metabolic oxygen requirement of the patient (5–10 mL/kg/min), plus enough additional gas flow to replace gases lost because of leaks in the circuit and/or via a side-stream gas analyser (see

Appendix 1). The anaesthetist should be aware that at flow rates < 250 mL/min, some precision vaporisers and flowmeters may not accurately deliver the dialled vaporiser concentration and oxygen flow rate.

Note: specific technical training in this technique and/or the use of gas analysers to monitor inspired and expired oxygen and anaesthetic partial pressures is recommended.

During anaesthetic recovery/emergence

Immediately after the vaporiser has been turned off, increase the fresh gas flow rate to 200–300 mL/kg/min (or as close to non-

rebreathing flow rates as possible). Then, with the APL valve open, apply gentle pressure to evacuate the reservoir bag, repeating this process when it refills. Where such high flow rates are applied and the fresh gas flow rate matches or exceeds the patient's minute ventilation (tidal volume \times respiratory rate), a rebreathing system can be made to function as a non-/minimal-rebreathing system. This strategy will wash out waste anaesthetic gas, increase the oxygen concentration in the breathing circuit and hasten the patient's emergence from anaesthesia. It is recommended that these high flow rates be maintained until the patient is extubated.

Note: See Appendix 2 – Quick reference chart: oxygen flow rate guidelines for rebreathing systems (L/min)

Important: the APL valve should be fully open at all times when the patient is spontaneously breathing and only closed temporarily during manually (bag) assisted ventilation by the anaesthetist.

Non-rebreathing systems. The distinguishing feature of non-rebreathing circuits is that elimination of carbon dioxide is accomplished by removing all expired gases from the system and venting them to the atmosphere. This is normally achieved by using the fresh gas flow from the anaesthetic machine to direct the expired gases out of the circuit via a valve or other arrangement. In general, non-rebreathing systems provide good control of the inspired gas concentrations, because the anaesthesia vaporiser concentration setting closely matches the inspired isoflurane concentration at all times and fresh gas delivered from the anaesthetic machine is inspired in each breath. They are, however, less economical to use than rebreathing systems because the minute volume of ventilation (or more) must be supplied to the patient to prevent rebreathing and they contribute more to the problem of atmospheric pollution with anaesthetic agents. Appropriate scavenging of anaesthetic waste gases is mandatory.

Non-rebreathing systems have traditionally been recommended for patients < 5 kg, because of lower resistance during spontaneous breathing, less equipment dead space and smaller total circuit volume compared with adult rebreathing circuits.¹⁵ However, by using newer paediatric and neonatal rebreathing systems, many of the aforementioned advantages of non-rebreathing systems are negated and it is possible to maintain patients weighing < 5 kg safely using rebreathing systems providing that the patient's tidal volume is sufficient to operate the unidirectional valves.¹⁵

There is no patient size recommendation for selecting a non-rebreathing, paediatric/neonatal rebreathing or adult rebreathing system that has been universally accepted among anaesthesiologists. It is, however, generally accepted that non-rebreathing systems are advisable for patients < 2.5 kg. Patients ranging from 2.5 to 10 kg are well-suited to paediatric/neonatal rebreathing systems and patients > 10 kg to adult rebreathing systems. Recommendations for selecting fresh gas flow rates in non-rebreathing systems are outlined as follows.

- The precise fresh gas flow rate to minimise the rebreathing of carbon dioxide in non-rebreathing systems differs with each individual patient and type of system.
- Ranges have been reported from 100–600 mL/kg/min for patients < 7 kg.

- In general, an approximate range of 100–300 mL/kg/min with a minimum of 500 mL/min and a maximum of 3 L/min is recommended for patients < 6.8 kg.¹⁸
- Continuous monitoring of expired carbon dioxide values (by capnography) is the ideal modality to determine an individual patient's fresh gas flow requirement.

