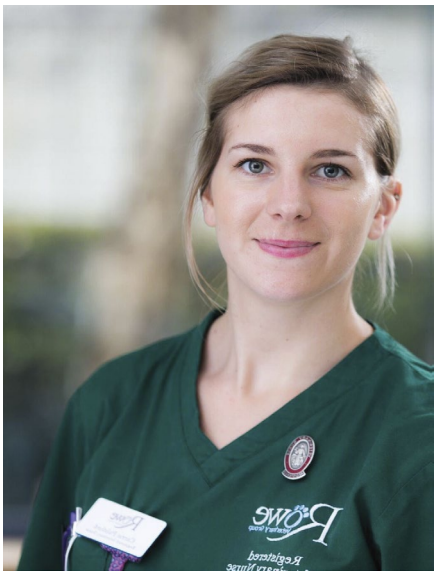
Anaesthetic management of underlying hypertrophic cardiomyopathy in the feline dental patient: An extended patient care report



Carrie Pulsford GradDipVN RVN

Carrie qualified as a Registered Veterinary Nurse in 2016 and has since completed the Graduate Diploma in Clinical and Professional Veterinary Nursing with the Royal Veterinary College in 2019. Carrie is the head veterinary nurse at a busy first opinion practice in Bristol and has a keen interest in anaesthesia, pain management and medical nursing.
Email: carriepulsford@rowevetgroup.com

Carrie Pulsford **GradDipVN RVN**

Rowe Veterinary Group, Bristol, UK

ABSTRACT: Hypertrophic Cardiomyopathy (HCM) is a common cardiac disorder diagnosed in many feline patients. HCM causes the ventricles of the heart to become thickened, therefore affecting its ability to pump blood around the body efficiently. Careful handling and anaesthetic management is important in patients with this condition and will be discussed throughout this case report. HCM leads to cardiovascular effects such as a reduced cardiac output, decreased blood pressure and embolisms. An understanding of the pathophysiology relating to HCM will help when creating the anaesthetic plan for the patient.

Keywords: hypertrophic cardiomyopathy; feline; anaesthesia; monitoring; cardiovascular; pre-medication; patient care report

Patient signalment

Species: Feline

- Breed: Domestic short haired
- Age: 4 years 9 months
- Sex: Male (Neutered)
- Weight: 4.8KG
- American Society of Anaesthesiologists (ASA) Physical Status Scale: Class III (Table 1) (Academy of Veterinary Technician Anaesthetists, 2013)

Patient assessment

The patient presented to the clinic for routine vaccination. Upon clinical examination, the Veterinary Surgeon (VS) noted gingivitis and a feline odontoclastic resorptive lesion (FORL) on the upper premolar, requiring surgical removal. Upon presentation, the cat was tachycardic, with moist mucous membranes, and a brisk capillary refill time. Thoracic auscultation revealed the presence of a grade III heart murmur, which had not been previously noted (Table 2).

Veterinary investigations

A full blood profile was taken and submitted for analysis, including biochemistry, haematology and B-type Natriuretic Peptide test (ProBNP). ProBNP detects the presence of cardiomyopathy in cats by measuring Nt-proBNP which is released from the heart muscle in proportion to the severity of heart disease (Fox et al., 2011). The peptide BNP is synthesised in the atria and ventricles, therefore an increase in the proBNP marker suggests myocardial stretch (Hsu et al., 2009). The patients proBNP was raised (620 pmol/L – abnormal >100pmol/L; Idexx Laboratories), which was indicative of clinically significant cardiomyopathy. Although this is a sensitive marker for cardiomyopathies, other cardiac diseases may increase proBNP, making it non-specific (Fox et al., 2011; Wess et al., 2011). However, this is a quick, non-invasive tool which indicated the need for further investigations prior to general anaesthesia. The haematology and biochemistry samples were unremarkable so the cat was scheduled for an echocardiogram prior to surgery.

DOI: 10.1080/17415349.2021.1876538

Table 1. ASA Physical Status Scale (Academy of Veterinary Technician Anaesthetists, 2013).

