AKADÉMIAI KIADÓ

Long-term use of an implantable loop recorder for ECG recording in horses

SZILVIA KOVÁCS[1*], GÁBOR BODÓ[1], FERENC ZS. TÓTH[2], LÁSZLÓ NÉDER[2] and ZOLTÁN BAKOS[1]

[1] Department and Clinic of Equine Medicine, University of Veterinary Medicine Budapest, Hungary

[2] Medtronic Hungary Ltd, Hungary

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RESEARCH ARTICLE

ABSTRACT

Potential arrhythmias recorded by cardiac monitors using the built-in human algorithm are as follows: total number of episodes, ventricular tachycardia, asystole, bradycardia, atrial tachycardia, atrial fibrillation and the percentage of time spent in atrial tachycardia or atrial fibrillation. Long-term use of an insertable cardiac monitor (loop recorder) has been reported in one horse earlier, but its accurate role as a diagnostic tool is still unclear. The aim of the present study was to investigate the long-term applicability of the Reveal XT cardiac monitor for recording cardiac arrhythmias in adult horses. The Reveal XT cardiac monitor was implanted in 12 horses under sedation in standing position. Median duration of data recording calculated for the population was 1,169 days. The number of false positive detections of asystole and bradycardia was extremely high in all horses. For atrial fibrillation, false positive detection occurred in five and false negative detection occurred in one horse. The present study showed that the long-term use of the Reveal XT cardiac monitor is feasible, well-tolerated and the devices work reliably, without complications. The human algorithm could not be used for automatic detection of arrhythmic episodes in the study population. The device could detect atrial fibrillation in horses, but the recorded AF burden was inaccurate and the stored ECGs had to be manually interpreted. Because the human analyser algorithm of this cardiac monitor fails to identify bradyarrhythmias in horses based on our results, this instrument is not capable for accurately determining the aetiology of episodic collapse in this species.

KEYWORDS

equine, cardiac monitoring, arrhythmia, atrial fibrillation, electrocardiography

INTRODUCTION

Although normal heart rate and rhythm can be evaluated by cardiac auscultation, electrocardiography (ECG) has an important role in the detection of cardiac arrhythmias in human and veterinary patients (Ioannidis et al., 2001; Bacharova et al., 2014; Lorello et al., 2019). The clinical use of ECG is influenced by the anatomical properties of the equine heart. One of these is that the extensive Purkinje network penetrates the myocardium deeply to facilitate myocardial contraction which is inevitable for the quick escape of the animal. Besides the anatomy of Purkinje fibres, the atrioventricular conduction delay is strongly influenced by the vagal tone. Because of these anatomical and functional variations, routine ECGs are obtained by a few leads, which is enough to diagnose the common arrhythmias in this species. Besides resting ECG, Holter and exercise ECGs are frequently used (Trachsel et al., 2010; Vezzosi et al., 2019). Smartphone application-based ECGs, wearable devices and 12-lead ECGs are still under investigation (Ter Woort et al., 2023; Corradini et al., 2020; Hesselkilde et al., 2021; Van Steenkiste et al., 2018; Vezzosi et al., 2018; Brloznik et al., 2019; Nath et al., 2022). Implantable loop recorders (ILRs) are small, battery-powered electric devices which detect and store abnormal ECG events by continuous monitoring of subcutaneous ECG. Device programming

*Corresponding author. Current affiliation: Department of Anatomy and Histology, University of Veterinary Medicine, Budapest, Hungary.
E-mail: szilvia.kovacs@univet.hu