Note: the APL valve should be fully open at all times when the patient is spontaneously breathing and only closed temporarily during manually (bag) assisted ventilation by the anaesthetist.

Anaesthetic waste gas scavenging

It is advised that practitioners familiarise themselves with relevant Australian state/territory-based legislation pertaining to occupational health and safety procedures or requirements concerning control of waste anaesthetic gases. Veterinary surgeons boards within each individual state/territory can provide information regarding compliance with all relevant standards.

For a detailed resource outlining recommendations for the control of waste anaesthetic gases in the workplace please refer to 'Commentary and recommendations on control of waste anaesthetic gases in the workplace' produced by The American College of Veterinary Anesthesia and Analgesia (http://www.acvaa.org/docs/2013_ACVAA_Waste_Anesthetic_Gas_Recommendations.pdf).

Induction and maintenance of anaesthesia

Team approach

All personnel involved in the delivery of anaesthesia should be fully informed of the details and plan related to the patient's scheduled procedure and relevant clinical history, and aware of their individual roles and responsibilities. It is also essential for all members of the anaesthesia and procedural team to be familiar and practised in the delivery of any potential emergency contingencies. All team members should be familiar with emergency protocols and supplies (including emergency drug doses to be calculated) for each individual patient prior to anaesthetic induction. A full description of the most current clinical cardiopulmonary resuscitation (CPR) guidelines, including new algorithms and drug dosing charts, is available online: <https://www.veccs.org/recover-cpr/>.

A diligent anaesthetist who is ready for varying contingencies can intercept developing problems before they reach the 'crisis' stage. Diligent monitoring and timely, well thought out responses to changes in patient status are crucial in avoiding adverse events.

The maintenance period is made easier by prior planning. For those practices that may not have a dedicated anaesthetist, ensure that everything required for the procedure is organised prior to induction (e.g. surgical kit, suture material etc.). This will enable personnel responsible for anaesthesia maintenance to be able to spend more time dedicated to monitoring the patient and less time spent performing other tasks during this period.

Surgical safety checklist

The management of risk and patient safety are major drivers in the implementation of surgical safety checklists. Checklists designed to

ensure effective communication and improve collaboration and the delivery of patient care have been implemented in both human and veterinary healthcare sectors. The World Health Organization (WHO) surgical safety checklist has been shown to decrease mortality and complications and has been adopted worldwide.¹⁹ The WHO surgical safety checklist has been modified to achieve veterinary relevance and successfully implemented by many practices and institutions. An example of such a checklist can be found in Appendix 3. Development of a surgical safety checklist is strongly recommended and should be tailored to individual needs and work practices. The development of such a surgical safety checklist should involve all members of the perioperative team in order to ensure engagement and compliance.

Patient preparation

Preparation of a patient for anaesthesia should include the following:

- IV catheter placement (mandatory)
- connecting monitoring equipment and recording the patient's pre-anaesthesia baseline blood pressure, heart rate, haemoglobin oxygen saturation (pulse oximetry) and evaluation of the ECG for any anomalies
- managing/optimising any detected cardiovascular or respiratory problems. **Anaesthesia for elective procedures should be postponed until a patient is appropriately stabilised.** Cardiovascular stabilisation and ongoing maintenance of patients, may include, but is not limited to:
 - administration of IV fluids. Hypovolaemic patients may require isotonic crystalloids, colloids, and/or hypertonic saline to optimise intravascular hydrostatic pressure, improve venous return, cardiac output and improve tissue perfusion. Dehydration should be corrected in animals that are moderately to severely dehydrated, prior to anaesthesia if time permits. Only 75–80% of the dehydration deficit should be replaced during the 24 h before anaesthesia to avoid fluid overload. The remaining fluid deficit caused by dehydration can gradually be replaced over 24–48 h after surgery.²⁰ In addition, preoperative volume loading of normovolaemic patients is not recommended and, in humans, blood volume is unchanged after overnight fasting^{21–25}
 - managing cardiac arrhythmias (when feasible based on the patient's condition and the urgency of the procedure to be performed)
 - administration of blood products (when indicated and available). Anaemia and coagulation disorders can decrease the delivery of oxygen to tissues, and hypoalbuminaemia can alter drug transport and binding and effect fluid balance
- preoxygenating the patient with 100% oxygen via a firm-fitting face mask (demeanour permitting) for a minimum of 3 min prior to induction of anaesthesia. Preoxygenation for 3 min prior to induction of anaesthesia increases the time to desaturation of haemoglobin by a factor of 3–4 compared with non-preoxygenated patients and is particularly beneficial if a prolonged or difficult intubation is expected.²⁶ Removal of the rubber diaphragm from the facemask may increase patient tolerance.

