Open Veterinary Journal, (2024), Vol. 14(6): 1483-1490
ISSN: 2226-4485 (Print)
ISSN: 2218-6050 (Online)

Case Report
DOI: *10.5455/OVJ.2024.v14.i6.17*

Submitted: 03/02/2024 Accepted: 15/05/2024 Published: 30/06/2024

Anesthetic management of a dog undergoing unilateral adrenalectomy for phaeochromocytoma excision using a partial intravenous anesthetic protocol

Morgane Gavet* and Stéphane Junot

Service d'Anesthésie, Université de Lyon, Marcy l'Etoile, France

Abstract

Background: The anesthetic management of adrenalectomies for phaeochromocytoma excision, a catecholamine-secreting tumor, is challenging due to the potential for fatal complications following severe hemodynamic variations, including hypertensive crisis following tumor manipulation or sympathetic stimulation, but also severe hypotension and volume depletion post resection.

Case Description: An 11 kg, 15-year-old male neutered Jack Russel Terrier, with mitral valve disease stage B2, was referred for adrenalectomy for phaeochromocytoma resection. The patient was administered per os prazosin 0.11 mg/kg twice a day and amlodipine 0.125 mg/kg once a day for preoperative stabilization. On the day of surgery, the dog received maropitant 1 mg/kg intravenously (IV) and was premedicated with 0.2 mg/kg methadone IV. Anesthesia was induced with alfaxalone 1 mg/kg IV and midazolam 0.2 mg/kg IV and maintained with partial intravenous anesthesia using sevoflurane in 70% oxygen and constant rate infusions of dexmedetomidine 0.5 µg/kg/hour and maropitant 100 µg/kg/hour. After induction of anesthesia, the dog was mechanically ventilated, and a transversus abdominal plane block was performed with ropivacaine 0.2%. The dog remained remarkably stable with a single, self-limiting, hypertension episode recorded intraoperatively. Postoperative rescue analgesia consisted of methadone and ketamine. The dog was discharged 48 hours after surgery, but persistent hypertension was reported at suture removal.

Conclusion: The use of a low-dose dexmedetomidine CRI, a maropitant CRI, and a transversus abdominal plane block provided stable perioperative hemodynamic conditions for phaeochromocytoma excision in a dog.

Keywords: Anesthesia, Dexmedetomidine, Maropitant, Phaeochromocytoma, TAP.

Introduction

Phaeochromocytomas are catecholamine-secreting tumors of the chromaffin cells in the adrenal medulla. They account for 0.01%–0.1% of all canine tumors (Galac and Korpershoek, 2017). Clinical signs are non-specific and mostly result from catecholamine-induced hypertension, but they may also arise from a mass effect. Clinical signs include neurological signs, weakness, collapse, restlessness, polyuria-polydipsia, anorexia, and respiratory signs (Twedt and Wheeler, 1984). The treatment of choice is surgical adrenalectomy.

The anesthetic management of adrenalectomies for phaeochromocytoma excision is challenging due to the potential for fatal complications following severe hemodynamic variations. These include hypertensive crisis following tumor manipulation or other sympathetic stimulation (anesthetic drugs, physiological changes, surgical stress). Severe hypotension and volume depletion can also occur after tumor resection because of a sudden decrease in catecholamine levels, which may require prompt correction with vasoactive drugs and blood volume resuscitation (Ramakrishna, 2015). The goal of the anesthetist is to avoid the occurrence of any sympathetic discharge during the surgical procedure but also to limit any hypotensive response following the tumor removal. The use of both anti-hypertensive, such as short acting β-blockers, and vasodilator agents, in particular sodium nitroprusside and nitroglycerin, is often raised for intraoperative hemodynamic management. There is however no consensus regarding their use, and they are not readily available for veterinary surgeons.

Dexmedetomidine is a highly selective α-2 adrenoceptor agonist commonly used in veterinary anesthesia (Pan *et al*., 2021). Its sympatholytic properties (Gertler *et al*., 2001) render this agent attractive for the anesthetic management of phaeochromocytoma resection. While its use as an intraoperative constant rate infusion (CRI) has been described in humans (Wong and Cheung, 2004; Bryskin and Weldon, 2010; Schumann and Hudcova, 2010; Jung *et al*., 2012; Khetarpal *et al*., 2014; Ali Erdogan *et al*., 2015; Dias *et al*., 2015; Hedge *et al*., 2016; Shrestha *et al*., 2016; Giordano *et al*., 2019;), concomitant vasodilators were still frequently needed during surgical manipulation. There is, to date, a single case report of its perioperative use

***Corresponding Author:** Morgane Gavet. Service d'Anesthésie, Université de Lyon, , Marcy l'Etoile, France.
Email: *morgane.gavet@vetagro-sup.fr*

for phaeochromocytoma removal in a canine patient (Viilmann and Vettorato, 2021).

We hereby present the successful anesthetic management of a dog undergoing unilateral adrenalectomy for a phaeochromocytoma excision using a low-dose dexmedetomidine CRI as part of the hemodynamic stabilization strategy.