Status	Description
ASA I	Minimal risk Normal healthy animal, no underlying disease
ASA II	Slight risk, minor disease present Slight to mild systemic disturbance, animal able to compensate Neonate or geriatric animals, obese
ASA III	Moderate risk, obvious disease present Animal with moderate systemic disease or disturbances, mild clinical signs Anaemia, moderate dehydration, fever low grade heart murmur or cardiac disease
ASA IV	High risk, significantly compromised by disease Pre-existing systemic disease or disturbance of a severe nature Severe dehydration, shock, uraemia or toxaemia, high fever, uncompensated heart disease, uncompensated diabetes, pulmonary disease, emaciation
ASA V	Extreme risk, moribund Surgery often performed in desperation on animal with life threatening systemic disease Advanced cases of heart, kidney, liver or endocrine disease, profound shock, severe trauma, pulmonary embolus, terminal malignancy
E	Emergency

Table 2. Heart murmur classification.

Grade	Description
I	Low intensity murmur only heard in a quiet environment after careful auscultation over a localised cardiac area
II	Low intensity murmur heard immediately when the stethoscope is placed over the PMI
III	Murmur of moderate intensity
IV	High intensity murmur that can be ausculated over several areas without any palpable precordial thrill
V	High intensity murmur with a palpable precordial thrill
VI	High intensity murmur with a palpable precordial thrill that may even be heard when the stethoscope is slightly lifted off the chest wall

Table 2 shows classification of heart murmurs: Kvart (2010); Pace (2017).

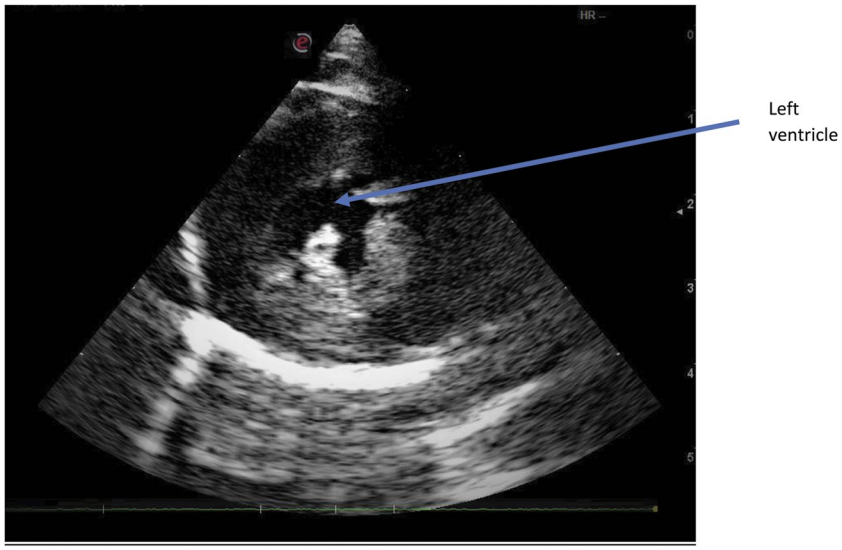


Figure 1. Echocardiogram showing complete obliteration of the left ventricle due to HCM (photo courtesy of The Rowe Veterinary Group).

The registered veterinary nurse (RVN) obtained a systolic blood pressure (BP) measurement using the Doppler method (CAT+, Thames medical) of 120 mmHg prior to the echocardiogram, which is considered normal in the feline patient. The patient remained conscious for the scan which revealed almost complete obliteration of the left ventricle due to moderate hypertrophy of the papillary muscles (Figure 1). The patient was diagnosed with hypertrophic cardiomyopathy (HCM). This is the most common cardiac disease in cats and clinical manifestations include congestive heart failure and aortic thromboembolism (Bonagura et al., 1998). HCM is a risk among breeds such as Maine Coon and Ragdoll cats due to mutations in myosin binding protein C (Meurs et al., 2005, 2007) and screening is often recommended routinely.

RVN's have an important role in pre-anaesthetic assessment and monitoring. The author will focus on the main considerations for anaesthetic management to include:

- Prevention of tachycardia
- Reduction of stress
- Choice of drugs
- Haemodynamic parameters
- Oxygen supplementation

Nursing interventions

Pre-anaesthetic management

Tachycardia can result from stress, but in the presence of HCM, it is important to avoid excess work load on the heart by shortening the duration of diastole and limiting coronary perfusion (Rush, 1998). Whilst hospitalised, cats are confined in an unfamiliar environment and are likely to show emotions such as frustration, fear and anxiety (Carney et al., 2012), leading to tachycardia. Methods to minimise stress may include the use of a hiding place (Figure 2). Wright and Baugh (2018) found that providing a box for a cat to hide in appeared to reduce behavioural signs of stress. The addition of a hiding box had a positive effect on the patient, and enabled a safe and secure environment. The kennel was sprayed with pheromones (Feliway, Ceva) before use. Pheromones are common

Figure 2. Example of a hiding place for cats (photo courtesy of The Rowe Veterinary Group).

in veterinary practices, with diffusers often placed in cat wards with the aim of reducing acute stress on the patients (Mills et al., 2013).