When the patient is as deemed to be as stable as possible, proceed according to the individual patient plan.

Anaesthetic induction phase

Anaesthesia is best achieved via IV administered induction agents carefully titrated slowly to effect. The equipment and steps involved are detailed as follows.

Equipment

- 3–10-mL syringe for cuff inflation. It is recommended not to use greater than 3-mL syringe for cuff inflation in cats.
- Endotracheal (ET) tubes in varying sizes – the correct ET tube should be measured from a point immediately rostral to the upper incisors to the thoracic inlet. The safest ET tubes are the high-volume, low-pressure cuffs because they generate less pressure per given volume of inflation with less risk of tracheal trauma.
- Gauze squares (to grasp the tongue).
- Laryngoscope – Although it is possible to intubate a cat without laryngoscopy, the visualisation is poor and therefore the risk of trauma is much greater. If there is not a laryngoscope in your practice, you may choose to purchase your own as the time and stress it will save is invaluable. There are various models available from most veterinary equipment suppliers. Alternatively, a good light source and a tongue depressor could be used (head torches can be useful).
- Facemask and oxygen supply.
- Lubricant (preferably sterile).
- Supplies to secure the endotracheal tube (i.e. rolled gauze to tie the tube to the upper jaw, lower jaw or behind the head).
- Stylet – recommended for use with small, delicate or flexible silicon ET tubes. Use a stylet with a flexible tip to avoid tracheal trauma. Once the stylet has been inserted slightly beyond the vocal chords, the tube should be advanced over the stylet rather than advancing a protruding stylet into the trachea, which may result in tracheal trauma, especially if the patient is lightly sedated and coughs or the neck is bent down during intubation.

Steps

1. Ideally, the patient has been preoxygenated with an oxygen mask for a minimum of 3 min before intubation. Oxygen flow-by should always be available. **Two team members should be involved in the procedure.**
2. Induction agent is administered until a suitable plane of anaesthesia is reached – manifested by a loss of righting reflex. Patients should typically be placed in sternal recumbency; however, team members should also prepare for and be able to intubate patients in lateral and dorsal recumbency. When intubating a patient in sternal recumbency, an assistant should place one hand behind the base of the head (occipital bone), while the opposing hand holds the maxilla (upper lips) and extends it in a dorsal direction. This should fully extend the head and neck as close to a horizontal position as possible.
3. When the patient has received an adequate amount of anaesthetic to sufficiently relax the muscles of the jaw and decrease the gag-reflex, the anaesthetist should gently pull the tongue forward and down between the lower incisors, thus pulling the lower jaw down and the epiglottis forward. This should be done in a gentle manner as the hypoglossal/glossopharyngeal nerves can be stretched, leading to neuropraxia and problems with the tongue post-anaesthesia.

4. The blade of the laryngoscope should be placed just in front of the epiglottis and downward pressure applied to depress the tongue, so that the epiglottis is drawn forward and the soft palate is disengaged, allowing visualisation of the larynx. Assess the glottal diameter to determine an appropriate ET tube size. If possible, avoid directly contacting the epiglottis as this can cause damage leading to swelling and laryngeal spasm.