Case Details

A 15-year-old male neutered Jack Russel Terrier weighing 11 kg was referred to the VetAgro Sup Small Animal Hospital for the treatment of a suspected phaeochromocytoma. The patient was referred for alternance of severe lethargy and agitation phases, tremors, and polyuria-polydipsia. The dog also presented a left-sided grade IV/VI apical heart murmur with a diagnosed ACVIM stage B2 mitral valve disease (MVD) treated with pimobendan (Cardisure 2.5 mg, Dechra, France) 0.25 mg/kg per os (PO) twice a day (BID). No other abnormality was noted on physical examination. Blood work only revealed mildly elevated ALT. Abdominal ultrasonography performed by the referring veterinarian revealed a mass on the left adrenal and a diffuse hypertrophy of the right adrenal gland. A low-dose dexamethasone suppression test was performed and was not supportive of hyperadrenocorticism (T0 149 nmol/l, T+4H 32 nmol/l^{-}, T+8H 30 nmol/l). Systolic arterial blood pressure (SAP) was measured with Doppler ultrasonography at 190 mmHg. Urinary metanephrine/creatinine (513) and normetanephrine/creatinine (660) ratios were in favor of a phaeochromocytoma (Salesov *et al*., 2015). The patient was started on amlodipine (Amodip 1.25, CEVA, France) 0.125 mg/kg PO once a day (SID) and referred to the VetAgro Sup Small Animal Hospital 1 month later for adrenalectomy. Upon admission, physical examination appeared normal, with a body condition score of 3/5 and a Doppler systolic blood pressure measurement of 220 mmHg. Hematology and biochemistry analysis were repeated and revealed no other abnormality than the mild ALT elevation (182IU/l). A computed tomography scan revealed the presence of a 16 × 14 × 23 mm well-demarcated left adrenal mass with no vascular invasion, diffuse hypertrophy of the right adrenal gland, and the absence of overt metastasis. Prazosin (Alpress 2.5 mg, Pfizer, France) 0.11 mg/kg PO BID was added to his treatments. Surgery was scheduled for 1 week later.

Upon admission the day before surgery, the patient appeared agitated. Physical examination revealed a HR of 120 bpm with a stable heart murmur. Preoperative thromboelastometry ROTEM (EXTEM, INTEM) showed no abnormality. Blood typing was DEA1.1+. A Doppler SAP measurement revealed an SAP of 180 mmHg. The dog received acepromazine (Calmivet, Vetoquinol, France) 10 µg/kg intramuscularly every 8 hours (q8h) during preoperative hospitalization for anxiolysis and potential blood pressure reduction until 8 hours before premedication. Prazosin was withheld 24 hours before the surgery while amlodipine and pimobendan were continued. The dog was fasted from food 8 hours before surgery.

The patient was classified as an American Society of Anesthesiologists grade 3. Before premedication, a 22G intravenous (IV) catheter was placed in the left cephalic vein. On the morning of the surgery, the dog received pimobendan 0.25 mg/kg, amlodipine 0.125 mg/kg PO, and maropitant 1 mg/kg (Prevomax, Dechra, France) IV. The dog was premedicated 15 minutes (minute) later with 0.2 mg/kg methadone (Comfortan, Dechra, France) IV. The patient was mildly sedated. Mask preoxygenation was performed with 100% oxygen for 5 minutes before induction. Anesthesia was induced with midazolam (Midazolam, Viatris, France) 0.2 mg/kg and alfaxalone 1 mg/kg (Alfaxan, Jurox, France) given slowly IV to effect to allow endotracheal intubation. Once intubated, the animal was placed in dorsal recumbency for surgical preparation. Anesthesia was maintained with sevoflurane (SevoFlo, Zoetis, France) in 70% oxygen through a rebreathing circuit, and a 0.5 µg/kg/hour dexmedetomidine (Asthenodex, Osalia, France) CRI was immediately started after induction. A 22G arterial catheter was placed in the right dorsal pedal artery for continuous invasive blood pressure (IBP) measurement. A second 22G IV catheter was placed in the right cephalic vein in anticipation of potential needs for administering emergency drugs, massive fluid therapy, or transfusion during the surgery. The depth of anesthesia was clinically evaluated with jaw tone, eye position, and palpebral reflexes.

Sevoflurane concentration was adapted to maintain a surgical plane of anesthesia. Lactated Ringer's solution (Ringer Lactate, CEVA, France) was infused at a rate of 3 ml/kg/hour. An ultrasound-guided Transversus Abdominal Plane (TAP) block was performed with a cranial subcostal and caudal lateral abdominal injection bilaterally under sterile conditions with ropivacaine 0.2% 0.3 ml/kg (Ropivacaïne, Mylan, France) per point, as described by Romano *et al*. (2021). The patient was then transferred to the operating theatre in dorsal recumbency. A maropitant CRI was initiated at 100 µg/kg/hour and the dexmedetomidine CRI was continued. Ampicillin sulbactam (Unacim, Pfizer, France) was administered IV at a dose of 20 mg/kg q90 minute. Mechanical ventilation with a GE anesthesia machine ventilator (Carestation 620, GE Healthcare, France) was initiated in a volume-controlled mode. A tidal volume of 10ml/kg was set with a RR of 16 breaths/minute, with 4 cmH_20 positive end-expiratory-pressure. These parameters resulted in a peak inspiratory pressure of 16–18 cmH_20 and mild permissive hypercapnia.

Vital functions of the animal were assessed using a multiparameter monitor (ePM 12M Vet, Mindray, China) that displayed continuously the following parameters: a lead-II electrocardiogram, heart rate (HR), oscillometric non-invasive blood pressure (NIBP), IBP,

pulse oximetry (SpO2), temperature (T), RR, end-tidal CO2 (PE'CO2), spirometry, and gas analysis including inspired and expired fraction of sevoflurane and oxygen (Fi'Sevo, Fi'O2, Et'Sevo, Et'O2) and recorded q5min. Variations in the parameters during the anesthesia are presented in Table 1.

A midline laparotomy was performed for left adrenalectomy. After meticulous surgical dissection, the adrenal gland was removed without complication within a total surgical time of 93 minutes.