Pre-medication is beneficial prior to anaesthesia as it provides anxiolysis, pre-emptive analgesia and allows for calmer handling and restraint. It also has minimum alveolar concentration (MAC) sparing effects which are beneficial in cardiac disease where maintaining normotension is crucial. Phenothiazines are a popular choice for premedication and can provide anxiolysis, good sedation and a reduce cardiac afterload, which in turn can reduce cardiac work load (Robinson & Borgeat, 2016). Acepromazine is commonly used in first opinion practice. Relatively high doses may be required to reduce afterload to a beneficial therapeutic level, and phenothiazines may cause vasodilation and hypotensive side effects (Murrell, 2007).

Alpha 2-adrenergic agonists have shown to improve cardiac performance in a small study of cats with HCM (Lamont et al., 2002), with dexmedetomidine being popular choices of alpha 2 s in veterinary practice. This is more advantageous over medetomidine as it provides improved analgesia, more predictable sedation and a reduced metabolism of the drug (Duke-Novakovski, 2016). Alpha 2 agonists provide good sedation, minimal stress and analgesia, but also produce bradycardia; a common side effect caused by a baroreceptor- mediated reflex in response to vasoconstriction (Duke-Novakovski, 2016). This bradycardia is usually well tolerated, but in the presence of cardiac disease its use must be carefully justified. The bradycardic effects of dexmedetomidine may be beneficial in some cardiac disease and can assist with ventricular filling time, which may be desirable in HCM (Robinson & Borgeat, 2016). Physiologically, bradycardia can also cause an increased cardiac preload and risk of CHF (Robinson & Borgeat, 2016). Therefore, the use of alpha 2 agonists in cases of HCM remains controversial.

There are varying views on the best drug protocol for HCM. The VS prescribed dexmedetomidine 1 µg/kg (Dexdomitor, Zoetis 0.5 mg/ml) with methadone 0.3 mg/kg (Comfortan, Dechra 10 mg/ml) administered intravenously. This produced profound sedation, allowing less induction agent requirements and MAC sparing effects. Flow by oxygenation was administered for five minutes prior to induction. Pre-oxygenation reduces the risk of haemoglobin desaturation and hypoxaemia during the induction process (Bednarsk, 2011). The patient was induced with incremental dosing of Alfaxalone (Alfaxan, Jurox 10 mg/ml), to a total dose of 2 mg/kg due to the minimal effects on cardiopulmonary function and vascular system parameters (Muir et al., 2009).

Peri-anaesthetic management

Anaesthesia was maintained with Isoflurane (Iso-Vet, Chanelle) delivered in oxygen via an Ayres T-piece. Volatile agents can cause dose dependent hypotension due to negative inotropic and systemic vasodilatory effects (Hodgson et al., 1998). Haemodynamic parameters were regularly monitored throughout the peri-operative period. The use of advanced direct techniques such as arterial catheters are "gold standard" for accurate BP and cardiac output (CO) measurements, however, this is not available in all veterinary practices so other techniques are required (Boag & Hughes, 2005). In this patient, non-direct BP via Doppler was monitored alongside peripheral pulse palpation. A limitation of the Doppler technique is the fact that only information regarding systolic BP can be obtained; whereas oscillometric BP measures systolic, diastolic and mean arterial pressure (MAP) (Clapham, 2011). MAP is a good indicator for tissue perfusion (Cooper & Cooper, 2012) but is also reliant on CO and systemic vascular resistance (Pachtinger & Drobatz, 2008). Physiologically, left ventricle hypertrophy often leads to diastolic dysfunction resulting in poor CO (Robinson & Borgeat, 2016); therefore, this is likely to be decreased in this patient. It has been reported that oscillometric monitors fail to produce results more often than the Doppler method and accuracy is thought to be reduced in patients under 5KG (Love & Harvey, 2006). Jepson et al. (2005) found that the Doppler method succeeded the oscillometric machine for measuring systolic BP in cats in terms of repeatability of results.

