Monitoring of anaesthetised dogs and cats: Australian and New Zealand College of Veterinary Scientists Veterinary Anaesthesia and Analgesia Chapter position statement

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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.

INTRODUCTION

The Veterinary Anaesthesia and Analgesia Chapter of the Australian and New Zealand College of Veterinary Scientists (ANZCVS) is the only official veterinary special interest group for anaesthesia and analgesia in Australasia. Members of the Chapter identified a gap in the resources available to veterinarians in Australia and New Zealand with regards to defining the minimum standards for the monitoring of anaesthesia in companion animal practice. This position statement provides clear guidance on the minimum requirements for adequate monitoring during anaesthesia to optimise animal safety and meet the expectations of registering bodies, professional colleagues, and pet owners.

Currently there are no Australian and New Zealand standards or guidelines pertaining specifically to the provision of monitoring during anaesthesia and the various state, territory and national Veterinary Surgeons' Boards (or equivalent) do not consistently articulate their expectations of appropriate

and safe monitoring of dogs and cats during anaesthesia. There are extensive resources on the process of anaesthesia and many comprehensive publications and textbooks on the subject, including a recent publication endorsed by the Australian Small Animal Veterinarians (ASAV)[1]. However, resources such as this example do not clarify expectations on a minimum standard of practice.

Furthermore, the ANZCVS Veterinary Anaesthesia and Analgesia Chapter is committed to "empower veterinarians and veterinary professionals to safely and skilfully work in this discipline with pride, confidence and acumen."[2] To this end, the creation of a position statement on monitoring during anaesthesia will provide clarity to veterinary practitioners on how to, as a minimum, monitor dogs and cats during anaesthesia.

In 1941 a system was proposed to define the "physical state of a human patient" prior to anaesthesia and surgery.[3] The system is referred to as the American Society of Anesthesiologists (ASA) physical status classification and it helps to predict or determine the extent of monitoring required for a patient. A higher physical status (ASA 3-5) is attributed to patients with severe systemic disease from any cause or causes.[3] As this position statement is intended to define minimum standards of monitoring, it focuses on animals that would be categorised as either ASA 1 or 2 (healthy or with mild systemic disease). More complex cases that require a more complex approach to all aspects of care are not within the scope of this position statement.

The aims of the working group were to review the current international recommendations for monitoring during veterinary anaesthesia and to review the literature, where possible and appropriate, to justify a position statement for minimum monitoring requirements.

APPROACH AND METHODS

The ANZCVS Veterinary Anaesthesia and Analgesia Chapter established a working group of voluntary members of the Chapter. Members of the Chapter, by examination or by recognition of equivalent specialist level qualifications (Associate Members) were included. Active and engaged members were nominated by the Chapter Executive in late 2018 to include members with extensive experience in general, as opposed to specialist, practice.

Within the working group tasks were delegated for subgroups to focus on, including: review of the existing local (individual veterinary boards' webpage review) and international guidelines [Association of Veterinary Anaesthetists (Assoc VA), the European College of Veterinary Anaesthesia and Analgesia (ECVAA), the American College of Veterinary Anaesthesia and Analgesia (ACVAA), the American Animal Hospital Association (AAHA), the World Small Animal Veterinary Association (WSAVA) and the Australian Small Animal Veterinarians (ASAV)] for monitoring during anaesthesia: allowances for veterinary nurse involvement in anaesthesia in the various states and territories of Australia and New Zealand (individual veterinary boards' webpage review); and a literature review of evidence based practices for monitoring in veterinary and where necessary, human anaesthesia practice.

Webpage review was performed using search terms including "anaesthesia, monitoring, veterinary, resources, nurses, guidelines and requirements" to navigate the website and find reference to expectations for monitoring during anaesthesia.

For the literature review, multiple databases were used including Google Scholar, PubMed, Web of Science, and Scopus, to ensure a wide-ranging collection of literature pertaining

to monitoring guidelines, and patient safety in veterinary and human anaesthesia. Initially, the search yielded a total of 40,500 papers. Papers that focused on monitoring guidelines and safety aspects of anaesthesia were then selected.