Throughout the surgery, HR varied between 60 and 70 bpm with a mean IBP ranging from 80 to 95 mmHg which correlated well with NIBP. During adrenal mass manipulation, 40 minutes after the start of surgery, an increase in HR up to 80 bpm was noticed, associated with an increase in MAP and SAP up to 120 mmHg and 140 mmHg, respectively. This self-limiting episode lasted a couple of minutes. The adrenal gland was removed 20 minutes after this hypertension peak, and no further hemodynamic instability was noted thereafter. Et'Sevo was kept between 1.4 and 1.7% with an anesthetic plane considered adequate. No additional analgesia was deemed necessary intraoperatively. The only other intraoperative complication noticed was moderate hypothermia, with an oesophageal T ranging from 34.8°C to 35.5°C despite active warming. Thus, apart from one mild episode of hemodynamic instability, the patient remained stable despite phaeochromocytoma manipulation and adrenal gland removal.

Table 1. Hemodynamic, respiratory, thermic, and sevoflurane-related parameters during anesthesia of a dog for phaeochromocytoma excision anesthetized with partial intravenous anesthesia, including dexmedetomidine and maropitant CRIs.

	Mean ± SD
HR (beats per minute)	65 ± 7
SAP (IBP)	102 ± 19
MAP (IBP)	85 ± 9
DAP (IBP)	71 ± 9
SpO_2	96 ± 1
RR (breath per minute)	14 ± 2
PE'CO2 (mmHg)	48 ± 5
T (°C)	35.1 ± 0.7
Sevoflurane evaporator %	2 ± 0.3
Fe'Sevo	1.6 ± 0.1
Fi'Sevo	1.85 ± 0.1

Note: Parameters expressed as mean ± standard deviation (SD) Abbreviations: DAP, diastolic arterial blood pressure; Fe'Sevo, expired fraction of sevoflurane; Fi'Sevo, inspired fraction of sevoflurane; HR, heart rate; IBP, invasive blood pressure; MAP, mean arterial blood pressure; PE′CO2, end-tidal CO2; RR, respiratory rate; SAP, systolic arterial blood pressure; SpO_2, pulse oximetry; T, temperature.

Total anesthesia time was 156 minutes. At the end of sevoflurane anesthesia, the maropitant and dexmedetomidine CRIs were discontinued, and the patient was transferred to the intensive care unit (ICU) for recovery. The dog was extubated 10 minutes later and initially appeared quiet and comfortable during the first postoperative hour.

Pain was assessed using the 4AVet pain scale (Holopherne-Doran *et al*., 2010), vital signs and Abdominal Point-of-Care Ultrasound (A-POCUS) were conducted q4h in the postoperative period. Blood pressure measurements using Doppler ultrasonography were performed q2h. Concurrent blood pressure measurements with Doppler and IBP were performed initially during recovery before removal of the arterial catheter and confirmed the accuracy of Doppler measurement in this patient. Pain scores were subsequently increased (9–10 on day 1, 4–7 on day 2, 0–3 on day 3) requiring treatment with methadone 0.2 mg/kg IV as needed up to q4h and a ketamine CRI 2-4 µg/kg/minute for 48 hours. Physical examination was otherwise unremarkable. Free fluid around the left kidney and the surgical site was initially noticed with A-POCUS but resolved within 24 hours. Persistent hypertension (SAP 160-230 mmHg) was noticed during the ICU stay, from undetermined origin. If pain, stress, incomplete removal of phaeochromocytoma or metastasis, concurrent kidney disease, cardiac or endocrine disease were considered as potential causes, no consequences of hypertension were noted. Renal parameters remained within normal limits and fundic examination was unremarkable. The dog was discharged after a 48 hours ICU stay with gabapentin (Gabapentine 100 mg Biogaran, France) 10 mg/kg PO q8h for 10 days, paracetamol (Doliprane 2.4%, Opella Healthcare, France) 10 mg/kg PO BID for 3 days and maropitant (Cerenia 24 mg, Zoetis, France) 2 mg/kg PO SID for 5 days. Amlodipine and prazosin were also continued. Histopathology confirmed the diagnosis of phaeochromocytoma.

Two weeks later, at suture removal, no complications were reported by the owner; however, hypertension remained present (PAS 200 mmHg). Further investigation of this abnormality was advised.

Discussion

The anesthetic management of patients undergoing phaeochromocytoma resection is challenging. Apart from a few case reports (Ferreira and Raszplewicz, 2016; Miller and Pawson, 2019; Viilmann and Vettorato, 2021; Maidanskaia *et al*., 2022;) and a single study (Merlin and Veres Nyéki, 2019), there is a gap in the veterinary literature investigating the efficacy of different intraoperative anesthetic protocols on patient stabilization and outcome.