Hypotension is a common finding during anaesthesia and can result from drug administration, or underlying cardiac disease (Duke-Novakovski, 2016). In this case, it was desirable to maintain normotension and support cardiac function. Patients presenting with HCM are at risk of CHF, and so the use of intravenous fluid therapy can increase preload and present a risk of decompensation (Robinson & Borgeat, 2016). Judicious fluid therapy use may be needed to maintain normotension and replace fluid deficits, but the choice and rate should be carefully considered and balanced with clinical assessment. Therefore, treatment for hypotension with drug therapy may be required, including positive inotropes and alpha1 adrenergic agonists. Prior to anaesthesia a Dobutamine (Hameln, 12.5 mg/ml) constant rate infusion was calculated (2 µg/kg/min). The risk of cardiac arrhythmias is low when using dobutamine compared to dopamine because endogenous noradrenaline is not released (Duke-Novakovski, 2016). The use of positive inotropes such as dobutamine increase BP by increasing CO (Pascoe et al., 2006). Alternatively, pure alpha-1 adrenoceptor agonists such as phenylephrine can be administered (Riesen et al., 2007). Phenylephrine specifically increases systemic vascular resistance without increasing myocardial contractility, making this ideal for use with HCM patients (Robinson & Borgeat, 2016). Pascoe et al. (2006) argues that this protocol may be less desirable because tissue perfusion and CO may decrease. A study looking at the effects of dopamine and phenylephrine administration in anaesthetised cats with HCM found that heart rate increased during dopamine administration (Wiese et al., 2012). This is expected due to its ability to increase CO and activity as a B1-adrenergic receptor agonist (Adams, 2009). It could be discussed whether this effect is beneficial, as medical management of cats with HCM often includes treatments to reduce tachycardia. Further study is required to determine the best treatment for anaesthetic induced hypotension in cats with HCM. The systolic BP remained between 100-120mmHg throughout the procedure so interventions were not required.

Following full mouth radiographs, a FORL present on the upper premolar necessitated extraction. Analgesia provided by a maxillary nerve block (Lidocaine 1%, Hameln, maximum dose 4 mg/kg) provides analgesia, prevents peripheral sensation and decreases N-methyl-D-aspirate receptor activity, allowing decreased inhalation agent percentages (Reuss-Lamky, 2007; Rochette, 2005). It is important to not exceed the maximum dose rate of lidocaine in cats as toxicity can lead to cardiovascular depression (Duke-Novakovski, 2016). The RVN performed the block under supervision of the VS following aseptic preparation, using a 25 g needle. A study conducted by Aguiar et al. (2015) found that maxillary nerve blocks with lidocaine and bupivacaine in cats decreased the patients HR, BP and isoflurane percentage in comparison to the control group. Post-operatively, the study also found that pain scores were lower two and four hours after. The maxillary block had a good effect on the patients HR, BP and isoflurane percentage. There is some

discussion as to the best time to administer Non-steroidal anti-inflammatory drugs (NSAIDs) during anaesthesia. Concerns surrounding prostaglandin protection in the face of hypotension result in some VS opting to wait until the hypotensive effect of anaesthetic drugs have worn off before administering NSAIDs (Gurney, 2012). This was applicable for this case, and the patient received an injection of meloxicam 0.2 mg/kg (Metacam mg/ml, boehringer) in the recovery period.

During anaesthesia, the monitoring of patients often falls to the RVN. For this patient, a multi-parameter monitor was used (Surgi-vet, Burtons). The electrocardiogram (ECG) monitor was placed onto the patient throughout the anaesthetic, although no abnormalities were noted. A side-stream capnograph was attached to the patient's endotracheal tube, enabling the RVN to monitor the ventilation status throughout the anaesthetic. Capnography detects the highest and lowest values for carbon dioxide in the respired gas and then reports them as inspired and end-tidal partial pressures ($ETCO_2$) (Barter, 2012). It is a simple and practical indicator of CO in any anaesthetised patient (Vigani, 2015). A reduction of BP and $ETCO_2$ in an anaesthetised patient may reflect a primary reduction in CO (Shibutani et al., 1994; Vigani, 2015). The patients $ETCO_2$ parameter remained normal throughout the procedure (35–40 mmHg). A "steep expiratory upstroke" was noted mid-way through the surgery, indicating a potential blockage to the endotracheal tube (Figure 3). The patient was re-intubated and the issue rectified.