RESULTS AND FINDINGS

Working group meetings of the 9 members were conducted intermittently online, with a significant hiatus in progress during 2020 and 2021.

Australian and New Zealand Veterinary Boards webpage review

There are no specific references to monitoring during anaesthesia within the policies and guidelines of the boards of Western Australia,[4] South Australia,[5] Queensland,[6] Victoria,[7] Tasmania,[8] or the Australian Capital Territory.[9] However, the Veterinary Board of the Northern Territory states the clear expectation that anaesthesia will be monitored as a strategy to avert anaesthetic death and that for routine cases in normal business hours a second person would be available to assist with the task of monitoring and record keeping.[10] Furthermore, the advice of the New South Wales Veterinary Practitioners Board on how to avoid anaesthesia related complaints is to: "Ensure appropriate monitoring of anaesthesia including skills, knowledge and experience of staff and use of appropriate and required equipment".[11]

The Veterinary Council of New Zealand maintains a listed set of Competency Standards for performance indicators for veterinarians and the Veterinarians Act 2005 requires the veterinary council to prescribe minimum standards for practicing veterinarians. Standard 5 of these Competency Standards is "Implement safe and effective veterinary procedures and therapeutic strategies", which outlines the requirements "Safely induce(s), maintain(s) and monitor(s) analgesia and anaesthesia and takes( )steps to ensure safe and humane recovery".[12]

The Australasian Veterinary Boards Council does not provide detailed guidance on their expectations of veterinarians working in this region with the statement: "Safely perform sedation and general and regional anaesthesia; implement chemical methods of restraint".[13]

For veterinary nurses, Western Australia is the only jurisdiction which approves persons to perform specific duties prescribed for veterinary nurses and Queensland is the only jurisdiction that defines the term 'veterinary nurse' in legislation.[14] In Western Australia, registered veterinary nurses are authorised to "assist with and monitor the administration of anaesthetics" and "monitor the recovery of animals from anaesthesia" under personal supervision of a registered veterinarian.[15] In Queensland, there are no specific references to how nurses can contribute to the safe anaesthesia of veterinary patients.

The Veterinary Nurses Council of Australia refers to various specific skills of veterinary nurses including their role in veterinary anaesthesia and analgesia in a position statement related to promoting the utilisation of veterinary nurses and technicians in veterinary practice.[16] Herein, anaesthesia and analgesia are recognised as important components of a career development path for veterinary nurses.[16]

International guidelines review

The details of content within the resources produced by veterinary anaesthesia and analgesia organisations were varied (*Table 1*). The ECVAA did not have information on their website pertaining to guidelines or benchmarks for the provision of anaesthesia in small animals;[17] whilst the ACVAA publishes a set of guidelines pertaining specifically to monitoring anaesthetised small animals.[18] The ACVAA guidelines discuss monitoring of circulation, oxygenation, ventilation, temperature and neuromuscular blockade along with record keeping, expectations during the recovery period and the role of

personnel. Minimum expectations are not defined in the ACVAA guidelines.

The Assoc VA has a position statement on anaesthetic monitoring requiring "dedicated anaesthetist monitoring [for] each case and additional monitoring equipment of pulse oximetry, capnography and blood pressure".[19] The rationale for this approach is that "a suitable trained and focused person responsible for anaesthesia is the most vital instrument for safely monitoring anaesthesia and cannot be replaced by a machine. The additional information gained from pulse oximetry, capnography and blood pressure measurement cannot be objectively gained by a person alone and the interpretation of this information will regularly improve case management."[19] The Assoc VA position is based on best available evidence and/or endorsement by six veterinary anaesthesia professionals.[19]