The anesthetic management starts with preoperative hemodynamic stabilization, as chronic release of catecholamines causes long-term vasoconstriction, and hypertension, resulting in secondary blood volume depletion. The use of α-blockers has historically been recommended in humans for preoperative volume resuscitation (Fang *et al*., 2020) and prevention of secondary organ damage that may occur, mainly related to the heart, kidneys, brain, and eyes (Mensah *et al*., 2002). The use of preoperative phenoxybenzamine, a non-competitive non-selective long-acting α-antagonist, has been shown to decrease mortality associated with phaeochromocytoma resection in dogs in one study (Herrera *et al*., 2008). However, this study may be biased owing to its retrospective nature including cases from 1986 to 2005 with only the latter receiving phenoxybenzamine. Importantly, in this study, the authors also found no effect on intraoperative cardiovascular stabilization. Moreover, more recent literature did not support the preoperative phenoxybenzamine administration in dogs undergoing phaeochromocytoma excision, since no reduced mortality was found (Appelgrein *et al*., 2020; Enright *et al*., 2022; Piegols *et al*., 2023). These three studies question the Herrera *et al*. (2008) findings and their recommendation of a 2-week pre-treatment with phenoxybenzamine before surgery. Another potential alternative to phenoxybenzamine would be the use of competitive selective α-1 antagonists, such as prazosin, as they do not cause reflex tachycardia, and decrease the risk of rebound hypotension. However, there is no evidence supporting their use preoperatively in dogs undergoing phaeochromocytoma resection. In the present case, prazosin was administered for 1 week preoperatively to potentially mitigate the risk of end organ damage associated with hypertension. Even though a 2-week treatment was generally recommended to achieve complete α-blockade preoperatively (Herrera *et al*., 2008), it was administered for 1 week only in the present case. This was not considered a major concern, as recent literature generally does not support their use (Appelgrein *et al*., 2020; Enright *et al*., 2022; Piegols *et al*., 2023). Nevertheless, normotension was never achieved preoperatively, despite the concomitant administration of prazosin and amlodipine, a calcium channel blocker. This may be due to the lack of gradual upward titration of the prazosin dose, but also to the patient's stress during measurements. Acepromazine was also administered the night before surgery for its α-1-antagonist receptor activity and anxiolytic effect (Monteiro *et al*., 2007). However, it was not chosen as a premedication agent due to its non-reversibility and long duration of action, the occurrence of post-resection hypotension being a concern (Ramakrishna, 2015).

Perianesthetic management should focus on avoiding a phaeochromocytoma crisis and catecholamine release. Based on the human literature, a phaeochromocytoma crisis can occur spontaneously (Scholten *et al*., 2013) or may be triggered. The most important factor is tumor manipulation (Ramakrishna, 2015), which should be gentle and restricted. Metoclopramide, succinylcholine, desflurane should not be used (Ramakrishna, 2015) due to their potential for sympathetic activation. Ketamine, ephedrine, and pethidine are also best avoided due to their sympathomimetic effects (Ramakrishna, 2015). Corticosteroids and β-blockers can also precipitate a phaeochromocytoma crisis (Scholten *et al*., 2013). β-blockers should never be administered to patients with phaeochromocytoma unless adequate α-blockade has been established since it would result in profound unopposed α-mediated vasoconstriction (Myklejord, D.J., 2004). Physiological changes, such as hypercapnia (Masterson *et al*., 2021), acidosis, hypoxaemia (Iturriaga *et al*., 2016), and nociception can also trigger sympathetic activity.

Alfaxalone was chosen as an induction agent due to the MVD diagnosed in the patient, in an attempt at maintaining cardiac output at induction by avoiding a decrease in HR (Okushima *et al*., 2015). Co-induction with benzodiazepines, especially midazolam, was shown to decrease the induction dose and improve the quality of intubation and induction (Italiano and Robinson, 2018). Midazolam can also blunt the norepinephrine release associated with intubation in humans (Nishiyama *et al*., 2002). Surprisingly, Merlin and Veres-Nyéki (2019) found an association between alfaxalone induction and mortality in canine adrenalectomies. Mortality causes included pulmonary thromboembolism and disseminated intravascular coagulation in these cases, raising the question of a possible effect of alfaxalone on the coagulation cascade, but this has not been further investigated to date to the best of our knowledge. Thromboelastography was performed preoperatively in our case, as recommended, but was not repeated postoperatively, as no coagulation trouble was suspected.

In the present case, a partial intravenous anesthesia protocol was used with low-dose dexmedetomidine and maropitant CRIs. The main anesthetic challenge was to provide hemodynamic stability. The aim was to avoid a catecholamine surge resulting in potentially harmful hypertension and arrhythmias. Dexmedetomidine, a highly specific α-2 adrenoreceptor agonist, is known to cause a state of sympatholysis, decreasing norepinephrine release at presynaptic receptors and inhibiting sympathetic activity with postsynaptic receptor activation in the central nervous system (Gertler *et al*., 2001). In addition, it causes an increase in systemic vascular resistance that may be beneficial to maintain blood pressure after tumor removal. Dexmedetomidine has therefore theoretically unique properties for the management of a catecholamine-releasing tumor. Maropitant, a Neurokinin-1 (NK-1) antagonist, was used as a CRI primarily for its minimum alveolar concentration (MAC)-sparing and potential visceral analgesic effects (Kinobe and

Miyake, 2020). Its use has probably contributed to multimodal analgesia and participated in the prevention of a nociception-related catecholamine surge.