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and data collection is wireless. Usability of ILRs in horses suffering from collapse has been reported (Lyle et al., 2010). Buhl et al. investigated the usefulness of ILRs in the detection of atrial fibrillation (AF) in horses with induced AF and in a population of Standardbreds suffering from reduced performance (Buhl et al., 2021a). Besides horses (Lyle & Keen, 2010; Lyle et al., 2010; Buhl et al., 2021a; Buhl et al. 2021b; Vernemmen et al., 2024), application of ILRs have been investigated in other domesticated species like dogs (Santilli et al., 2010) and cats (Willis et al., 2003). In human medicine, implantable loop recorders are used in the diagnosis of syncope, collapse, or intermittent weakness (MacKie et al., 2010) and they provide help in the therapeutic decision-making after cardiac interventions and monitoring the appearance or recurrence of arrhythmias (Poole et al., 2020; Simantirakis et al., 2018). They are also implanted for the diagnosis of transient loss of consciousness, palpitations, syncope and are suitable for monitoring myocardial infarction, some congenital heart diseases, and cardiomyopathy (Kwok et al., 2022). The proper use of ILRs in humans is still under investigation. Although real-time recognition of suspected arrhythmias is facilitated, the subcutaneous nature of these devices causes over-sensing, which leads to falsely detected episodes. According to a multicentre study of 1,470 human patients, 59.8% of detected episodes were false positive (O'Shea et al., 2021). The implantation and the remote reading of the device offers continuous heart rhythm monitoring of the patient, avoiding the cost of Holter-monitoring lasting from 24 h to one week, but besides the cost of the device, it requires an invasive implantation procedure. The aim of our study was to investigate the long-term usability of the Reveal XT loop recorder in horses, including the determination of the ideal body region, the long-term tolerability of the device and the evaluation of arrhythmia detection.

MATERIALS AND METHODS

Animals

Twelve horses (6 mares and 6 geldings) were used in the study. These were from different breeds: Nonius (4), Hungarian Sport Horse (3), Hungarian Half-bred (2), Shagya Arabian (1), Standardbred (1) and Zweibrücker (1). They varied in age from 10 to 19 years (mean ± standard deviation: 13.7 ± 3.0 years) and in body weight from 460 to 680 kg (mean ± standard deviation: 552.5 ± 87.1 kg). Before inclusion, all horses underwent physical examination with special regard to the cardiovascular system as well as two-dimensional, M-mode and colour-flow Doppler echocardiography, including standardised measurements (Marr, 2011) as well as 10 min resting and then 20 min exercising ECG (5 min walk, 5 min trot, 5 min canter, 5 min rest) done by a Televet II electrocardiograph (Engel Engineering Services GmbH, Germany).

Device and implantation

The loop recorders were provided by Medtronic Hungary Ltd. The 62 × 19 × 8 mm Reveal XT device is 15 g. The distance between the electrodes is 40 mm and battery life is approximately 3 years. This loop recorder is optimised for detecting the subcutaneous R-wave of the electrocardiogram. The differentiation between normal rhythms and pathological arrhythmias is based on the sensed RR intervals. The detection of atrial fibrillation is based on the ventricular response to the abnormal atrial rhythm. Differences in the RR intervals are evaluated during a two-minute period to detect irregularity of the ventricular rhythm. Considering the everyday life and work of the animals, different anatomical sites (lateral aspect of neck, thoracic inlet and ventral abdomen) were tested before the implantation. ECG signals were checked by using single-lead surface electrodes (Vector Check Tool, Medtronic, USA) which allowed testing to obtain the highest recordable R-wave amplitude. Based on these results, we implanted the loop recorders in a ventral position to avoid artefacts from the motion of the shoulder and girth area. The exact site for implantation was the ventral body wall, approximately 5 cm from the midline on the left side, just behind the girth area. Twelve devices were implanted in twelve horses in standing position, under sedation using intravenous romifidine (20 $\mu g^* kg^{-1}$, Sedivet inj., Boehringer Ingelheim Vetmedica GmbH, Germany), detomidine (10 $\mu g^* kg^{-1}$, Domosedan inj., Orion Pharma Animal Health A/S, Finland) butorphanol (10 $\mu g^* kg^{-1}$, Nalgosed inj., Bioveta a. s., Czech Republic) and xylazine (0.5 $mg^* kg^{-1}$, CP-Xylazin 2%, Produlab Pharma b. v., The Netherlands), as well as local anaesthesia (10 mL lidocaine, Lidobel inj. 20 $mg^* mL^{-1}$, Bela-Pharm Gmbh & Co, Germany). After clipping, the skin was prepared aseptically. Following local infiltration of the skin and subcutaneous tissue with lidocaine, a 2.5 cm long incision was made on the skin, perpendicularly to the horse's longitudinal axis with a number 20 scalpel blade, after which we created a pocket (approximately 2.5*6.5 cm in size) between the subcutis and the fascia using Mayo scissors. After activation, the device was placed into this pocket in a way that the electrodes on the device faced towards the surface of the skin. After implantation, the device was secured through the suture holes found on its connector block with non-absorbable suture material (USP 1 Prolene, Johnson & Johnson Medical GmbH, Germany) and then the incision was closed with USP 1 Ethilon suture material (Johnson & Johnson Medical Ltd, United Kingdom), using interrupted, vertical mattress suture pattern. The wound was covered with a sterile dressing (sterile gauze swab and Snögg Animal Polster, Orkla Wound Care AB, Norway) for 17 days, during which the horses were kept in stall rest. The skin sutures were removed on day 14. After 17 days, the horses returned to their usual routine.