5. Spray the larynx with a single spray of lignocaine (ALL cats, AND dogs with sensitive reactive/inflamed larynx). Test the spray before use to ensure the pump mechanism is loaded.

6. Allow at least 60–90 s for the local anaesthetic to take effect. Initially, the larynx may spasm because of irritation from the spray, but once the local anaesthetic has taken effect the larynx should relax. During the waiting period the tongue should be relaxed and the laryngoscope removed from the oral cavity.

7. Flow-by oxygen should be provided and additional induction agent administered if further relaxation of the jaw or larynx is required.

8. Lightly lubricate the balloon of the selected ET tube, avoiding the lumen and side-port (Murphy-Eye) of the tube to prevent obstruction. Cuff lubrication has been shown to reduce pulmonary aspiration.²⁸

9. Reposition the patient, with the head and neck extended (to allow better visualisation and personal comfort this can be at more of an angle to the table than before). Use the laryngoscope as before to depress the tongue.

With the laryngoscope in place, there should be a clear view of the arytenoids. Guide the ET tube over the epiglottis, aiming the bevel at the most ventral point of the laryngeal opening. Gently advance the tip of the ET tube through the laryngeal opening during inspiration (the laryngeal folds should abduct), a gentle twisting motion can be used to aid passage of the tube. It is very important to visualise the tube passing between the arytenoids and into the glottal opening. It is not sufficient simply to pass the tube over the epiglottis as this will most likely result in the tube passing into the oesophagus. Other methods to assure proper placement include observing condensation in clear tubes as the patient breathes, auscultation of lung sounds and observation of a capnography trace.

10. Once correctly positioned, the ET tube should be secured by tying rolled gauze first around the tube then in a bow behind the canines and around upper or lower jaw; or behind the base of the head in cats and brachycephalic breeds.

11. Connect the ET tube to the breathing circuit. Remember that the cuff can cause shear damage to the wall of the trachea if twisted so during patient repositioning the ET tube should be disconnected from the breathing system.

12. Inflate the ET tube cuff to achieve an appropriate tracheal seal.

ET tube cuff inflation techniques: an inflatable cuff has a pilot tube with a port for a syringe. It is **important not to over-inflate** the cuff as tracheal ischaemic necrosis or rupture can result.²⁹ To ensure correct inflation pressure, attach a syringe full of air to the pilot tube; inflate the lungs by forcing air down the endotracheal tube

(by squeezing the reservoir bag) and listen for air escaping around the tube; slowly inject air into the pilot tubing, inflating the cuff until you can no longer hear air escaping. Once the cuff has sealed the trachea, the leak will cease and an optimal airway pressure of 20–30 cmH₂O should be maintained (if an airway manometer is present).³⁰ Some pilot tubes have a valve, while others have to be clamped to keep the cuff inflated. A reliable method for ensuring that cuff pressures are within the recommended range is to use a cuff monitor to inflate cuffs. A cuff monitor is essentially a low-pressure manometer, similar to those used for Doppler blood pressure measurement, that is attached to the pilot balloon of the cuff and provides a measure of intra-cuff pressure.

13. Remember to assess your patient's vital parameters immediately after intubation.

Mask or chamber inductions increase patient anxiety, are stressful on the cardiovascular and respiratory systems, delay airway control and increase the risk of environmental and personnel exposure to gaseous anaesthetics.²⁷ It is strongly advised to reserve these techniques as options of 'last resort' when other alternatives are not suitable.

Anaesthetic maintenance phase

Positioning. During anaesthesia patients should, if possible, be positioned in a normal physiological position. The head should be extended to promote a 'free' airway and reduce the likelihood of endotracheal tube kinking. The eyes should be protected from contact with abrasive surfaces and corneal lubricant should be applied following induction to protect the eyes from corneal ulceration.