In human medicine, the cardiovascular effects of dexmedetomidine are more controversial, with hypotension reported in both adults and children (Ebert *et al*., 2000; Buck, 2010;). However, regarding its sympatholytic effects, the use of dexmedetomidine has been reported in patients undergoing adrenalectomies for phaeochromocytoma. In a patient, 1 µg/kg dexmedetomidine IV resulted in a 49.42% decrease in blood norepinephrine levels (Singh and Singh, 2014). Several case reports in human medicine have consistently described a possible advantage of using dexmedetomidine and overall conclude that it does not totally prevent hemodynamic fluctuations during mass manipulation, but it contributes greatly to intraoperative hemodynamic stability, reducing hypertensive episodes (Wong and Cheung, 2004; Bryskin and Weldon, 2010; Schumann and Hudcova, 2010; Jung *et al*., 2012; Khetarpal *et al*., 2014; Ali Erdogan *et al*., 2015; Dias *et al*., 2015; Hedge *et al*., 2016; Shrestha *et al*., 2016; Giordano *et al*., 2019;). In the veterinary literature, a decrease in vascular resistance following a dexmedetomidine infusion has not been reported. To date, there is a single case report describing the use of a dexmedetomidine CRI in a canine patient undergoing phaeochromocytoma resection (Viilmann and Vettorato, 2021). Similarly to our case, a single hypertension episode occurred, which was successfully treated with magnesium sulphate. However, a loading dose of dexmedetomidine followed by a CRI of 1 µg/kg/hour was used, which was twice as high as in our case where no loading dose was administered. We chose to avoid the loading dose to limit the occurrence of massive hemodynamic variations. The increase in afterload commonly reported with bolus administration of α-2 agonists (Saponaro *et al*., 2013) was also contraindicated due to the pre-existing MVD. Given at a low dose rate, this CRI did not adversely affect the hemodynamic and may have contributed to cardiovascular stability. Dexmedetomidine not only inhibits stress response, including catecholamines and cortisol release (Wang *et al*., 2019) but also provides analgesia, sedation, and anxiolysis (Gertler *et al*., 2001) which may result in quiet recoveries (Jarosinski *et al*., 2021). In addition, dexmedetomidine has potent MAC sparing (Pascoe *et al*., 2006), neuroprotective (Liaquat *et al*., 2021), cardioprotective and renoprotective properties (Chrysostomou and Schmitt, 2008; Xu *et al*., 2019), which may protect the patient from target organ damage in case of a hypertensive crisis. The ideal dose rate to reach the therapeutic benefits discussed above remains however unknown and may be patient and context dependant. We, therefore, cannot assert that the dose rate chosen for this patient was optimal to fulfill the objectives.

Regarding, the other CRI used; maropitant is an anti-emetic agent that may confer additional benefits since it has MAC-sparing effects, and potential anti-inflammatory and analgesic effects (Kinobe and Miyake, 2020). It has also been shown to shorten the time to return to postoperative feeding and improve anesthetic recoveries after bolus administration in healthy dogs undergoing ovariohysterectomy (Marquez *et al*., 2015). In a similar context, it has recently been shown to provide better visceral analgesia and lower postoperative pain scores than meloxicam (Bozkurt *et al*., 2024). The cardiovascular effect of maropitant was a matter of concern, as a dose of 1 mg/kg maropitant IV promoted hypotension in healthy dogs (Chi and Kraus, 2020). The effects of NK-1 antagonists on systemic vascular resistance have been documented in humans and if potentially interesting to limit the hypertensive response associated with tumor manipulation, could have been detrimental after its removal (Dzurik *et al*., 2007). However, in the present case, no deleterious effect related to its use could be noted.

Adequate analgesia is a key component of the anesthetic management of phaeochromocytoma removal, as it prevents the potentially fatal release of catecholamines. In the present case, the multimodal analgesia consisted of premedication with methadone, CRIs of dexmedetomidine and maropitant, and a TAP block. The TAP block was used to desensitize the abdominal wall (Skouropoulou *et al*., 2018; Santos *et al*., 2018) and has been reported in several adrenalectomies (Merlin and Veres-Nyéki, 2019; Maidanskaia *et al*., 2022). However, it does not provide visceral analgesia of the abdomen, conversely to other techniques, such as lumbosacral epidural (Maidanskaia *et al*., 2022; Merlin and Veres-Nyéki, 2019), thoracic epidural (Viilmann and Vettorato, 2021), thoracic paravertebral block (Merlin and Veres-Nyéki, 2019; López-Ramis *et al*., 2022;), and Quadratus Lumborum Block, which has proven to be efficacious in canine ovariohysterectomies (Viscasillas *et al*., 2021) and in a human patient for phaeochromocytoma resection under laparoscopy (Giordano *et al*., 2019). The choice for the TAP block was guided by the fact it was routinely performed for laparotomies in our institution.

To control intraoperative blood pressure spikes, various pharmacological agents are commonly used in human patients: sodium nitroprusside, phentolamine, prazosin, nitroglycerin, magnesium sulfate, nicardipine, diltiazem, esmolol (Ahmed, 2007), urapidil (Tauzin-Fin *et al*., 2020), increase in inhaled agents (Khetarpal *et al*., 2014) or remifentanil (Jung *et al*., 2012). In canine patients, in the few cases reported, hypertension peaks were treated with phentolamine (Kyles *et al*., 2003; Merlin and Veres-Nyéki, 2019), nitroprusside (Kyles *et al*., 2003; Miller and Pawson, 2019), acepromazine (Ferreira and Raszplewicz, 2016), increase in inhaled agents (Ferreira and Raszplewicz, 2016; Miller and Pawson, 2019), fentanyl (Ferreira and Raszplewicz, 2016), magnesium sulfate (Viilmann and Vettorato, 2021; Maidanskaia *et al*., 2022) or urapidil (Maidanskaia *et al*., 2022).

Importantly, the availability and accessibility of these drugs are often limited in veterinary medicine, and dexmedetomidine may help reduce the need for anti-hypertensive treatments intraoperatively.

Severe hypotension commonly occurs after tumor ligation due to a sudden decrease in catecholamine level, contracted blood volume, potential surgical bleeding, anesthesia-induced effects (Ramakrishna, 2015), and vasodilation induced by anti-hypertensive treatments. However, this was not observed in our case. In the other case report where a dexmedetomidine CRI was administered, the CRI was discontinued after tumor removal and hypotension occurred 20 minutes later (Viilmann and Vettorato, 2021). Dexmedetomidine continuation probably contributed to intraoperative cardiovascular stability in our patient.