Normal thermoregulatory mechanisms can be impaired by anaesthesia as it reduces the temperature threshold required to stimulate reflex vasoconstriction in the hypothalamus and vasodilation associated with anaesthetic agents (Armstrong et al., 2005). Some patients, including cats have a large surface area to volume ratio and are at increased risk of hypothermia (Murison, 2001). During dental procedures heat is lost through evaporation and wetting of the patient's fur with water from the dental drill and scaler. Normothermia was maintained by placing the cat on a Vet-bed, a blanket wrapped around the body and a thermostatic controlled warm air device (Bair Hugger) placed over the top of the cat. Hypothermia can delay post-anaesthetic recovery due to reduced hepatic drug metabolism (Pottie et al., 2007) and reduced CO (Murison, 2001).

Post anaesthetic management

Tracheal and laryngeal injury relating to intubation is well documented in cats (Bauer et al., 2009; Bhandal & Kuzma, 2008; Hardie et al., 1999; Mitchell et al., 2000). The patient was extubated following clear palpebral reflexes and ear twitching. Laryngospasm typically occurs immediately after extubation and is particularly common following dental procedures and in cats (Mosing, 2016). A rolled towel was placed under the patients neck to ensure the head remained extended and the tongue pulled forward in order to maintain a patent airway (Figure 4).

RVN's have a significant role to play in identifying pain post operatively. Cats response to pain is more subtle than dogs and therefore hide pain as a protective mechanism (Capner et al., 1999). In this patient, it was important to prevent tachycardia, so identifying pain without causing stress to the patient was important. The RVN used the Colorado State University Feline Acute Pain Scale to assess pain in the patient every hour following surgery. This scale incorporates images showing different postures and expressions as a guideline to the descriptions (Barratt, 2013). The patient scored low (2) and his HR remained stable. The patient was monitored throughout the afternoon and further analgesia was not needed.

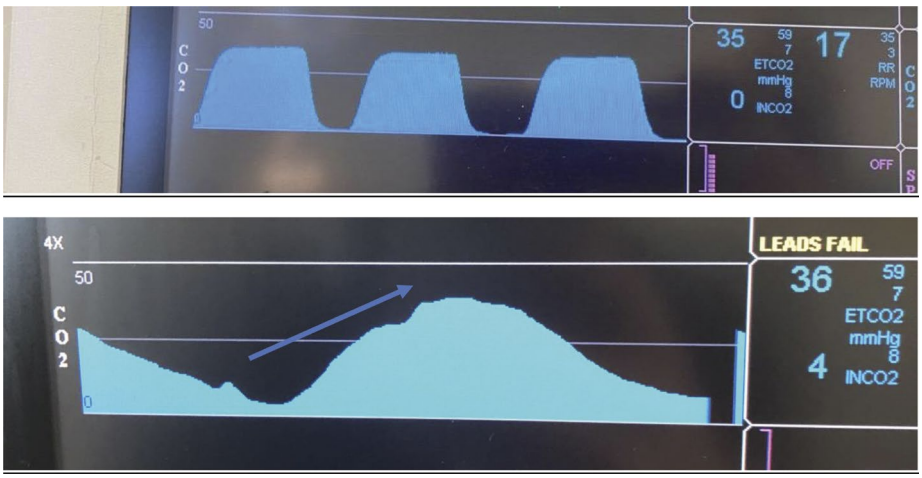


Figure 3. Example of a normal capnograph trace vs "steep expiratory upstroke" on the capnograph (photo courtesy of The Rowe Veterinary Group).

Figure 4. Example of a feline patient recovering from dental surgery (photo courtesy of The Rowe Veterinary Group).

Conclusion

The patient made a full recovery and was discharged later that day. FORLs are a painful condition which could lead to the patient becoming in-appetent, therefore despite this being a high-risk anaesthetic it was necessary to remove this tooth. Constant nursing support and expectations of complications must be prepared for prior to the surgery to allow all personnel involved in the anaesthetic to be prepared.

Acknowledgment

This care report was produced as part of her studies for the Royal Veterinary College Graduate Diploma in Professional and Clinical Veterinary Nursing.

Disclosure statement

No potential conflict of interest was reported by the author.

References

Adams, R. (2009). Adrenergic agonists and antagonists. In J. E. Riviere & M. G. Papich (Eds.), *Veterinary pharmacology and therapeutics* (9th ed., pp. 125–143). Iowa State Press.

