Cardiac rhythm disturbances in a bactrian camel (*Camelus bactrianus*) during anaesthesia for oral surgery: a case report

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Abstract

A 7-year-old intact male camel (*Camelus bactrianus*) weighing 972 kg was presented for canine teeth extraction. The clinical examination could not be performed as the animal was aggressive and non-domesticated. The animal was premedicated with 10 µg kg^{-1} medetomidine and 0.5 mg kg^{-1} tiletamine-zolazepam intramuscularly. Anaesthesia was induced with 0.04 mg kg^{-1} diazepam and 1.6 mg kg^{-1} ketamine intravenously using a catheter placed in a branch of the left femoral vein. One hour after induction of anaesthesia, the electrocardiogram trace showed multiple monomorphic ventricular premature complexes, defined as ventricular tachycardia. A bolus of 0.4 mg kg^{-1} lidocaine was injected followed by a constant rate infusion of 2 mg kg^{-1} h^{-1}. Sinus rhythm was restored (within 30 minutes) after a second 0.4 mg kg^{-1} bolus of lidocaine, and the procedure completed without further complications. Total anaesthesia time was 90 minutes. The camel recovered uneventfully.

Key words: arrhythmia, camel, lidocaine, oral surgery

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Introduction

General anaesthesia in farm animals, like cattle, small ruminants, camelids and pigs requires special attention due to anatomic and physiologic differences from dogs, cats and horses. The stomach of camelids has three compartments. Though anatomically different, the digestive system of these animals works similarly as in other ruminants such as cattle, sheep and goats. Furthermore, camelids are less tolerant to physical restraint and general anaesthesia is more frequently performed for even minor surgical procedures (e.g. oral cavity examination) (HuiChu Lin, 2013). Considerations for pre-anaesthetic preparation include fasting, assessment of haematology and blood chemistry values, venous catheterization, and estimation of body weight. Finally, not all drugs used in small animal and equine anaesthesia practice are also available for farm animals. As few drugs are labelled for use in farm animals in Europe, the cascade system often needs to be applied and minimum withdrawal times must be respected.

Rezakhani and Szabuniewicz (1997) evaluated 504 ECGs from 72 awake camels (*Camelus dromedarius*) under field conditions. The study conclusion was that the camel ECG resembles that of other ruminants and that the depolarisation process can be classified as Type B. In this class, the Purkinje network implants deeply in the myocardium. This occurs in most ruminants, pigs, horses, elephants, chickens and other birds (Rezakhani and Szabuniewicz, 1997).

To the authors' knowledge, there are no reports on the incidence of arrhythmias in camelids, but these are not uncommon in the perioperative period in other species, both in healthy and sick animals, and may be pre-existing. While some arrhythmias are due to primary cardiac disease, non-cardiac causes, such as electrolyte abnormalities, hypoxaemia or hypercapnia may also contribute (Miller and Flaherty-part I, 2017; Bolton, 1972). According to a recent report in human medicine, 11% of patients experience abnormal HR or rhythm during general anaesthesia (Methangkool, 2019). While most intraoperative arrhythmias in this study were transient and clinically insignificant, some indicated underlying pathology (e.g. myocardial ischemia, electrolyte abnormalities), and some were due to a procedure-specific or medication-specific aetiology. Occasionally, an arrhythmia may cause intraoperative hemodynamic instability. With regard to small animal anaesthesia, cardiac arrhythmias occurred in 2.5% and 1.8% of dogs and cats, respectively anaesthetised over a period of one year in a university teaching hospital (Gaynor et al.,1999). The prevalence and nature of arrhythmias in horses during general anaesthesia and surgery has been determined in a study from the University of Liverpool and it reported supraventricular and bradyarrhythmias as being predominant (Morgan et al., 2011).

This case report describes the occurrence and treatment of an episode of ventricular tachycardia in a camel undergoing general anaesthesia for oral cavity examination and teeth extraction.