Programming

The human algorithm of Reveal XT can detect atrial tachyarrhythmia (AT), atrial fibrillation, ventricular tachyarrhythmia (VT), fast ventricular tachyarrhythmia (FVT), bradyarrhythmia, asystole and the total number of episodes as well as the percentage of time spent in AT/AF. The device can store a total of 49.5 min of electrocardiograms, which consist of a 22.5-min, patient-activated recording (3*7.5 min, 6.5 min prior and 1 min after activation) and 27 min of automatic activation up to 27 episodes with a one minute duration each. Automatic recordings are classified by the algorithm according to arrhythmia type and stored separately. After the memory of the device is full, the oldest recordings of each type of arrhythmia are overwritten by newly detected episodes. The Reveal XT can store the data of an additional 30 detected episodes without ECGs, hence these are not available for manual evaluation. A dedicated programmer device (CareLink 2090 Programmer, Medtronic, USA) was used to set the parameters of the loop recorders immediately after implantation. The default sensing threshold of the R-wave is 0.035 mV. Because of the thicker thoracic wall of horses, the device is farther from the heart than in humans, therefore, we lowered the sensing threshold to the minimum (0.025 mV). Because lowered sensing threshold caused double sensing (the sensing of T-waves as R-waves), we changed the blanking delay (the minimal time before a new R-wave can be sensed) from 150 ms (ms) to 500 ms. We programmed the loop recorders to detect all types of arrhythmias: atrial tachyarrhythmia/atrial fibrillation (AT/AF), ventricular tachyarrhythmia (VT), fast ventricular tachyarrhythmia (FVT), bradyarrhythmia and asystole. The device has an AF detection algorithm which continuously examines the regularity of RR intervals and detects AF, when the duration of irregularity is above two minutes. VT and FVT episodes are sensed according to the preset thresholds. The interval was set to 260 ms (231 beats*minute^{-1}) with a duration of 30 beats for FVT. The same values for VT were 340 ms (176 beats*minute^{-1}) and 16 beats. FVT episodes are supervised by an algorithm examining the noise level of the obtained ECG. If the noise level is high, the episodes are not stored. An FVT episode ends when one of eight consecutive R-waves are detected with an interval equal to or longer than the programmed VT interval, or the median ventricular interval is equal to or longer than the programmed VT interval during a period of 20 s, or no R-wave is detected during a period of 10 s. Bradyarrhythmia is detected when the number of R-waves in the examined interval is lower than the preset one. In our study, the interval was set to the maximum (2,000 ms) which equals to a heart rate of 30 beats*minute^{-1}. Bradyarrhythmia-sensing stops when four consecutive R-waves are detected at the preset or shorter interval, or if no R-wave is detected for 10 s. In this case, asystole is detected. Besides this, the device detects an asystole episode when the interval from the previous ventricular sense to the current event exceeds the programmed asystole duration. This parameter was set to the maximum, 4.5 s in our study. The asystole episode is suspended after 12 sensed ventricular events.

After implantation, 8 horses were exercised on lunge, under saddle and four horses were driven. All horses were exercised regularly. The operability of the devices was controlled by a Televet II ECG unit during data collection. The graphical display of long-term electrocardiograms is usually based on RR intervals. The data export capabilities of the two devices used in the study (Televet II ECG and Reveal XT loop recorder) are technically different. The RR intervals were exported as Microsoft Excel files from the desktop software of the Televet system. From these RR intervals, Lorenz plots could be created. In these plots, each RR interval was plotted against the next RR interval (Jingxiu et al., 2021) The software of the programmer of the loop recorder does not support the export of RR intervals. Instead, the programmer itself creates plots of the individual ECG events which were exported as pdf files. Due to the different nature of the graphs, it was impossible to create completely matching plots, but the tendencies were obvious (Fig. 1). Data from the loop recorders were collected wirelessly using the same programmer every 8 weeks.