Aguiar, J., Chebroux, A., Martinez-Taboada, F., & Leece, E. A. (2015). Analgesic effects of maxillary and inferior alveolar nerve blocks in cats undergoing dental extractions. *Journal of Feline Medicine and Surgery*, *17*(2), 110–116. https://doi.org/10.1177/1098612X14533551

Armstrong, S. R., Roberts, B. K., & Aronsohn, M. (2005). Perioperative hypothermia. *Journal of Veterinary Emergency and Critical Care*, *15*(1), 32–37. https://doi.org/10.1111/j.1476-4431.2005.04033.x

AVTAA. (2013). American Society of Anesthesiologists (ASA) Physical Status Scale. https://www.avtaa-vts.org/asa-ratings.pml

Barter, L. (2012). Capnography. In J. Burkitt & H. Creedon (Eds.), *Advanced monitoring and procedures for small animal emergency and critical care* (pp. 340–348). John Wiley and Sons, Inc.

Barratt, L. (2013). Feline pain assessment and scoring systems. *The Veterinary Nurse*, *4*(8), 470–477. https://doi.org/10.12968/vetn.2013.4.8.470

Bauer, M., Clark-Price, S., & McFadden, M. (2009). Anesthesia case of the month. *Journal of the American Veterinary Medical Association*, *234*(12), 1539–1541. https://doi.org/10.2460/javma.234.12.1539

Bednarsk, R., Grimm, K., Harvey, R., Lukasik, V., Penn, S., Sargent, B., Spelts, K., & American Animal Hospital Association. (2011). AAHA anesthesia guidelines for dogs and cats. *Journal of the American Animal Hospital Association*, *47*(6), 377–385. https://doi.org/10.5326/JAAHA-MS-5846

Bhandal, J., & Kuzma, A. (2008). Tracheal rupture in a cat: Diagnosis by computed tomography. *The Canadian Veterinary Journal*, *49*, 595–597.

Boag, A., & Hughes, D. (2005). Assessment and treatment of perfusion abnormalities in the emergency patient. *The Veterinary Clinics of North America. Small Animal Practice*, *35*(2), 319–342. https://doi.org/10.1016/j.cvsm.2004.10.010

Bonagura, J. D., Miller, M. W., & Darke, P. G. G. (1998). Doppler echocardiography I: Pulsed-wave and continuous-wave examinations. *Veterinary Clinics of North America: Small Animal Practice*, *28*(6), 1325–1359. https://doi.org/10.1016/S0195-5616(98)50126-X

Capner, C., Lascelles, B., & Waterman-Pearson, A. (1999). Current British veterinary attitudes to perioperative analgesia for dogs. *The Veterinary Record*, *145*(4), 95–99. https://doi.org/10.1136/vr.145.4.95

Carney, H., Little, S., Brownlee-Tomasso, D., Harvey, A., Mattox, E., Robertson, S., Rucinsky, R., Stephens-Manley, D., & International Society of Feline Medicine. (2012). AAFP and ISFM feline-friendly nursing care guidelines. *Journal of Feline Medicine and Surgery*, *14*(5), 337–349. https://doi.org/10.1177/1098612X12445002

Clapham, L. (2011). How to measure blood pressure: Direct and indirect techniques. *The Veterinary Nurse*, *2*(6), 324–326. https://doi.org/10.12968/vetn.2011.2.6.324

Cooper, E., & Cooper, S. (2012). Direct systemic arterial blood pressure monitoring. In J. Burkitt-Creedon & H. Davies (Eds.), *Advanced monitoring and procedures for small amimal emergency and critical care* (pp. 122–133). Wiley-Blackwell.

Duke-Novakovski, T. (2016). Pain management II: Local and regional anaesthetic techniques. In T. Duke-Novakovski, M. Vries, & C. de Seymour (Eds.), *BSAVA manual of canine and feline anaesthesia and analgesia* (3rd ed., pp. 143–158). British Small Animal Veterinary Association.