Case description

A 7-year-old cryptorchid male Bactrian camel (*Camelus bactrianus*) weighing 972 kg was diagnosed with an apical infection caused by a slab fracture of element 410, according to the modified Triadan system, for describing dentition in veterinary patients (Floyd, 1991). An abscess was present at the level of the right lower jaw, in the proximal third of the body of the mandible. The abscess was drained, element 410 was extracted and a putty was placed. Antibiotic (Draxxin 100 mg/ml - Tulathromycine) was administered intramuscularly twice per week for the next 20 days.

One and a half year later, the camel was presented at the Department of Anaesthesia and Surgery. The camel showed aggressive behaviour and often created severe bite lesions on the female's back and neck during reproductive events. Castration was proposed to improve the general behaviour of the camel and to ensure the safety of caregivers and female camels, but the owner declined and requested extraction of the canine teeth. Due to the uncooperative behaviour of the patient, general anaesthesia was preferred for further examination of the oral cavity before proceeding with possible canine teeth extraction. The camel was premedicated intramuscularly in the neck region with a combination of 0.5 mg kg^{-1} tiletamine-zolazepam and 10 µg kg^{-1} medetomidine. Sternal and left lateral recumbency were respectively achieved 10 and 25 minutes after injection. A 12 gauge over the needle catheter was inserted into a branch of the left femoral vein and 0.04 mg kg^{-1} diazepam together with 1.6 mg kg^{-1} ketamine were administered. The trachea was blindly intubated with a red rubber endotracheal tube (inner diameter 30 mm) and the cuff was inflated to ensure a sealed airway. The camel was moved to the theatre and then positioned in left lateral decubitus on a surgical table. Anaesthesia was maintained with isoflurane in oxygen delivered through a rebreathing system connected to an anaesthetic machine (Tafonius, Vetronic Services Ltd., UK). The vaporizer was adjusted to maintain an adequate plane of anaesthesia. Volume-controlled, pressure-limited mechanical ventilation was set to a tidal volume (VT) of 8 ml kg^{-1} and a peak inspiratory pressure (PIP) limit of 40 cmH_2O. The respiratory frequency (fR) was adjusted to maintain the arterial carbon dioxide partial pressure ($PaCO_2$) below 60 mmHg (8 kPa). Lactated Ringer's solution was administered at 10 ml kg^{-1} h^{-1} through the left femoral vein catheter.

A branch of the left femoral artery was cannulated with a 22 gauge over-the-needle catheter for arterial blood sampling and pressure monitoring, using a pressure transducer placed at the level of the right atrium and zeroed to atmospheric pressure. Arterial blood pressure (ABP), the electrocardiogram (ECG), heart rate (HR) and rhythm, fR, end tidal carbon dioxide partial pressure ($PE'CO_2$), inspired oxygen concentration (FIO_2) and expiratory isoflurane concentration (FE´ISO) were monitored continuously with an anaesthetic multiparameter monitor (Datex Ohmeda S/5, Finland) and recorded every 5 minutes. The ECG was recorded from lead II of the primary limb leads, with the electrodes positioned immediately dorsal to the right jugular vein at the level of mid-cervical region (Right Arm), behind the right elbow (Right Foot) and at the sternal manubrium (Left Arm). Fifteen minutes after the start of anaesthesia, 2.5 mg kg^{-1} tulathromycine (Draxxin 100 mg ml^{-1}, Zoetis, USA) and 0.5 mg kg^{-1} meloxicam (Metacam 20 mg ml^{-1}, Boehringer Ingelheim, Germany) were administered intramuscularly and intravenously, respectively. The oral cavity was examined, and X-rays were taken to evaluate the position and direction of the canines in the oral cavity: three maxillary canine teeth were counted on the left side while two were present on the right side. At the mandibular level, 1 canine tooth was present on each side. The permanent dental formula in camel is 2 (I 1/3, C 1/1, P 3/2, M 3/3) = 34. (Misk et al., 2006). As the owner declined castration of the camel and requested extraction of the canine teeth to avoid severe accidents to female camels in the future, a surgical extraction of 3 maxillary canine teeth (2 at the left side and 1 at the right side) was performed. A mucogingival flap with medial and distal releasing incisions was made to expose underlying labial bone. These incisions were about 5 - 7 cm. The flap was elevated, and a big part of the labial alveolar bone plate was removed using hammer and chisel. A dental elevator was used to loosen the tooth in the alveolar socket, the tooth was removed using the extraction forceps. Fifty minutes after the start of anaesthesia, during the time when the first canine tooth was extracted, an arrhythmia was noted on the ECG, consisting of multiple, isolated, monomorphic ventricular premature complexes (VPC's). Arterial pressure and blood gas values were within normal limits at this moment. Shortly thereafter, the arterial catheter got displaced, but palpation of the peripheral pulse confirmed non pulsatile VPC's. Immediately after establishing the diagnosis of isolated non pulsatile VPC's, a first bolus of lidocaine, 0.4 mg kg^{-1} was administered and a constant rate infusion (CRI) of 2 mg kg^{-1} h^{-1} was started. However, fifteen minutes after the initial bolus of lidocaine, the cardiac rhythm regularly showed more than four non-pulsatile VPCs suggestive of Ventricular Tachycardia (VT). A second 0.4 mg kg^{-1} bolus of lidocaine was administered, and the cardiac rhythm converted to sinus rhythm. During the period of arrhythmia, the surgical procedure was continued. After extraction of the canine teeth, all bone margins were smoothed, wound margins freshened, the tooth alveoli debrided and flushed. The flaps were closed in a simple interrupted pattern.