In the present case, the tumor was non-invasive, allowing its surgical removal to proceed seamlessly. The patient was particularly hemodynamically stable in consideration of the surgery. Dexmedetomidine may have played a role. Interestingly, in a recent retrospective study, only 7/12 phaeochromocytoma dogs undergoing adrenalectomies presented hypertensive episodes intraoperatively (Merlin and Veres-Nyéki, 2019) with no dog receiving a dexmedetomidine CRI but we lack detail on the anesthetic management of the cases to analyze this information further. However, it should be reminded that some dogs undergoing phaeochromocytoma removal do not experience hypertensive episodes. It is thus uncertain whether the present dog would have maintained adequate blood pressure without the dexmedetomidine CRI. Moreover, the administration of multiple medications, including amlodipine, pimobendan, maropitant, and isoflurane, may have also influenced blood pressure control. Although uncertain, we believe that the pharmacological effects of dexmedetomidine likely contributed to the hemodynamic stability observed in this case.

To conclude, a canine patient with MVD Stage B2 undergoing unilateral adrenalectomy exhibited stable perioperative hemodynamic status, facilitated by the use of low-dose dexmedetomidine CRI, a maropitant CRI, and a TAP block. While dexmedetomidine may have contributed to this stability; other factors likely played a role as well. Ideally, randomized controlled trials would be required to further investigate the efficacy of a dexmedetomidine CRI in maintaining hemodynamic stability in veterinary patients with phaeochromocytoma, intraoperatively, and to determine an optimal dose rate.

Acknowledgments

None.

Conflict of interest

The authors declare that there is no conflict of interest.

Authors' contributions

Both authors made substantial contributions. Morgane Gavet and Stéphane Junot prepared and managed the anesthesia of the case. Morgane Gavet wrote the manuscript. Stéphane Junot reviewed and approved the final version of the manuscript.

Funding

The authors received no financial support for this work.

Data availability

More detailed data are available from the corresponding author upon request.

References

Ahmed, A. 2007. Perioperative management of pheochromocytoma: anaesthetic implications. J. Pak. Med. Assoc. 57, 140–146.

Ali Erdogan, M., Selim Ozkan, A., Ozgul, U., Colak, Y. and Ucar, M. 2015. Dexmedetomidine, remifentanil, and sevoflurane in the perioperative management of a patient during a laparoscopic pheochromocytoma resection. J. Cardiothorac. Vasc. Anesth. 29, e79–e80.

Appelgrein, C., Hosgood, G., Drynan, E. and Nesbitt, A. 2020. Short-term outcome of adrenalectomy in dogs with adrenal gland tumours that did not receive pre-operative medical management. Aust. Vet. J. 98, 449–454.

Bozkurt, G., Kaya, F. and Yildiz, M. 2024. Does maropitant provide more effective perioperative pain management than meloxicam in bitches undergoing ovariohysterectomy? The first report on the comparison of visceral algesia-analgesia for ovariohysterectomy. Res. Vet. Sci. 169, 105179.

Bryskin, R. and Weldon, B.C. 2010. Dexmedetomidine and magnesium sulfate in the perioperative management of a child undergoing laparoscopic resection of bilateral pheochromocytomas. J. Clin. Anesth. 22, 126–129.

Buck, M.L. 2010. Dexmedetomidine use in pediatric intensive care and procedural sedation. J. Pediat. Pharmacol. Therap. 15, 17–29.

Chi, T.T. and Kraus, B.L.H. 2020. The effect of intravenous maropitant on blood pressure in healthy awake and anesthetized dogs. PLoS One 15, e0229736.

Chrysostomou, C. and Schmitt, C.G. 2008. Dexmedetomidine: sedation, analgesia and beyond. Expert. Opin. Drug Metab. Toxicol. 4, 619–627.

Dias, R., Dave, N. and Garasia, M. 2015. Dexmedetomidine for anaesthetic management of phaeochromocytoma in a child with von Hippel–Lindau type 2 syndrome. Indian J. Anaesth. 59, 319–321.

Dzurik, M. V., Diedrich, A., Black, B., Paranjape, S.Y., Raj, S.R., Byrne, D.W. and Robertson, D. 2007. Endogenous substance P modulates human cardiovascular regulation at rest and during orthostatic load. J. Appl. Physiol. 102, 2092–2097.

Ebert, T.J., Hall, J.E., Barney, J.A., Uhrich, T.D. and Colinco, M.D. 2000. The effects of increasing plasma concentrations of dexmedetomidine in humans. Anesthesiology 93, 382–394.

Enright, D., Dickerson, V.M., Grimes, J.A., Townsend, S. and Thieman Mankin, K.M. 2022. Short- and long-term survival after adrenalectomy in 53 dogs with pheochromocytomas with or without alpha-blocker therapy. Vet. Surg. 51, 438–446.

Fang, F., Ding, L., He, Q. and Liu, M. 2020. Preoperative management of pheochromocytoma and paraganglioma. Front. Endocrinol. (Lausanne) 11, 1–10.

Ferreira, J.P. and Raszplewicz, J. 2016. Management of life-threatening hypertension in a 12-year-old bichon frise undergoing an adrenalectomy for phaeochromocytoma excision. Vet. Rec. Case Rep. 4(2), e000365.

Galac, S. and Korpershoek, E. 2017. Pheochromocytomas and paragangliomas in humans and dogs. Vet. Comp. Oncol. 15, 1158–1170.

Gertler R, Brown C, Mitchell H. Donald, Silvius N. Erin. 2001. Dexmedetomidine-a novel sedative analgesic agent. Baylor University Medical Center Proceedings, Dallas, USA, 14, 13–21.

Giordano, C., Bassoricci, E., Fusco, P. and Scimia, P. 2019. Ultrasound-guided quadratus lumborum block type 2 associated to continuous intravenous infusion of dexmetomidine for anesthesiologic management in laparoscopic adrenalectomy for pheochromocytoma: could it be a safe strategy? minerva. Anestesiol. 85, 919–920.