Fox, P. R., Rush, J. E., Reynolds, C. A., DeFrancesco, T. C., Keene, B. W., Atkins, C. E., Gordon, S. G., Schober, K. E., Bonagura, J. D., Stepien, R. L., Kellihan, H. B., MacDonald, K. A., Lehmkuhl, L. B., Nguyenba, T. P., Sydney Moise, N., Lefbom, B. K., Hogan, D. F., & Oyama, M. A. (2011). Multicenter evaluation of plasma N-terminal probrain natriuretic peptide (NT-pro BNP) as a biochemical screening test for asymptomatic (occult) cardiomyopathy in cats. *Journal of Veterinary Internal Medicine*, *25*(5), 1010–1016. https://doi.org/10.1111/j.1939-1676.2011.00776.x

Gurney, M. (2012). Pharmacological options for intra-operative and early postoperative analgesia: An update. *Journal of Small Animal Practice*, *53*(7), 377–386. https://doi.org/10.1111/j.1748-5827.2012.01243.x

Hardie, E. M., Spodnick, G. J., Gilson, S. D., Benson, J. A., & Hawkins, E. C. (1999). Tracheal rupture in cats: 16 cases (1983-1998). *Journal of the American Veterinary Medical Association*, *214*(4), 508–512.

Hodgson, D., Dunlop, C., Chapman, P., & Grandy, J. (1998). Cardiopulmonary effects of anesthesia induced and maintained with isoflurane in cats. *American Journal of Veterinary Research*, *59*(2), 182–185.

Hsu, A., Kittleson, M., & Paling, A. (2009). Investigation into the use of plasma NT-proBNP concentration to screen for feline hypertrophic cardiomyopathy. *Journa of Veterinary Cardiology*, *11*(1), 63–70.

Jepson, R. E., Hartley, V., Mendl, M., Caney, S. M. E., & Gould, D. J. (2005). A comparison of CAT Doppler and oscillometric Memoprint machines for non-invasive blood pressure measurement in conscious cats. *Journal of Feline Medicine and Surgery*, *7*(3), 147–152. https://doi.org/10.1016/j.jfms.2004.08.003

Kvart, C. (2010). Clinical approach to cardiac murmurs. In V. Luis Fuentes, L. R. Johnson, & S. Dennis (Eds.), *BSAVA manual of canine and feline cardiorespiratory medicine* (2nd ed.). BSAVA.

Lamont, L., Bulmer, B., Sisson, D., Grimm, K., & Tranquilli, W. (2002). Doppler echocardiographic effects of medetomidine on dynamic left ventricular outflow tract obstruction in cats. *Journal of the American Veterinary Medical Association*, *221*(9), 1276–1281. https://doi.org/10.2460/javma.2002.221.1276

Love, L., & Harvey, R. (2006). Arterial blood pressure measurement: Physiology, tools and techniques. *Compendium Vet*, *1* 450–462.

Meurs, K. M., Norgard, M. M., Ederer, M. M., Hendrix, K. P., & Kittleson, M. D. (2007). A substitution mutation in the myosin binding protein C gene in ragdoll hypertrophic cardiomyopathy. *Genomics*, *90*(2), 261–264. https://doi.org/10.1016/j.ygeno.2007.04.007

Meurs, K. M., Sanchez, X., David, R. M., Bowles, N. E., Towbin, J. A., Reiser, P. J., Kittleson, J. A., Munro, M. J., Dryburgh, K., Macdonald, K. A., & Kittleson, M. D. (2005). A cardiac myosin binding protein C mutation in the Maine Coon cat with familial hypertrophic cardiomyopathy. *Human Molecular Genetics*, *14*(23), 3587–3593. https://doi.org/10.1093/hmg/ddi386

Mills, D., Dube, M., & Zulch, H. (2013). *Stress and pheromotherapy in small animal clinical behaviour*. Wiley and Blackwell.

Mitchell, S. L., McCarthy, R., Rudloff, E., & Pernell, R. T. (2000). Tracheal rupture associated with intubation in cats: 20 cases (1996-1998). *Journal of the American Veterinary Medical Association*, *216*(10), 1592–1595. https://doi.org/10.2460/javma.2000.216.1592

Mosing, M., (2016). General principles of perioperative care. In T. Duke-Novakovski, M. Vries, & C. de Seymour (Eds.), *BSAVA manual of canine and feline anaesthesia and analgesia* (3rd ed., 13–23). British Small Animal Veterinary Association.