The AAHA consensus statement for monitoring are within a comprehensive publication, where statements such as "dedicated anaesthetist", "monitoring of respiratory function (respiratory rate, EtCO2, SpO2)", "monitoring of cardiovascular function (heart rate, blood pressure, assessment of cardiac rhythm)", "monitoring and support of normal body temperature", "monitoring in recovery", and "documentation of patient parameters during anaesthesia and recovery" are clear requirements to mitigate risk during anaesthesia.[20]

The WSAVA does not provide guidance on monitoring during anaesthesia.[21] Currently, ASAV resources can only be accessed by members of the Australian Veterinary Association, however, the aforementioned anaesthesia guidelines produced by the ASAV are readily available and comprehensive.[1]

The common factors in all guidelines were ensuring adequate monitoring of the cardiovascular and respiratory systems (oxygenation and ventilation), thermoregulation and the dedication of appropriate trained and skilled personnel to the task of monitoring anaesthesia with continuous attention and frequent recording of monitored variables (at least every 5 minutes).[18-20]

Organisation	Guidelines or other relevant guidance for monitoring
European College of Veterinary Anaesthesia and Analgesia (ECVAA)[17]	None applicable. (Activities are limited to assessment and registration of specialists in veterinary anaesthesia and analgesia)
American College of Veterinary Anaesthesia and Analgesia (ACVAA)[18]	Minimum expectations not defined. Reference to importance of monitoring the circulation, oxygenation, ventilation, temperature and neuromuscular blockade. Record keeping, monitoring during recovery and role of personnel also described.
Association of Veterinary Anaesthetists (Ass Vet Anaes)[19]	Dedicated trained person monitoring each case with additional monitoring equipment of pulse oximetry, capnography and blood pressure.

American Animal Hospital Association (AAHA)[20]	Dedicated trained person, monitoring of respiratory function, cardiovascular function, body temperature and recovery, and documentation of patient parameters during anaesthesia and recovery.
World Small Animal Veterinary Association (WSAVA)[21]	Nil
Association Small Animal Veterinarians (ASAV)[1]	Minimum expectations not defined. Comprehensive description of how to monitor the cardiovascular system, respiratory system, thermoregulation and recovery.

Table 1: Summary of guidelines produced by Australian and International organisations representing the discipline of veterinary anaesthesia and analgesia.

Literature Review

Twenty-seven papers were found to be relevant to this literature review to inform the position statement. Ten of these papers were from the veterinary literature and 17 were medical.

One medical study analysed 2,000 anaesthetic incidents reported to the Australian Incident Monitoring Study (AIMS).22 In > 50% of incidents, at least one monitor detected the problem before clinical signs were apparent. The combination of pulse-oximetry and capnography detected more than half of the incidents. Furthermore, ECG and blood pressure monitors were responsible for 19% and 12% reduction on incidents, respectively.[22]

However, the presence of an appropriately trained and experienced anaesthetist is considered the main determinant of patient safety during anaesthesia and should not be replaced by monitoring equipment.[23,24] The patient and the information provided by monitoring devices must be regularly observed and recorded.[25] If monitoring equipment is available it should be utilised by skilled and experienced personnel dedicated to monitoring anaesthesia.[26] Regular observations of the patient´s mucosal colour, movement of the chest wall, palpebral reflex, pupil size, and response to painful stimuli are considered essential even when multi-parameter monitors are present.[27] The same standard applies when an anaesthetist is responsible for a 'twilight' procedure.[27] It is also essential that the standard of monitoring and care during transfer from the operating room to recovery areas are as high as in the operating room, and that skilled staff accompany the patient.