Data analysis

Statistical analysis was done by Microsoft Excel for Microsoft 365, IBM SPSS 22 and Wizard 2 software programs. Shapiro-Wilk statistic was used to assess normality of variables. Descriptive statistics were calculated. The mean ± standard deviation was used to describe normally distributed

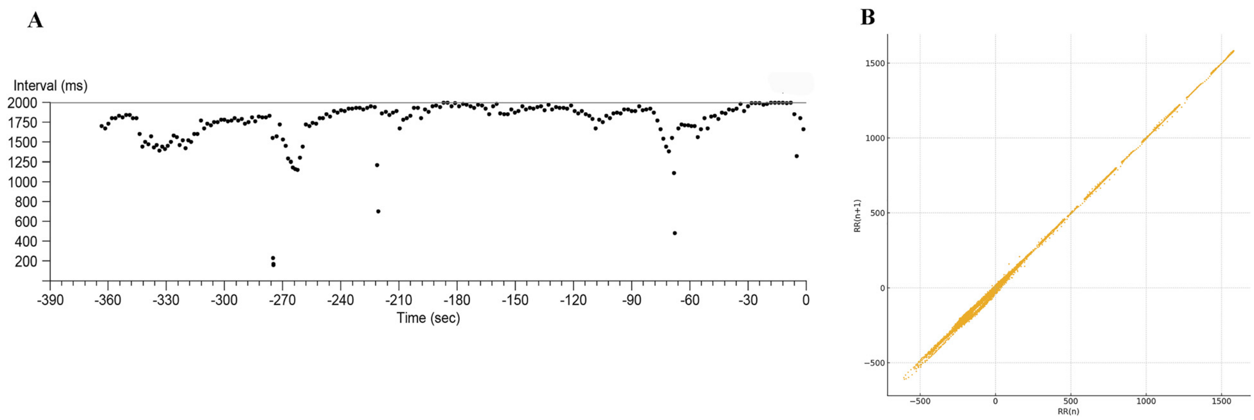

Fig. 1. RR intervals of a horse in sinus rhythm recorded by a Reveal XT cardiac monitor (A); differences between consecutive RR intervals exported from a Televet II electrocardiograph from the same horse and displayed as a Lorenz plot (B)

data and the median ± interquartile range was calculated for not normally distributed variables.

RESULTS

Animals and feasibility

Physical examination revealed normal cardiovascular findings in 11 horses. One horse had an irregular and chaotic cardiac rhythm with palpable pulse deficit on cardiac auscultation. Echocardiography showed no morphological abnormalities. Two-dimensional and M-mode measurements of different cardiac structures were within the reference intervals. Colour-flow Doppler echocardiography did not confirm regurgitation or turbulent flow at the valve areas or other blood flow abnormalities e.g. subclinical congenital cardiac shunts. Resting and exercise electrocardiograms did not show abnormalities in 11 horses and confirmed atrial fibrillation in one horse. Both resting and exercising heart rate of this animal was within normal limits. The exact previous duration of the arrhythmia in this animal was unknown, but resting electrocardiography demonstrated atrial fibrillation years before the beginning of the present study. Based on this history and our results, this horse suffered from persistent atrial fibrillation. No treatment was attempted previously and during the study period.

Tolerability of the device

After the implantation, the incisions healed primarily in all horses within 14 days. A purulent discharge appeared around the suture site after 135 days of implantation in one animal. The device was removed three days later, after 138 days of recording. The discharge originated from the interior non-absorbable sutures. All the remaining 11 devices worked reliably during our investigation without causing local complications. Three horses were sold during the study period therefore the loop recorders were removed earlier (175 days after implantation in two horses, and 271 days following implantation in one animal). The devices in the remaining eight horses were kept in until the programmer indicated that they reached the end of their service periods.