Temperature regulation. Anaesthesia invariably affects temperature regulation, which will typically manifest as hypothermia; however, during warmer weather large, hairy dogs may overheat. Small animals with large surface area to volume ratios lose heat rapidly under anaesthesia and sedation, but all animals may develop clinically relevant hypothermia. Hypothermia has many physiological effects and will delay greatly a patient's recovery from anaesthesia.³¹ Care should be taken to monitor body temperature and when required, provide supplemental heating to maintain a patient's temperature to as close to normal during anaesthesia. Thermal support may include warm IV fluids, use of a fluid line warming device, insulation of the patient's extremities (e.g. bubble wrapping of the feet), heated conductive warming blankets, circulating warm-water blankets and warm air circulation systems. Do not use supplemental heat sources that are not designed specifically for anaesthetised patients as they can cause severe thermal injury.³²

Intravenous fluids. The provision of fluids during anaesthesia, as well as the type and volume used, should be based on the individual patient's signalment, physical condition and the length and type of procedure. The dogma of administering crystalloid fluids at 10 mL/kg/h perioperatively, with higher volumes for anaesthesia-induced hypotension, is not evidence-based and should be re-evaluated. Such high fluid rates are likely contributors to adverse patient outcomes, including: increased body weight and lung water; abnormal pulmonary function; coagulation deficits; reduced gut motility; reduced tissue oxygenation; increased infection rate; decreased wound healing; decreases in PCV and total protein concentration.^{33,34}

In the absence of evidence-based anaesthesia fluid rates for veterinary patients, and taking into consideration the growing weight of evidence relating to the adverse effects of hypervolaemia we suggest that rarely should there be a need to exceed 3 mL/kg/h of balanced crystalloids in dogs and cats undertaking surgical procedures. Fluids volumes administered above this rate should be for the purpose of resuscitation (i.e. replacing blood volume as it is lost from the intravascular space).

Experimental data in isoflurane-anaesthetised dogs and clinical studies in people suggest that crystalloid fluid replacement ratios from $\geq 4\text{--}5$ mL for each 1 mL of lost blood (4:1 or 5:1) are required.^{20,35–37}

Monitoring

Clinical observation and assessment by a vigilant anaesthetist are essential for safe patient care during the perianaesthetic period. During the maintenance period **good monitoring is critical**. The person monitoring the patient should be suitably trained and skilled and **should not** be the practitioner performing the procedure. Clinical monitoring should be supplemented with monitoring devices as necessary, to assist the practitioner responsible for the anaesthesia. The anaesthetist whose sole responsibility is the provision of anaesthesia care for that patient must be constantly present from induction of anaesthesia until the patient has recovered. In exceptional circumstances, brief absences of the anaesthetist primarily responsible for managing the anaesthesia may be unavoidable. In such circumstances, observation, including recording of observations of the patient and a plan for responding to significant changes in monitored physiological variables, must be temporarily delegated to a suitably trained and skilled colleague who is judged to be competent for the task.

Minimum monitoring standards. The monitoring of a patient undergoing any type of anaesthesia should include regular assessment and accurate recording of physiological parameters, including circulation, oxygenation, ventilation and temperature, as well as diligent post-anaesthetic care in the recovery period.

The guidelines for anaesthesia monitoring are adapted from existing standards developed by The American College of Veterinary Anesthesia and Analgesia (ACVAA).

Circulation

Objective: to ensure adequate circulatory function

Methods:

- Palpation of peripheral pulse to determine rate, rhythm and quality, and evaluation of mucous membrane colour and capillary refill time (CRT).
- Auscultation of heart beat (stethoscope; oesophageal stethoscope or other audible heart monitor). Continuous (audible heart or pulse monitor) or intermittent monitoring of the heart rate and rhythm.
- Pulse oximetry to determine the % haemoglobin saturation.
- Electrocardiogram (ECG) continuous display for detection of arrhythmias.
- Blood pressure:
 - a non-invasive (indirect): oscillometric method: Doppler ultrasonic flow detector
 - b invasive (direct): arterial catheter connected to an aneroid manometer or to a transducer and oscilloscope

Recommendations: continuous awareness of heart rate and rhythm during anaesthesia, together with gross assessment of peripheral perfusion (pulse quality, mucous membrane colour and CRT) are mandatory. Blood pressure and ECG should also be monitored.