In one veterinary study, anaesthesia monitoring by dedicated personnel decreased the odds of anaesthetic death in both dogs and cats[28] whereas in another study, cats that were not adequately monitored had an increased odds of anaesthetic death by a factor of 5 – 35.[29]

Another veterinary study conducted in New Zealand concluded that the use of appropriate anaesthetic monitoring equipment by a skilled, attentive anaesthetist is likely to reduce morbidity and mortality.[30] Amongst respondents to this survey, most practices had access to a pulse-oximeter, oesophageal stethoscope, apnoea alarm and a thermometer. Apnoea alarms are easy to use, non-invasive and relatively inexpensive but the common availability of these alarms in private practices was of concern, because they only provide information about

respiratory rate and tend to be unreliable and inaccurate.[31] Capnographs were only available in approximately 10% of practices studied. Blood pressure monitors were only present in under half the practices. It was encouraging that most respondents reported that a dedicated anaesthetist usually monitored the patient during anaesthesia in their practice. Most frequently the dedicated anaesthetist utilised was a veterinary nurse.

PULSE-OXIMETRY

The aforementioned AIMS paper[22] showed that more than 26% of anaesthetic incidents were first detected by pulse-oximetry.[32] In 1993, Moller and colleagues published data on the use of pulse oximetry in anaesthesia, in a study population of 20,000 patients.[33] During anaesthesia and in the recovery area, substantially more patients in the oximetry group had at least one respiratory event than the control patients, due to an increase in the incidence of diagnosed hypoxaemia in the oximetry group. Despite these findings, no significant difference in clinical outcome could be identified.

However, in 1986, the American Society of Anesthesiologists (ASA) approved the first anaesthetic monitoring guidelines with an emphasis on pulse-oximetry.[24] Anaesthesia risk dramatically decreased during the first decade that the pulse oximeter was mandated in the ASA guidelines.[34] In fact, the World Health Organisation's Checklist for International Standards for Safe Practice of Anaesthesia clearly states that it is no longer acceptable for routine anaesthesia to be conducted without a pulse-oximeter.[35]

Capnography

Capnography is the instantaneous measurement of carbon dioxide (CO^2) concentration in the expired gases during a respiratory cycle. Although the first infra-red CO^2 measuring and recording apparatus was introduced in 1943 by Luft, capnography gained widespread popularity in healthcare only in the early 1980s.[36] Continuous waveform capnography, combined with clinical assessment is the most reliable method of confirming and monitoring correct placement of an endotracheal tube at induction of anaesthesia, and during the procedure in people.[37] Given that one veterinary study reported 16 incidences of temporarily unrecognised oesophageal intubation in a 12 month period,[38] capnography has the potential to reduce potentially fatal anaesthetic mishaps, especially during induction of anaesthesia, in veterinary practice. Capnography can also be used to ensure ventilation with supraglottic devices like the V-gel, and to confirm that a spontaneously ventilating patient is breathing.

Blood Pressure

Continuous observation of cardiovascular changes has been considered essential since the early days of general anaesthesia.[24] Blood pressure monitoring in anaesthesia may be useful in two respects: to titrate anaesthetic drugs and fluid management, and to provide a warning of unexpected incidents manifesting as hypo- or hypertension, which could affect patient safety. The recommendation of the Australian and New Zealand College of Anaesthetists is that "the circulation must be monitored at frequent and clinically appropriate intervals by ... measurement of the arterial blood pressure", and this is echoed by the "International Standards for a Safe Practice of Anaesthesia" which state "Arterial blood pressure should be determined ... at least every five minutes, and ... continual registration of arterial pressure is encouraged in appropriate cases".[35]

Of the incidents reported to AIMS,[22] 1,256 out of 2000 occurred in relation to general anaesthesia and 81 of these were first detected by blood pressure (BP) monitoring. A further 25 incidents not associated with general anaesthesia were first detected by blood pressure monitoring. In the detection of incidents in relation to general anaesthesia,

BP monitoring ranked fourth after oximetry, capnography and low-pressure alarms. On the other hand, 38 incidents in which the problem was primarily one of significant change in BP were first detected by means other than the BP monitor (20 clinically, 12 by pulse oximetry and 6 by ECG). In a theoretical analysis of the 1256 anaesthesia incidents, it was considered that on its own, BP monitoring would have detected 919 (73%) incidents, but in the vast majority, by the time this detection has occurred, potential organ damage could have occurred.[22]