ECG data obtained by the loop recorders

Median ± interquartile range of duration of data recording was 1,169 ± 1,085 days (minimum: 138 days, maximum: 1,373 days). The number of total episodes was 1,163,068 (median ± interquartile range: 42,791 ± 182,737 per horse). As the duration of data recording was extremely variable between horses, the number of episodes per day was also calculated for better comparison. Interestingly, these values also showed extreme variability (median ± interquartile range: 46.35 ± 119). The number of atrial tachycardia (AT) episodes was 2,091 (0.18% of all episodes). Atrial fibrillation (AF) occurred more frequently (31,408 episodes, 2.7%). The mean time spent in AT/AF was 2.1%. Evaluating this parameter separately in the 11 healthy horses and in the horse affected by AF, the values were 0.35% and 16.33%, respectively. The total number of the detected fast ventricular tachycardias (FVTs) was 1,671 (0.14% of all episodes). Total number of VTs was even lower (149, 0.013% of all episodes). Asystole (when no R-wave is detected for 10 s or when the interval from the previous ventricular sense to the current event exceeds 4.5 s) was the most frequently detected alteration (908,359 episodes, 78.1%) followed by bradycardia (219,390 episodes, 18.86%).

DISCUSSION

In human medicine, implantable loop recorders are subcutaneous devices that can be used for continuous monitoring of arrhythmias. In the past years, these devices have been miniaturised and the algorithms have become more sophisticated, providing ECG monitoring up to 3-year periods (Bisignani et al., 2019; Kwok et al., 2022). The main benefit of the use of ILRs in clinical practice is the all-time remote monitoring of patients, improving the diagnostic method and decreasing the costs of healthcare at once (Bisignani et al., 2019). Besides the automated recording system, the monitors are usually equipped with a patient activator device, allowing the human patients to record ECGs during the symptoms (Bisignani et al., 2019). The main limitation of the use of ILRs is the recording of a subcutaneous ECG, which can lead to false positive and false negative detection of arrhythmias.

In humans, loop recorders are used in the diagnosis of transient loss of consciousness, recurrent falls, unexplained syncope, postural orthostatic tachycardia syndrome, palpitations, cryptogenic stroke and obstructive sleep apnoea. It can also be implanted after heart failure, myocardial infarction, AF ablation, or coronary artery bypass graft. ILRs can also be useful in the evaluation and modification of antiarrhythmic therapy (Pezawas, 2023; Bisignani et al., 2019; Kwok et al., 2022). Previous studies using ILR's in horses focused on the diagnosis of paroxysmal atrial fibrillation based on Standardbred racehorses with poor performance at work (Buhl et al., 2021a) and among research conditions (Buhl et al., 2021b). According to the type of device, Buhl et al. used Reveal Linq cardiac monitor, which is also from the Reveal series of Medtronic Ltd, but a smaller device. Data from a single Warmblood horse with multiple episodes of paroxysmal atrial fibrillation (Kjeldsen et al., 2023) and a tutorial on an unknown horse were also reported (Lyle et al., 2010). In these reports, only short-term results were published. The aim of the present study was to investigate the long-term application of loop recorders in adult horses with a focus on the clinical usability in the diagnosis of different arrhythmias. In our population, horses were from different breeds, use and daily activity. The usual implantation sites for ILRs are the pectoral region (Lyle & Keen, 2010; Lyle et al., 2010) and the girth area (Buhl et al., 2021b). The use of the xiphoidal region was described previously in one horse (Buhl et al., 2021a). This was very similar to the site we used. Although the left cardiac region would have provided better quality ECGs at rest, motion artefacts during exercise could have significantly decreased the signal-to-noise ratio, hence we chose a different implantation site on the ventral abdomen behind the xiphoid cartilage which did not interfere with the tack, independently from the type of exercise (lunging, riding or driving). During rest and exercise, ILRs were well tolerated by all horses without any signs of discomfort, similarly to previous studies (Buhl et al., 2021a; Kjeldsen et al., 2023). The duration of the implantations published earlier varied between a few weeks and 3 years (Buhl et al., 2021a, 2021b; Kjeldsen et al., 2023; Lyle & Keen, 2010; Lyle et al., 2010; Vernemmen et al., 2024).

In humans, the implantation of ILRs should be done by an aseptic protocol independently from the size of the device (Gunda et al., 2015). The human implantation method required minimal modification in horses. In our study, the implantation and wound healing were free of complications in all but one case. From this horse, the device was removed 138 days after implantation. There was no visible injury within or around the area, but a mild, odourless purulent discharge appeared from the position of the former skin sutures. When the recorder was removed, it seemed that the inflammation was induced by one of the two non-absorbable sutures holding the device in place. Bacterial culture of the discharge provided negative result. The recording period was more than 3 years in eight horses which was enough to evaluate if the technique was equally safe both for the device and the horse. No complications were noted during the recording time in these 8 horses.