The total amount of blood loss was estimated to be 1L. Surgery ended 25 minutes after conversion to sinus rhythm. The duration of surgery was 85 minutes, while the total anaesthetic period was 90 minutes. The camel was allowed to breathe spontaneously and moved to the recovery room. A venous blood sample was taken to determine concentrations of sodium, potassium, ionised calcium and chloride. All values were within normal limits (Viesselmann *et al.*, 2018). Ten minutes after the end of anaesthesia, 2 µg kg^{-1} atipamezole was administered intravenously. Soon after this, the camel started to swallow, and the endotracheal tube was removed. The behaviour during lateral recumbency was calm. The animal went into sternal recumbency around 55 minutes after extubation and was finally standing 1 hour after the end of the anaesthestic period. The transition from sternal to standing position was well coordinated with normal strength. Once standing, the balance and coordination were stable and good, respectively.

Literature

The occurrence of cardiac rhythm disturbances is one of the most common cardiovascular complications during both human and animal anaesthesia (Santilli et al., 2018 dog; Miller and Flaherty-part I, 2017 dog and cat; Kwon and Kim, 2017 human ; Rodrigo, 1988 human; Cohen and Tilley, 1979 small animal (dog and cat); Katz and Bigger, 1970 human). Although some arrhythmias are physiological in both anaesthetised or awake large and small animal patients, others are pathological and may pose a certain risk for the patient outcome. In case of pathological arrhythmias, the patient should be examined for the presence of underlying cardiac disease (valvular disease, congenital deformations, myocardial damage and peri- or endocarditis) or noncardiac disease (systemic diseases/organ dysfunctions, electrolyte and acid-base disturbances, hypoxaemia, endotoxaemia and intoxication) (van Loon, 2019 horse; Santilli et al., 2018 dog; Miller and Flaherty-part I, 2017 dog and cat). However, the aetiology of rhythm disturbances during general anaesthesia has not been fully elucidated. It seems to be multifactorial as less-than-optimal anaesthetic management, endotracheal intubation, stress, catecholamine release following a surgical insult, use of volatile (halothane over isoflurane or enflurane) instead of intravenous anaesthetics, spontaneous ventilation, hypercapnia, electrolyte derangements and Autonomic Nervous System (ANS) imbalances are all thought to be factors that increase the incidence of cardiac arrhythmias in different animal species, as well as in human (Santilli et al., 2018 dog; Miller and Flaherty-part I, 2017 dog and cat; Marr and Bowen, 2011 horse; Rodrigo, 1988 human; Katz and Bigger, 1970 human). Interestingly, dental surgery is often associated with arrhythmias due to profound and frequent stimulation of the ANS (Kwon and Kim, 2017 human) and the fifth cranial nerve (Casson and Jones, 1985 human; Alexander and Murtagh, 1979 human; Thomas et al., 1978 human).