Recovery period

Although many complications occur throughout anaesthesia, most anaesthetic associated deaths in animals occur during recovery, especially in the first 3 hours.[39] Forty-seven percent of anaesthesia mortalities in dogs and 60% of anaesthesia mortalities in cats have been reported to occur in the immediate postoperative period.[39]

DISCUSSION

The requirement for this position statement is multifactorial: anaesthesia is performed daily in most veterinary practices in Australia and New Zealand; anaesthesia is not without risk (mortality reported to be 0.1-0.3% in healthy dogs and cats [39-48]); monitoring practices vary greatly;[49] and registration bodies do not provide adequate detail on minimum expectations. The last point has created a situation where many practitioners find themselves in a mandate vacuum, not knowing what, how, when, and why to monitor their patients during anaesthesia.

The rationale for the content of this position statement is based upon a combination of evidence-based detail regarding anaesthesia related complications[28, 39, 41, 44-47,50] and empirical evidence that monitoring of the cardiovascular system (by palpation of a peripheral pulse, measurement of pulse rate, observation of mucous membrane colour and capillary refill time), the respiratory system (measurement of respiratory rate and observation of mucous membrane colour) and the central nervous system (subjective assessment of depth of anaesthesia) is informative and simple to achieve with a stethoscope, timer or watch and targeted observations. To compliment these variables more sophisticated monitoring equipment is suggested to enhance understanding of changes associated with the cardiovascular system (pulse oximetry, capnography and blood pressure), the respiratory system (capnography) and the central nervous system and thermoregulatory system (thermometer). Nevertheless, the most important component of the position statement is that someone is dedicated to the role of monitoring during anaesthesia and ensuring that their attention is focused solely on anaesthesia. This requirement is specified by the Veterinary Board of the Northern Territory,[10] the Assoc VA and the AAHA[19,20] and implied by the other aforementioned guidelines and policies. Interestingly, monitoring of depth of anaesthesia was not referred to in any of the guidelines that were reviewed by the working group. This important factor is included here as it is essential to ensure that animals under veterinary care do not experience any unnecessary pain or suffering during the procedure for which they are being anaesthetised.

The role veterinary nurses and technicians in monitoring anaesthesia cannot be understated. This workforce may often be best placed to fulfil the requirements proposed in this position statement as they are more available to dedicate time and attention to monitoring animals during anaesthesia. Ongoing professional development for these staff is encouraged and supported by the Veterinary Anaesthesia and Analgesia Chapter.

Monitored parameters

Pulse oximetry: despite inconsistent evidence to demonstrate better safety associated with pulse oximetry, medical clinicians agree that

pulse-oximetry should be used in every patient for two reasons: first, the consequences for the patient with arterial hypoxaemia are severe and can result in hypoxic tissue damage; second, hypoxaemia secondary to hypoventilation could be prevented with pulse-oximetry in most patients, especially those patients transitioning from 100% to 21% fraction of inspired oxygen, as seen in the recovery period of general anaesthesia.[33] These risks are also important in veterinary medicine as mortality associated with anaesthesia is most likely to occur in the post-operative period (6-24 h after extubation) for both dogs and cats.[28,51] Additionally, observation of mucous membrane colour is not a sensitive indicator of hypoxaemia.[52]

Capnography: various factors result in either increased, decreased or absent EtCO2. It is more advantageous to have a continuous recording of the capnogram (the waveform): than simply a numerical display of EtCO2 since an analysis of the capnogram gives more information and better insight into the clinical situation. This information permits early diagnosis and intervention when abnormalities develop. There is only one normal capnogram and all variations must be recognised and corrected where possible. As an example, airway pressure monitors used to detect breathing system leaks occasionally fail to detect some disconnections. Under these circumstances a capnograph will detect disconnection instantaneously. In addition, capnography gives an early warning of CO^2 retention by the patient due to a faulty anaesthetic machine, exhausted CO^2 absorber and malfunction of unidirectional valves in circle anaesthetic systems. Further, complete occlusion or accidental disconnection of the endotracheal tube results in an abrupt decrease in EtCO2, whereas a partially kinked or obstructed tube can result in either increased or decreased EtCO2. No studies specifically focus on the association of abnormal capnograms and problem identification and management, but this monitoring equipment provides valuable information about ventilation, pulmonary circulation and equipment.