Hedge, H., Maheshwari, S., Pai, B. and Ahmed, S. 2016. Dexmedetomidine in anaesthesia for a highrisk case of pheochromocytoma with poor left ventricular function. Indian J. Anaesth. 60, 146–148.

Herrera, M.A., Mehl, M.L., Kass, P.H., Pascoe, P.J., Feldman, E.C. and Nelson, R.W. 2008. Predictive factors and the effect of phenoxybenzamine on outcome in dogs under going Adrenalectomy for Pheochromocytoma. J. Vet. Intern. Med. 22, 1333–1339.

Holopherne-Doran, D., Laboissière, B. and Gogny, M. 2010. Validation of the 4Avet postoperative pain scale in dogs and cats. Vet. Anaesth. Analg. 37, 10–11.

Italiano, M. and Robinson, R. 2018. Effect of benzodiazepines on the dose of alfaxalone needed for endotracheal intubation in healthy dogs. Vet. Anaesth. Analg. 45, 720–728.

Iturriaga, R., Del Rio, R., Idiaquez, J. and Somers, V.K. 2016. Carotid body chemoreceptors, sympathetic neural activation, and cardiometabolic disease. Biol. Res. 49, 1–9.

Jarosinski, S.K., Simon, B.T., Baetge, C.L., Parry, S. and Araos, J. 2021. The effects of prophylactic dexmedetomidine administration on general anesthesia recovery quality in healthy dogs anesthetized with sevoflurane and a fentanyl constant rate infusion undergoing elective orthopedic procedures. Front. Vet. Sci. 8, 1–10.

Jung, J.W., Park, J.K., Jeon, S.Y., Kim, Y.H., Nam, S.H., Choi, Y.G. and Bang, S.R. 2012. Dexmedetomidine and remifentanil in the perioperative management of an adolescent undergoing resection of pheochromocytoma: a case report. Korean J. Anesthesiol. 63, 555–558.

Khetarpal, M., Yadav, M., Kukami, D. and Gopinath, R. 2014. Role of dexmedetomidine and sevoflurane in the intraoperative management of patient undergoing resection of phaeochromocytoma. Indian J. Anaesth. 58, 496–497.

Kinobe, R.T. and Miyake, Y. 2020. Evaluating the anti-inflammatory and analgesic properties of maropitant: a systematic review and meta-analysis. Vet. J. 259–260, 105471.

Kyles, A.E., Feldman, E.C., De Cock, H.E.V., Kass, P.H., Mathews, K.G., Hardie, E.M., Nelson, R.W., Ilkiw, J.E. and Gregory, C.R. 2003. Surgical management of adrenal gland tumors with and without associated tumor thrombi in dogs: 40 cases (1994-2001). J. Am. Vet. Med. Assoc. 223, 654–662.

Liaquat, Z., Xu, X., Zilundu, P.L.M., Fu, R. and Zhou, L. 2021. The current role of dexmedetomidine as neuroprotective agent: an updated review. Brain Sci. 11(7), 846.

López-Ramis, V., Canfrán, S. and Gómez de Segura, I.A. 2022. Caudal thoracic paravertebral block in a dog undergoing surgical adrenalectomy. Vet. Anaesth. Analg. 49, 219–220.

Maidanskaia, E.G., Spadavecchia, C., Vincenti, S. and Mirra, A. 2022. Anaesthetic management of a labrador retriever undergoing adrenalectomy for phaeochromocytoma excision, a case report. Front. Vet. Sci. 9, 1–9.

Marquez, M., Boscan, P., Weir, H., Vogel, P. and Twedt, D.C. 2015. Comparison of nk-1 receptor antagonist (maropitant) to morphine as a pre-anaesthetic agent for canine ovariohysterectomy. PLoS One 10, 1–10.

Masterson, C., Horie, S., McCarthy, S.D., Gonzalez, H., Byrnes, D., Brady, J., Fandiño, J., Laffey, J.G. and O'Toole, D. 2021. Hypercapnia in the critically ill: insights from the bench to the bedside. Interface Focus. 11(2):20200032.

Mensah, G.A., Croft, J.B. and Giles, W.H. 2002. The heart, kidney, and brain as target organs in hypertension. Cardiol. Clin. 20, 225–247.

Merlin, T. and Veres-Nyéki, K. 2019. Anaesthetic management and complications of canine adrenalectomies: 41 cases (2007–2017). Acta Vet. Hung. 67, 282–295.

Miller, C. and Pawson, P. 2019. Anaesthetic management of a phaeochromocytoma excision in a dog. Vet. Rec. Case Rep. 9, 789101.

Monteiro, E.R., Teixeira Neto, F.J., Castro, V.B. and Campagnol, D. 2007. Effects of acepromazine on the cardiovascular actions of dopamine in anesthetized dogs1. Vet. Anaesth. Analg. 34, 312–321.

Myklejord, D.J. 2004. Undiagnosed pheochromocytoma: the anesthesiologist nightmare. Clin. Med. Res. 2, 59–62.

Nishiyama, T., Misawa, K., Yokoyama, T. and Hanaoka, K. 2002. Effects of combining midazolam and barbiturate on the response to tracheal intubation: changes in autonomic nervous system. J. Clin. Anesth. 14, 344–348.

Okushima, S., Vettorato, E. and Corletto, F. 2015. Chronotropic effect of propofol or alfaxalone following fentanyl administration in healthy dogs. Vet. Anaesth. Analg. 42, 88–92.