In human literature, several classifications have been proposed to define the different types of arrhythmias and these can be translated to veterinary medicine. Cardiac arrhythmias can be classified according to the heart rate (bradyarrhythmias and tachyarrhythmias), to the impulse formation (enhanced automaticity or triggered activity) or to the impulse conduction (block, re-entry, accessory pathway) (van Loon, 2019 horse; Santilli et al., 2018 dog). Moreover, arrhythmias are often described based on anatomical location from which they originate, followed by the type of arrhythmia: ventricular (originating in the ventricle) versus supraventricular (any origin except the ventricle) arrhythmias (van Loon, 2019 horse). In general, supraventricular tachycardias are better tolerated than ventricular tachycardias, which are more often associated with syncope, and on occasion cardiogenic shock (Santilli et al., 2018 dog). Furthermore, ventricular tachyarrhythmias carry a bigger risk to become unstable (van Loon, 2019 horse). Ventricular ectopic beats, also called ventricular premature beats, ventricular premature complexes or ventricular extrasystoles, are spontaneous isolated ventricular depolarisations (Santilli et al., 2018 dog), which occur earlier than expected based on the previous R-R interval. VPC's should be distinguished from ventricular escape beats, which normally occur whenever the dominant pacemaker fails to generate impulses or depolarizes at a slower rate than the pacemaker cells within the ventricle. Such escape beats occur after a long pause and reflect the activity of subsidiary pacemakers. When more than three ventricular escape beats occur in a row, they form an idioventricular rhythm (Santilli et al., 2018; Kwon and Kim, 2017; Thompson and Balser, 2004). Moreover, the literature concerning tachyarrhythmias in people defines an idioventricular rhythm as one whose rate is within the 10% of the underlying sinus rhythm, while a ventricular rhythm above it is termed ventricular tachycardia (VT) (Santilli et al., 2018).

Ventricular tachycardias can be described according to their morphology (monomorphic vs polymorphic) and their duration (sustained vs non-sustained). Non-sustained ventricular tachycardia (NSVT) is defined as three or more premature ventricular contractions, but with a maximal total duration of 30 seconds and without haemodynamic compromise (Thompson and Balser, 2004). These arrhythmias are routinely seen and may not require any treatment in the perioperative period. Sustained Ventricular Tachycardia (SVT) generally falls into one of two categories: monomorphic or polymorphic. While in monomorphic VT the amplitude of the QRS complex remains constant, in polymorphic VT the QRS morphology continually changes (Mitchell, 2017). This is due to the fact that the impulse is conducted differently through the ventricles, and depending on cell-to-cell conduction, the QRS complexes show different morphology and duration, according to the site of origin (van Loon, 2019). Tachyarrhythmias, regardless of the aetiology, increase the cardiac workload and myocardial oxygen demand (Miller and Flaherty-part II, 2017). Moreover, it can suddenly affect haemodynamics, as HR's higher than 180 beats per minute (bpm) in dogs (Santilli et al., 2018), and higher than 100 bpm in horses (Mitchell, 2017), shorten the diastolic filling time to a level which will result in a reduction in stroke volume (SV) and, subsequently in cardiac output (CO) (Kwon and Kim, 2017). Since blood flow to the myocardium occurs during the diastole, tachyarrhythmias have the potential to reduce myocardial blood flow and oxygen delivery (Steinbach et al., 1994).

Factors which may contribute to the development of VPCs and VT include hypoxaemia, hypercapnia, electrolyte imbalances and increased sympatho-adrenal activity (Casson and Jones, 1985). Furthermore, similar disturbances have been observed on manipulation of the fifth cranial nerve during surgery for trigeminal neuralgia (Casson and Jones, 1985) and when halothane was used compared to isoflurane and enflurane (Rodrigo, 1988; Casson and Bones, 1985).