In the event of cardiopulmonary arrest, cardiac output drops to zero, and thus no transport of CO^2 from the tissues to the lungs can occur. Once chest compressions are initiated, circulation of blood will again deliver CO^2 to the lungs, and the capnogram will rise and fall with each breath. EtCO2 levels of 20 mmHg or greater indicate adequate chest compressions during cardiopulmonary resuscitation (CPR), and failure to achieve a level of at least 10 mmHg after 20 minutes of CPR may help in making the decision to terminate resuscitative efforts.[37,53]

Blood pressure: in dogs and cats, arterial blood pressure can be measured invasively via a catheter placed in a peripheral artery connected to a transducer and noninvasively via a Doppler ultrasonic probe or oscillometric technology often incorporated in a multiparameter monitor.

Body temperature: hypothermia is the most common anaesthetic complication in veterinary anaesthesia, occurring in approximately 40% of anesthetized animals.[54] Hypothermia can be detrimental to overall outcomes because it causes or contributes to sympathetic activation, pharmacokinetic alterations, coagulation abnormalities, blood loss, cardiac morbidity, wound infection, and shivering.[55] Factors contributing to perioperative hypothermia are convection, conduction, radiation, evaporation, intravenous fluid administration, cold and dry inhaled gases, and patient surgical preparation using cold solutions.[55] Anaesthesia prevents heat-seeking behaviours and activities that cause heat production (movement and shivering), and some anaesthetic drugs cause vasodilation, which could contribute to heat loss, although this loss is minimal compared with losses due to blood redistribution.[56] Hypothermia reduces anaesthetic dose requirements, so that relative overdoses are possible if

patient cooling is not detected.[50] Furthermore, recovery from anaesthesia can be prolonged in hypothermic patients, resulting in increased morbidity.[57] Monitoring and management of body temperature is easy to achieve with consideration of ambient temperature, insulation and the use of active warming devices.

Depth of anaesthesia: in veterinary practice monitoring the depth of anaesthesia remains a subjective exercise where a composite approach to evaluate whether the animal is adequately anaesthetised must be performed throughout the process of anaesthesia. The factors that contribute to this composite assessment include autonomic nervous system alterations, muscle tone, eye position, response to stimulation, and respiratory character. As the use of direct monitoring of the central nervous system is not available for veterinarians in a clinical setting, the person responsible for monitoring anaesthesia must use all the information acquired during their continuous observations and integrate these details into the context of the procedure, personnel, the environment and the animal. The ultimate aim is to ensure that the depth of anaesthesia is sufficient to facilitate the performance of the procedure (surgery, dentistry, radiology etc) whilst minimising the adverse effects of anaesthesia and ensuring the patient does not perceive noxious stimuli.

The Veterinary Anaesthesia and Analgesia Chapter hopes this position statement will highlight the importance of monitoring during anaesthesia and provide guidance on how to improve patient safety. However, there are many steps to providing safe anaesthesia, of which monitoring is only one. Some or all the recommendations in this document may need to be exceeded depending on the results of the pre-anaesthetic patient evaluation or changing intra-operative demands. Anaesthetic agent monitoring, airway pressure measurement and direct arterial blood pressure monitoring are examples of more invasive and comprehensive monitoring strategies. Increasing patient comorbidities and sometimes complex procedural requirements also add to the complexity of care and the anaesthetic monitoring requirements. Additionally, it is hoped that this position statement will standardise the expectations of registration bodies to promote improvements in the monitoring of anaesthetised healthy dogs and cats.

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