Oxygenation

Objective: to ensure adequate oxygenation of the patient's arterial blood.

Methods:

- Pulse oximetry (non-invasive estimation of haemoglobin saturation)
- Arterial blood gas analysis for oxygen partial pressure (PaO₂)

Recommendations: assessment of oxygenation should be done whenever possible by pulse oximetry, with blood gas analysis being used when necessary for more critically ill patients.

Ventilation

Objective: to ensure that the patient's ventilation is adequately maintained.

Methods:

- Observation of thoracic wall movement or observation of breathing bag movement when thoracic wall movement cannot be assessed.
- Auscultation of breath sounds with an external stethoscope, an oesophageal stethoscope or an audible respiratory monitor.
- Capnography (end-expired CO₂ measurement).
- Arterial blood gas analysis for carbon dioxide partial pressure (PaCO₂).
- Respirometry (tidal volume measurement).

Recommendations: qualitative assessment of ventilation is essential, as outlined previously, and capnography is required when using continuous mechanical/mandatory ventilation, with blood gas analysis as necessary.

Temperature

Objective: to ensure that patients do not encounter serious deviations from normal body temperature.

Methods:

- Rectal thermometer for intermittent measurement.
- Rectal or oesophageal temperature probe for continuous measurement.

Recommendations: temperature should be measured periodically (ideally at least every 15 min) during anaesthesia and recovery, and if possible checked within a few hours after return to the ward (more frequently if temperature abnormalities are present).

Record keeping

Objectives:

- To maintain a legal record of significant events related to the anaesthetic period.
- To enhance recognition of significant trends or unusual values for physiologic parameters and allow assessment of the response to intervention.

Recommendations:

- Record all drugs administered to each patient in the perianaesthetic period and in early recovery, noting the dose, time and route of administration, as well as any adverse reaction to a drug or drug combination.
- Record monitored variables on a regular basis (minimum every 5 min) during anaesthesia. The minimum variables that should be recorded are heart rate and respiratory rate, as well as oxygenation status and blood pressure.
- Record heart rate, respiratory rate and temperature in the early recovery phase.
- Any untoward events or unusual circumstances should be recorded for legal reasons and for reference should the patient require anaesthesia in the future.

Recovery period

Half of all anaesthesia-related deaths occur during the recovery period (47% in dogs, 60% in cats), most frequently during the first 3 h.³⁸ **It is critical that patients are diligently monitored during this period** to ensure a safe and comfortable recovery from anaesthesia. Extubation should ONLY be performed once the patient has regained a gag-reflex and no patient should be left intubated and unattended during the recovery period.

Patient care during recovery from anaesthesia

The frequency with which patients are monitored following anaesthesia will vary according to the individual patient's procedure, signalment, disease process, pain profile and ongoing medical and/or surgical management requirements. The following recommendations are considered mandatory for the provision of care during the period following extubation or recovery from anaesthesia:

- observation of respiratory pattern
- observation of mucous membrane colour and CRT
- palpation of pulse rate and quality
- measurement of body temperature, with appropriate warming or cooling methods applied if indicated. Do not use supplemental heat sources that are not designed specifically for anaesthetised patients as they can cause severe thermal injury
- re-application of eye lubrication during the recovery period until an appropriate blink reflex is present, particularly if an anticholinergic was administered
- manually expressing a patient's urinary bladder if distended to minimise any associated discomfort
- observation of any behaviour that indicates pain, emergence delirium or dysphoria, with appropriate pharmaceutical intervention as necessary. Re-assessment of the patient's pain level and, if necessary, adjusting the pain management plan
- other measurements as indicated by the patient's medical status (e.g. blood glucose, pulse oximetry, PCV, TP, blood gases, etc.).