Discussion

It is important to prevent anaesthetic complications, identification of possible risk factors before anaesthesia, and also proper selection of the anaesthetic protocol. In this case, a thorough physical examination was not possible, but the animal was judged as healthy according to the past history. Proper sedation is important to reduce stress and anxiety that may increase the release of catecholamines and the likelihood of arrhythmias during the anaesthetic period. The camel was premedicated with a combination of tiletamine-zolazepam reconstituted with medetomidine. This combination is frequently used to produce excellent immobilization with muscle relaxation and analgesia in both wild and captive animals. Alpha 2 adrenergic agonists are frequently used as part of premedication as they are thought to provide sedation, anxiolysis, analgesia and muscle relaxation. Benzodiazepines are also considered to produce sedation, hypnosis, and anxiolysis by enhancing inhibitory transmission in the CNS. Consequently, the use of both α2-adrenergic receptor agonist and benzodiazepines modulates the release of catecholamine due to sympathetic nervous system activation. Possible alternatives for sedation were considered (e.g. xylazine-ketamine) but the large volume required limited their use. Unfortunately, there are no alternatives to the use of α2-agonist drugs capable of creating good restraint and immobilization in wild large animals. A bolus of ketamine was administered prior to intubation of the trachea. Available data suggest that ketamine inhibits ionic currents through sodium, potassium, and calcium channels, therefore it should not facilitate the occurrence of spontaneous arrhythmias (Ava et al., 1997). Also, it is unlikely that a single bolus administered more than 60 minutes earlier resulted in the occurrence of the VT. With regard to inhalation agents, there is a great variability for these agents to produce cardiac arrhythmias (Gaynor et al., 1999). When halothane is used as anaesthetic agent, the incidence for arrhythmias to occur is higher compared to when isoflurane or enflurane are employed (Casson and Jones, 1985 human). In addition, the arrhythmogenicity of anaesthetics can be influenced by other factors. For example, when halothane was compared to isoflurane as additional agent to nitrous oxide and oxygen to maintain general anaesthesia, the incidence of arrhythmias was higher with halothane, but only during spontaneous breathing (Thomas et al., 1978 human). A likely explanation is that the use of positive pressure ventilation prevents the respiratory depression and resulting hypercapnia, a well-known component for the occurrence of arrhythmias. Our camel was anaesthetised with an isoflurane and oxygen/medical air mixture and mechanical ventilation was applied since the beginning of the anaesthetic period to avoid hypoxaemia and hypercapnia. Careful monitoring of intraoperative anaesthesia depth and respiratory variables indeed showed that blood gas values remained within normal limits for anaesthetized patients. Unfortunately, electrolyte concentrations were not measured during the period of arrhythmia, but a venous sample taken during the recovery period showed normal values for sodium, potassium, chloride, and ionized calcium.

It could be hypothesized that the type of surgical procedure contributed to the occurrence of the arrhythmia in the present case. In humans, the occurrence of cardiac arrhythmias during dental extraction is indeed well documented (Kwon and Kim, 2017; Rashad and El-Attar, 1990; Rodrigo, 1988; Casson and Jones, 1985; Alexander and Murtagh, 1979; Pelkofski, 1974). Cardiac irregularities have been reported when handling the root of the trigeminal nerve

(Rashad and El-Attar, 1990; Pelkofski,1974, Plowman et al., 1974). The trigeminocardiac response is a well described phenomenon where stimulation of the sensory branches of the trigeminal nerve provokes bradycardia that can progress to asystole: In contrast, Fowler and Featherson (2004) reported a case where atrial tachyarrhythmia was triggered on two occasions by balloon compression of the trigeminal ganglion, a procedure classically associated with bradycardia. Nevertheless, it has been suggested that dental surgery and fifth cranial nerve stimulation are in large measure responsible for the appearance of arrhythmias during oral procedures (Plowman et al., 1974; Alexander et al., 1972; Alexander, 1971). It is likely that the stimulation of the sympatho-adrenal system through the fifth cranial nerve results in liberation of catecholamines (Smith and O'Connell, 1986). If the heart is sensitized by the anaesthetic agent, this may precipitate into arrhythmias (Plowman et al., 1974; Alexander et al., 1972; Alexander, 1971). Nevertheless, Kaufman (1966) related the onset of some arrhythmias to the actual moment of extraction of the tooth, making the surgical stimulation a predisposing factors to the occurrence of cardiac arrhythmias during general anaesthesia for oral surgery.