The devices were programmed with the human algorithm, but we changed the default parameters of sensing used by the previous studies in horses (Lyle & Keen, 2010; Lyle et al., 2010; Buhl et al., 2021a, 2021b). Tachyarrhythmia detection data were more precise with the new settings compared to the default ones because it was more sensitive with the exclusion of episodes caused by double sensing (sensing of T-waves as R-waves and counting them as separate cardiac cycles). With the human algorithm, the device was not able to detect real bradyarrhythmia in horses. With the modification of the human algorithm by lowering the heart rate sensing, use would be feasible in the future. Because of the longitudinal nature of the study, and the extremely high number of detected episodes, it was impossible to check all episodes individually. In order to draw conclusions, 100 episodes of each type were interpreted manually. Comparison of our results with those of other studies was difficult because of the different devices, implantation sites and recording intervals. Lyle et al. used implantable cardiac monitors for the examination of episodic collapse (Lyle & Keen, 2010; Lyle et al., 2010). During the investigation of 4 horses in two publications, arrhythmias have not been revealed (Lyle & Keen, 2010; Lyle et al., 2010). Paroxysmal atrial fibrillation has been diagnosed in Standardbreds and Warmblood horses by loop recorders earlier, but these publications did not report other ECG abnormalities (Buhl et al., 2021a, 2021b; Kjeldsen et al., 2023; Vernemmen et al., 2024).

The quality of the recorded ECGs was good in most cases, although traces recorded during exercise had a high noise ratio caused by motion artefacts. Atrial fibrillation episodes were detected correctly in the affected horse. However, there were false episodes both in the affected horse and in the healthy animals. The false detection was caused by motion artefacts, heart rate variability and double sensing. The persistent atrial fibrillation was detected correctly 28,816 times out of 31,408 total AF episodes (91.7%), although when the heart rate was low in this horse, false bradycardia or asystole were recorded, but in fact AF was still present (Fig. 2). Because of this anomaly, in this animal, the maximum time spent in AF between two interrogations, as detected by the loop recorder, was only 34.7%. According to previous human studies as well as to our current investigation, atrial fibrillation can be successfully detected by loop recorders. However, human studies and our data showed the over-detection of this arrhythmia (Afzal et al., 2020; O'Shea et al., 2021). Based on the manual interpretation of detected episodes in our population, AF was falsely detected in normal horses because of high heart rate variability or temporary double sensing. A recent systematic review reported a high rate (59.7%) of false positive alarms of the overall remote monitoring transmissions in human patients (Covino and

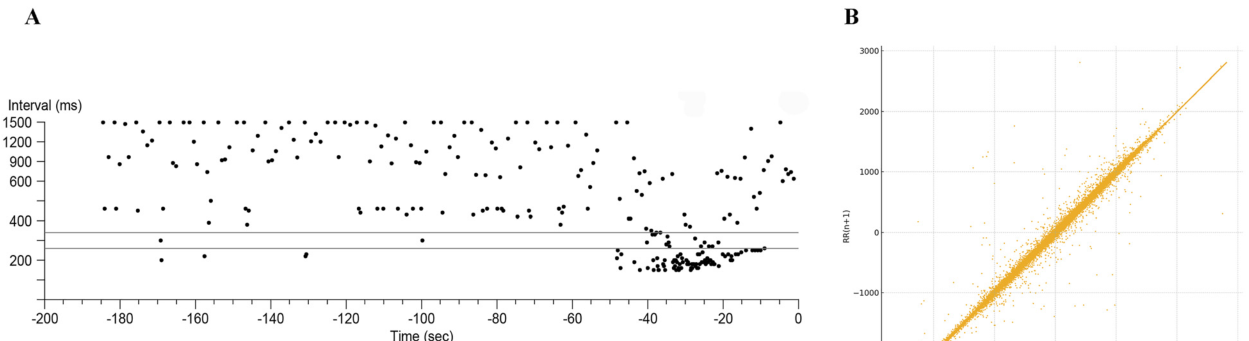

Fig. 2. RR intervals of a horse in atrial fibrillation recorded by a Reveal XT cardiac monitor (A); differences between consecutive RR intervals exported from a Televet II electrocardiograph from the same horse and displayed as a Lorenz plot (B)