Pan, S.Y., Liu, G., Lin, J.H. and Jin, Y.P. 2021. Efficacy and safety of dexmedetomidine premedication in balanced anesthesia: a systematic review and meta-analysis in dogs. Animals 11(11), 3254.

Pascoe, P.J., Raekallio, M., Kuusela, E., McKusick, B. and Granholm, M. 2006. Changes in the minimum alveolar concentration of isoflurane and some cardiopulmonary measurements during three continuous infusion rates of dexmedetomidine in dogs. Vet. Anaesth. Analg. 33, 97–103.

Piegols, H.J., Abrams, B.E., Lapsley, J.M., Cray, M.T., Dornbusch, J.A., Murphy, C., Wustefeld-Janssens, B.G., Souza, C.H., Traverson, M., Amsellem, P., Williams, E., Skinner, O.T., Liptak, J.M., Stephens, J.A. and Selmic, L.E. 2023. Risk factors influencing death prior to discharge in 302 dogs undergoing unilateral adrenalectomy for treatment of primary adrenal gland tumours. Vet. Comp. Oncol. 21, 673–684.

Ramakrishna, H. 2015. Pheochromocytoma resection: current concepts in anesthetic management. J. Anaesthesiol. Clin. Pharmacol. 31, 317–323.

Romano, M., Portela, D.A., Thomson, A. and Otero, P.E. 2021. Comparison between two approaches for the transversus abdominis plane block in canine cadavers. Vet. Anaesth. Analg. 48, 101–106.

Salesov, E., Boretti, F.S., Sieber-Ruckstuhl, N.S., Rentsch, K.M., Riond, B., Hofmann-Lehmann, R., Kircher, P.R., Grouzmann, E. and Reusch, C.E. 2015. Urinary and plasma catecholamines and metanephrines in dogs with pheochromocytoma, hypercortisolism, nonadrenal disease and in healthy dogs. J. Vet. Intern. Med. 29, 597–602.

Santos, L., Gallacher, K. and Bester, L. 2018. Analgesic efficacy of ultrasound-guided transverse abdominis plane block in dogs undergoing ovariohysterectomy. Vet. Anaesth. Analg. 45, 885.

Saponaro, V., Crovace, A., De Marzo, L., Centonze, P. and Staffieri, F. 2013. Echocardiographic evaluation of the cardiovascular effects of medetomidine, acepromazine and their combination in healthy dogs. Res. Vet. Sci. 95, 687–692.

Scholten, A., Cisco, R.M., Vriens, M.R., Cohen, J.K., Mitmaker, E.J., Liu, C., Tyrrell, J.B., Shen, W.T. and Duh, Q.Y. 2013. Pheochromocytoma crisis is not a surgical emergency. J. Clin. Endocrinol. Metab. 98, 581–591.

Schumann, R. and Hudcova, J. 2010. Dexmedetomidine infusion during surgery in patients with a pheochromocytoma. Acta Anaesthesiol. Scand. 54, 393–394.

Shrestha, G.S., Rupakhetee, S.S., Pathak, S., Acharya, P., Parajuli, B.D. and Shrestha, A. 2016. Dexmedetomidine and magnesium sulphate as the anaesthetic adjuncts for intraoperative management for resection of pheochromocytoma - a case report. J. Soc. Anesthesiolog. Nepal 3, 87–89.

Singh, S. and Singh, A. 2014. Dexmedetomidine induced catecholamine suppression in pheochromocytoma. J. Nat. Sci. Biol. Med. 5, 182–183.

Skouropoulou, D., Lacitignola, L., Centonze, P., Simone, A., Crovace, A.M. and Staffieri, F. 2018. Perioperative analgesic effects of an ultrasound-guided transversus abdominis plane block with a mixture of bupivacaine and lidocaine in cats undergoing ovariectomy. Vet. Anaesth. Analg. 45, 374–383.

Tauzin-Fin, P., Barrucand, L., Sesay, M., Roullet, S., Gosse, P. and Bernhard, J. 2020. Perioperative management of pheochromocytoma with intravenous urapidil to prevent hemodynamic instability: a 17year experience. J. Anaesthesiol. Clin. Pharmacol. 36, 49–54.

Twedt, D.C. and Wheeler, S.L. 1984. Pheochromocytoma in the dog. Vet. Clin. North Am. Small Anim. Pract. 14, 767–782.

Viilmann, I. and Vettorato, E. 2021. Perioperative use of thoracic epidural anaesthesia, dexmedetomidine and magnesium sulphate infusion in a dog undergoing neuroendocrine tumour resection. Vet. Rec. Case Rep. 9(4), e177.

Viscasillas, J., Sanchis-Mora, S., Burillo, P., Esteve, V., Del Romero, A., Lafuente, P. and Redondo, J.I. 2021. Evaluation of quadratus lumborum block as part of an opioid-free anaesthesia for canine ovariohysterectomy. Animals 11, 1–11.

Wang, K., Wu, M., Xu, J., Wu, C., Zhang, B., Wang, G. and Ma, D. 2019. Effects of dexmedetomidine on perioperative stress, inflammation, and immune function: systematic review and meta-analysis. Br. J. Anaesth. 123, 777–794.

Wong, A.Y.C. and Cheung, C.W. 2004. Dexmedetomidine for resection of a large phaeochromocytoma with invasion into the inferior vena cava. Br. J. Anaesth. 93, 873.

Xu, Z., Wang, D., Zhou, Z., Chen, Q., Zhang, D., Chen, S., Jiang, H., Jia, C. and Liu, X. 2019. Dexmedetomidine attenuates renal and myocardial ischemia/reperfusion injury in a dose-dependent manner by inhibiting inflammatory response. Ann. Clin. Lab. Sci. 49, 31–35.