It could be argued that the beneficial effects of blockade with local anaesthetic agents might be due to blockade of the sensory branches of the trigeminal nerve but also to the specific anti-arrhythmic effects of the drugs themselves, acting systemically on the myocardium. Furthermore, the use of local anaesthetic agents and local blockade of the trigeminal nerve were significantly effective in reducing the frequency and incidence of these arrhythmias (Thomas et al., 1978; Plowman et al., 1974). Unfortunately, in our case a local technique could not be employed as the veterinary literature is lacking on local blocks in camels and because of the limited experience of authors in performing head blocks in camelid species. Furthermore, a major concern was blocking the infraorbital or the inferior alveolar nerves bilaterally, which could have caused damage to the camel's tongue (Caldwell and Easley, 2012).

In the present report, pharmacological cardioversion was attempted using 2% lidocaine in order to restore sinus rhythm. Lidocaine is the most common drug used to treat VT in both horses (van Loon, 2019; Mitchell, 2017; Bradley et al., 2017) and dogs (Bolton, 1972; Santilli et al., 2018) and is universally recognised as the first line drug for antiarrhythmic therapy. According to the Vaughan Williams classification of antiarrhythmic drugs, lidocaine is listed as antiarrhythmic agent IB, it blocks the Na^+channel and shortens the action potential (Mitchell, 2017). Thus, lidocaine decreases cardiac excitability, cardiac impulse conduction and abnormal automacity and eliminates large disparities in myocardial refractoriness. A critical feature is the understanding that the current responsible for impulse initiation in the atria and ventricles is mediated through Na^+channels. Hence, drugs that suppress Na^+ current (class I agents) slow myocardial conduction and the incidence of arrhythmias. Lidocaine decreases automaticity in the ventricular myocardium by decreasing the slope of phase 4 (spontaneous depolarization) of the cardiac action potential and by increasing the threshold for excitability. It does not affect normal sinus nodal automaticity and part of its effect may be due to inhibition of sympathetic nervous system activity (Marr and Bowen, 2011). In our case, lidocaine administered as a single bolus followed by a CRI was chosen to more effectively maintain its plasma concentration compared to bolus treatment alone. Indeed, CRI administration has been previously referenced as an antiarrhythmic therapy towards ventricular arrhythmias (van Loon, 2019; Santilli et al., 2018; Bradley et al., 2017; Marr and Bowen, 2011). Owing to the fact that isolated VPC's continued to occur during the CRI, a second bolus of lidocaine was administered, and sinus rhythm was successfully restored.

Conclusion

We described the occurrence of VT in a camel undergoing general anaesthesia for canine teeth extraction. Although the occurrence of cardiac arrhythmias during oral surgery has been well described in human medicine, the reports in veterinary medicine are lacking. Despite a paucity of veterinary data, it appears reasonable to assume that veterinary patients may also develop cardiac rhythm disturbances during oral surgery/dental procedures.

In our case, the appearance of the ventricular arrhythmia occurred while the canine teeth were extracted. The integration of the ECG findings to the cardiovascular stability of the patient lead to a diagnosis of VT, which eventually evolve to ventricular fibrillation. Although a myocardial injury cannot be excluded, in our case the most plausible reasons for appearance of VT in a camel anaesthetised for teeth extraction seems to be the stimulation of the trigeminal nerve and the subsequent activation of the sympathetic nervous system, leading to an impairment between sino-atrial and nodal activation of the myocardial conducting system. Although a splash block with local anaesthetics was not performed, it could have been considered at the suture of the flaps, in a moment where the arrhythmia was already present.

To the authors' knowledge there are no similar reports in camelids on the occurrence of ventricular tachycardia during oral surgery.

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