Patient discharge

Discharge of patients that have undergone anaesthesia should only occur after the patient is awake, aware, warm, comfortable and ambulatory (if the patient's condition allows). Evaluate the animal

for its responses and its ability to interact safely with owners and maintain physiological homeostasis. Provide written instructions for owners, outlining the dose and potential side effects of analgesics and other medications to be given to the patient at home.

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Appendix 1

Recommendations for performing low-flow anaesthesia

During induction

- Use a total fresh gas flow that approximates minute ventilation and increase the fresh gas flow only if the measured (inspired) concentrations of oxygen and anaesthetic vapour are less than the set concentrations on the vaporiser.
- Decrease vaporiser setting as the difference between exhaled and inspired anaesthetic concentrations diminish. Monitor the exhaled concentration of anaesthetic vapour to ensure adequate anaesthetic depth.

During maintenance

(When expired anaesthetic concentration approaches the inspired concentration)

- Estimate patient oxygen consumption to be 5 mL/kg/min.
- Set total oxygen flow (oxygen +21% of air flow if used) to equal estimated oxygen consumption.
- Add 200 mL/min to total oxygen flow if using a side-stream gas analyser that does not return sampled gas to the circuit.
- Add the volume of any estimated/quantifiable leaks in the system to the total oxygen flow.
- Oxygen flow can be reduced in 50 mL/min increments until the inspired oxygen concentration begins to decrease.
- Monitor inspired oxygen concentration and set low oxygen concentration alarm at desired level.
- Monitor exhaled anaesthetic vapour concentration to ensure adequate MAC. Set alarm for desired level of expired vapour concentration.

During recovery/emergence

(When expired anaesthetic concentration approaches the inspired concentration)

- Increase the total fresh gas flow to > 200 mL/kg/min (effectively converting the system to a non/minimal-rebreathing circle system). This will promote the scavenging of exhaled anaesthetic agents from the system.

Note: specific technical training in this technique and/or the use of gas analysers to monitor inspired and expired oxygen and anaesthetic partial pressures is recommended.

Appendix 2

Quick reference chart: oxygen flow rate guidelines for rebreathing systems (L/min)

Weight (kg)	During induction, and changes in depth (50–100 mL/kg/min)	During maintenance (20–50 mL/kg/min)	Low-flow anaesthesia during maintenance (5–10 mL/kg/min)	During emergence – minimal-rebreathing system [†] (200–300 mL/kg/min)
2.5	0.25–0.3	0.25	0.25*	0.5–0.8
5	0.3–0.5	0.25	0.25*	1.1–1.5
10	0.5–1	0.25–0.5	0.25*	2–3
15	0.8–1.5	0.3–0.75	0.25*	3–4.5
20	1.0–2	0.4–1	0.25*	4–5
25	1.3–2.5	0.5–1.25	0.25*	5
30	1.5–3	0.6–1.5	0.25–0.3*	5
40	2–4	0.8–2	0.25–0.4*	5
50	2.5–5	1.0–2.5	0.25–0.5	5
60	3–5	1.2–3	0.3–0.6	5
70	3.5–5	1.4–3.5	0.35–0.7	5
80	4–5	1.6–4	0.4–0.8	5
90	4.5–5	1.8–4.5	0.45–0.9	5
100	5	2.0–5	0.5–1.0	5
150	5	3.0–5	0.75–1.5	5

> 150 kg: use a large-animal anaesthesia machine

* At flow rates < 250 mL/min, some precision vaporisers and flowmeters may not accurately deliver the dialled vaporiser concentration and oxygen flow.