Muir, W., Lerche, P., Wiese, A., Nelson, L., Pasloske, K., & Whittem, T. (2009). The cardiorespiratory and anesthetic effects of clinical and supraclinical doses of alfaxalone in cats. *Veterinary Anaesthesia and Analgesia*, *36*(1), 42–54. https://doi.org/10.1111/j.1467-2995.2008.00428.x

Murison, P. (2001). Prevention and treatment of perioperative hypothermia in animals under 5 kg bodyweight. *In Practice*, *23*(7), 412–418. https://doi.org/10.1136/inpract.23.7.412

Murrell, J. (2007). Choice of pre-medicants in cats and dogs. *In Practice*, *29*(2), 100–106. https://doi.org/10.1136/inpract.29.2.100

Pace, C. (2017). How to maximise your auscultation technique. *The Veterinary Nurse*, *8*(9), 512–515. https://doi.org/10.12968/vetn.2017.8.9.512

Pachtinger, G., & Drobatz, K. (2008). Assessment and treatment of hypovolemic states. *The Veterinary Clinics of North America. Small Animal Practice*, *38*(3), 629–643. https://doi.org/10.1016/j.cvsm.2008.01.009

Pascoe, P., Ilkiw, J., & Pypendop, B. (2006). Effects of increasing infusion rates of dopamine, dobutamine, epinephrine, and phenylephrine in healthy anesthetized cats. *American Journal of Veterinary Research*, *67*(9), 1491–1499. https://doi.org/10.2460/ajvr.67.9.1491

Pottie, R. J., Dart, C. M., Perkins, N. R., & Hodgson, D. R. (2007). Effect of hypothermia on recovery from general anaesthesia in the dog. *Australian Veterinary Journal*, *85*(4), 158–162. https://doi.org/10.1111/j.1751-0813.2007.00128.x

Reuss-Lamky, H. (2007). Administering dental nerve blocks. *Journal of the American Animal Hospital Association*, *43*(5), 298–305. https://doi.org/10.5326/0430298

Riesen, S. C., Kovacevic, A., Lombard, C. W., & Amberger, C. (2007). Prevalence of heart disease in symptomatic cats: An overview from 1998 to 2005. *Schweizer Archiv fur Tierheilkunde*, *149*(2), 65–71. https://doi.org/10.1024/0036-7281.149.2.65

Robinson, R., & Borgeat, K. (2016). Cardiovascular disease. In T. Duke-Novakovski, M. Vries, & C. de Seymour (Eds.), *BSAVA manual of canine and feline anaesthesia and analgesia* (3rd ed., 283–313). British Small Animal Veterinary Association.

Rochette, J. (2005). Regional anesthesia and analgesia for oral and dental procedures. *The Veterinary Clinics of North America. Small Animal Practice*, *35*(4), 1041–1058. https://doi.org/10.1016/j.cvsm.2005.02.004

Rush, J. E. (1998). Therapy of feline hypertrophic cardiomyopathy. *The Veterinary Clinics of North America. Small Animal Practice*, *28*(6), 1459–1479. https://doi.org/10.1016/S0195-5616(98)50132-5

Shibutani, K., Muraoka, M., Shirasaki, S., Kubal, K., Sanchala, V. T., & Gupte, P. (1994). Do changes in end-tidal PCO2 quantitatively reflect changes in cardiac output? *Anesthesia and Analgesia*, *79*(5), 829–833. https://doi.org/10.1213/00000539-199411000-00002

Vigani, A., (2015). Cardiac output measurement. In K. Grimm, L. A. Lamont, W. J. Tranquilli, S. A. Greene, & S. A. Robertson (Eds.), *Veterinary anesthesia and analgesia* (5th ed., pp. 473–482). John Wiley & Sons Inc.

Wess, G., Daisenberger, P., Mahling, M., Hirschberger, J., & Hartman, K. (2011). Utility of measuring plasma N-terminal pro-brain natriuretic peptide in detecting hypertrophic cardiomyopathy and differentiating grades of severity in cats. *Veterinary Clinical Pathology*, *40*(2), 237–244. https://doi.org/10.1111/j.1939-165X.2011.00305.x

Wiese, A., Barter, L., Ilkiw, J., Kittleson, M., & Pypendop, B. (2012). Cardiovascular and respiratory effects of incremental doses of dopamine and phenylephrine in the management of isoflurane-induced hypotension in cats with hypertrophic cardiomyopathy. *American Journal of Veterinary Research*, *73*(6), 908–916. https://doi.org/10.2460/ajvr.73.6.908

Wright, C., & Baugh, S. (2018). Effectiveness of providing a box, or partially covering the cage front, on reducing cat stress. *The Veterinary Nurse*, *9*(6), 328–396. https://doi.org/10.12968/vetn.2018.9.6.328