Russo, 2024). In their study, the most frequent type of false positive alarm was for atrial fibrillation, mainly caused by premature atrial and ventricular complexes (Covino and Russo, 2024). In our equine population, false detection of AF was much lower (2,592 out of 31,408 episodes, 8.3%). In humans, the detection of AT episodes and the time spent in atrial tachycardia or atrial fibrillation is relevant after electrophysiological interventions, when the AF burden can predict the recurrence of the arrhythmia. With the development of interventional techniques in horses (van Loon et al., 2020; Buschmann et al., 2023), the implantation of cardiac monitors with an equine-specific algorithm after ablation methods will have the same clinical significance in horses. Fast ventricular tachyarrhythmia (heart rate above 231 beats*minute^{-1}) and ventricular tachyarrhythmia (heart rate above 176 beats*minute^{-1}) were detected falsely in all manually checked ECGs. The main reasons of these errors were exercise (sinus tachycardia), motion artefacts and double sensing. Although the most frequently detected abnormalities were bradyarrhythmia and asystole, only one study has been published about these arrhythmias earlier (Nissen et al., 2022) According to our results, the causes of this extremely high false positive detection were the low resting heart rate of the animals and the presence of physiological sinus as well as second-degree atrioventricular blocks caused by high vagal tones. In the Reveal XT cardiac monitor, the maximum programmable RR interval was 2,000 ms (30 beats*minute^{-1}), but all horses had lower heart rates than this value. Although the reported physiological resting heart rate of horses is between 28 and 42 beats*minute^{-1}, in reality, without human interactions and the placement of electrodes and an external ECG device, the true resting heart rate is significantly lower. In the manually interpreted electrocardiograms, the lowest heart rate was 12 beats/minute when sinus blocks were present, which is lower than the previously published heart rate of a Quarter Horse (Nissen et al., 2022). Heart rates between 20 and 30 beats*minute^{-1} were very common in all horses, consequently it cannot be evaluated as a pathological rhythm disturbance.

The use of implantable loop recorders is limited even in human medicine. For most conditions, cost effective and non-invasive methods such as Holter-monitoring, external loop recorders and patient monitors as AliveCor or Apple Watch are available (Kwok et al., 2022). Because these devices cannot take action in case of arrhythmia detection, for life threatening arrhythmias in-site monitoring or the implantation of a pacemaker is inevitable. The use of ILRs is most appropriate in human patients with a mild disease for the detection of infrequent symptomatic or asymptomatic arrhythmias and in patients with a high risk of developing arrhythmias. In horses, similarly to human indications, these instruments are more successful in the detection of infrequent arrhythmias compared to Holter-monitoring or telemetric devices. Because atrial and ventricular tachycardias can be evaluated by manual inspection of the recorded ECG traces in horses, the devices with the current human algorithm may be convenient for the follow-up of the medical treatment of tachyarrhythmias. However, as the human algorithm fails to recognise bradyarrhythmias in horses, the device is not capable for the identification of the aetiology of episodic collapse. At the same time, it can provide information about tachycardias and the possible concurrent motion of the animal during collapse (Lyle et al., 2010). With the modification of the human algorithm for the equine heart rate, heart rate variability and ECG features, the use of ILRs can be extended to the general investigation of infrequent arrhythmias as suggested in the present study.

Limitations of our study were the relatively low number of horses, the fact that only one horse had pathologic arrhythmia in the population and the limited number of manually checked electrocardiograms compared to the total number of detected episodes. These lacks might be corrected in further studies performed on a larger equine population including more healthy horses and those with pathological arrhythmias. However, the extension of the number of cases can create hindrances, regarding the implanting technique as a semi-invasive method.

CONCLUSIONS

The present study showed that the use of the Reveal XT loop recorder is feasible, well-tolerated, and the devices worked reliably without complications even for long-term ECG recordings. At present, the human algorithm cannot be used for the automatic detection of all arrhythmic episodes in horses. The device could detect atrial fibrillation in horses, but the recorded AF burden was inaccurate and the stored ECGs had to be manually interpreted. Implantable loop recorders are currently suitable for diagnosing tachyarrhythmias in clinical equine patients if the use of Holter, smartphone, or wearable devices is not feasible. Development of ablation techniques in horses will require the routine use of intracardiac loop recorders. Our results may serve as an aid in the development of an equine algorithm, which automates the interpretation of electrocardiograms recorded by these devices.

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