[†] Minimal rebreathing occurs only when the oxygen flow matches or exceeds the patient's minute ventilation.

Appendix 3

The University of Melbourne U-Vet Animal Hospital Surgical Safety Checklist

BEFORE INDUCTION

Surgeon: _____ Anaesthetist: _____ Nurse: _____

- **SURGEON AND ANAESTHETIST +/- NURSE CONFIRM PATIENT DETAILS**
 - Identity
 - Procedure
 - CPR CODE confirmed
 - TPR AND BLOOD WORK performed and reviewed
 - CONFIRM SURGERY SITE L / R, front/hind limb
 - Are there second surgery sites?
 - Is a scope or other imaging planned?
- **ANAESTHESIA SAFETY CHECK COMPLETE**
 - Anaesthesia machine checked
 - Monitoring equipment checked
 - Ventilator checked
- **PRE-EXISTING CONDITIONS OR SURGICAL/ANAESTHESIA RELATED RISKS IDENTIFIED AND REVIEWED**
 - Yes
 - No
- **ARE ANTIBIOTICS NEEDED?**
 - Yes, and ready to administer
 - No
- **IS PRE-OP OR INTRA-OP IMAGING REQUIRED?**
 - Yes, Request form submitted Yes No
 - No
- **NURSE AND SURGEON**
 - CONFIRM PATIENT POSITIONING, SPECIAL EQUIPMENT, IMPLANTS and OR SETUP

Patient Identification Label

BEFORE SKIN INCISION

Surgeon: _____ Anaesthetist: _____ Nurse: _____

- CONFIRM ALL TEAM MEMBERS HAVE INTRODUCED THEMSELVES BY NAME AND ROLE
- **SURGEON AND NURSE VERBALLY CONFIRM**
 - Patient Identity
 - Procedure
 - Surgery site
- Ask **ANAESTHETIST** has **ANTIBIOTIC PROPHYLAXIS** been given at least 30 minutes previously?
 - Yes
 - No
- **SURGEON AND ANAESTHETIST VERBALLY CONFIRM ANTICIPATED CRITICAL EVENTS**
 - Blood test results reviewed
 - What are the critical steps?
 - What is the anticipated surgical time?
 - What is the anticipated blood loss?
 - Are blood products available if blood loss anticipated?
 - Are there any anaesthetic concerns?
- **NURSE REVIEW**
 - Has sterility (Indicators) been confirmed?
 - Confirm implants / equipment in the OR
 - Surgical sponges counted and reported
- **IS IMAGING DISPLAYED IN OR? SURGEON AND NURSE**
 - Yes
 - No or Not applicable
- **SURGEON ASKS ANAESTHETIST**
 - Is anaesthetic depth adequate for surgery?
 - Is additional induction agent available?

BEFORE PATIENT LEAVES SURGERY

Surgeon: _____ Anaesthetist: _____ Nurse: _____

- **NURSE CONFIRMS**
 - Name of procedure has been recorded
 - Record if sterility was compromised, how?
 - Sponge count reported and correct
 - Any equipment concerns
- **IS POST-OP IMAGING IS REQUIRED?**
 - Yes
 - No
- **CONFIRM LOCATION OF RECOVERY**
 - Wards or ICU
- **SURGEON AND ANAESTHETIST REVIEW KEY CONCERNS FOR RECOVERY AND POSTOP MANAGEMENT PLAN**
 - Were there any anaesthetic concerns?
 - Were there any surgical concerns?
 - Analgesia
 - Antibiotics
 - Intravenous fluid rate
 - Particular medication
- **SURGEON AND NURSE**
 - Confirm responsibilities for submission of samples collected
 - CONFIRM WHO WILL CALL THE OWNER and WHEN

Prior to the patient progressing to the next stage, a minimum number of signatures must be obtained to ensure successful completion of each stage of the checklist. A signature from the surgeon and anaesthetist are mandatory at each stage.

DATE: _____