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Clinical Usefulness of Digital ECG Recorder in Dogs : 4 Cases

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Abstract : Digital electrocardiogram (ECG) recorders are rapidly replacing to conventional paper ECG recorders. Digital ECG recorders have several advantages over conventional type ECG recorders, including better capability for data storage, better portability and better applicability in clinical settings. In this study, we presented 4 case studies related to cardiac rhythm disturbances, which were diagnosed and managed using a digital ECG recorder.

Key words **:** ECG, digital ECG recorder, arrhythmia, rhythm disturbance, dog.

Introduction

The conventional paper electrocardiography (ECG) has been used for several years to evaluate the cardiac electrical activity and in particular to detect cardiac rhythm disturbances (5-7). Routine electrocardiography is the gold standard for the diagnosis of cardiac arrhythmias in practice. However, as a standard ECG lasts 1 or 2 min, ECG sensitivity is very low for the detection of sporadic arrhythmias such as paroxysmal tachyarrhythmias (1,3).

There are several benefits of digital ECG data acquisition that use standard resting ECG recordings and 24-hour Holter ECG recordings (6-9). Continuous access to the monitored digital ECG data allows the analysis of dynamic features of each ECG parameters (including the PR, QT and RR intervals). Such a comprehensive digital-ECG based approach is likely to improve early identification of cardiac arrhythmias. Digital ECG data acquisition also provides the opportunity to improve quality control of ECG analysis and allows more comprehensive auditing (review) of ECG interpretation (4). Access to digital ECG recordings will provide the opportunity to achieve better assessment of duration and morphology of each ECG parameters.

In general, the ambulatory ECG recorders (i.e. Holter monitor) were used for continuous ECG recording, up to 24 to 72 hours (2,6-9). Longer ECG recordings enabled us to more easily identify paroxysmal tachyarrhythmias and occult cardiac rhythm disturbances. However the substantial cost of ambulatory ECG recorders and lacking of analytic computer software for dogs hindered the clinical use of those ECG recorders in veterinary fields. Digital ECG recorders are rapidly replacing to conventional paper ECG recorders in human and veterinary fields. Thanks to better storage of ECG tracings and more flexible data acquisition from the digital ECG recorders, it is believed to be a good alternative for Holter ECG monitor. Therefore in this study, we evaluated the applicability of digital ECG recorders in clinical situations and applied this technology in clinical cases.

Materials and Methods

Animals

Four dogs having cardiac conduction disturbances were included in this study.

Digital ECG recording

ECG tracings were obtained using a CU-PH1 digital ECG recorder (CU medical systems, Korea; Fig. 1). We cleaned the skin using a gauze with alcohol in order to remove sebum and dirt

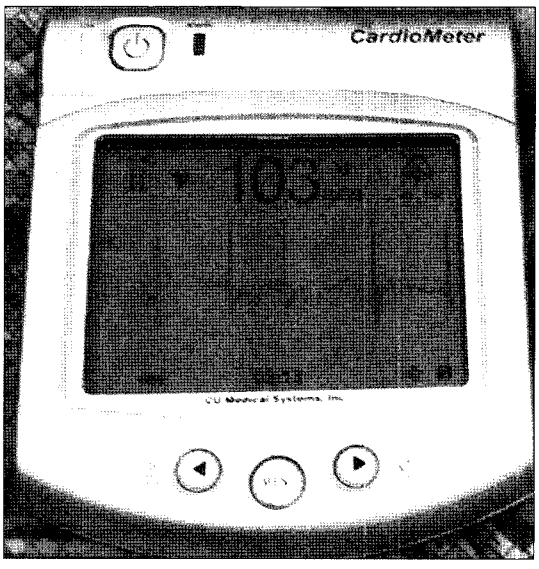

Fig 1. The digital ECG recorder used in this study.

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from the surface and to ensure a good contact between electrodes and the skin. We used either self-adhesive electrocardiographic patches with 2.4 cm diameter (3 M, USA) or alligator clipped electrodes. The LL-electrode was attached to the left hock joint, while the RA and LA electrodes were attached to right and left elbow joints respectively. All ECG tracings were recorded for 1 hr at the paper speed of 25 mm/sec and the amplitude of 10 mm/1 mV. Lead II ECG tracings were mostly recorded. Lead I and III tracings were also recorded for the measurement of mean electrical axis (MEA). The recording was then processed and analyzed using ECG Analyser (CU Expert, Ver 2.10, Korea).

Results

Digital ECG recordings were successfully applied to dogs in clinical settings. Descriptions of each clinical case are as followed.

Case 1

A 10-year-old desexed, female mixed breed dog was investigated for an arrhythmia detected during a physical examination. Routine hematological and biochemical tests were not remarkable. The arrhythmia was characterized as an irregularly irregular bradycardia; heart rate (HR) was 60-70 beats/min. Peripheral pulse was consistent with the heart rate and no murmur was detected. Diagnostic imaging studies for cardiopulmonary systems could not detect any significant abnormalities. The resting ECG revealed bradycardia (60-70 beats/min), sinus pauses of typically 1 to 2s, atrial premature beats and junctional escape beats (Fig 2). In the ECG traces recorded after exercising for 2 min, there were no significant changes from

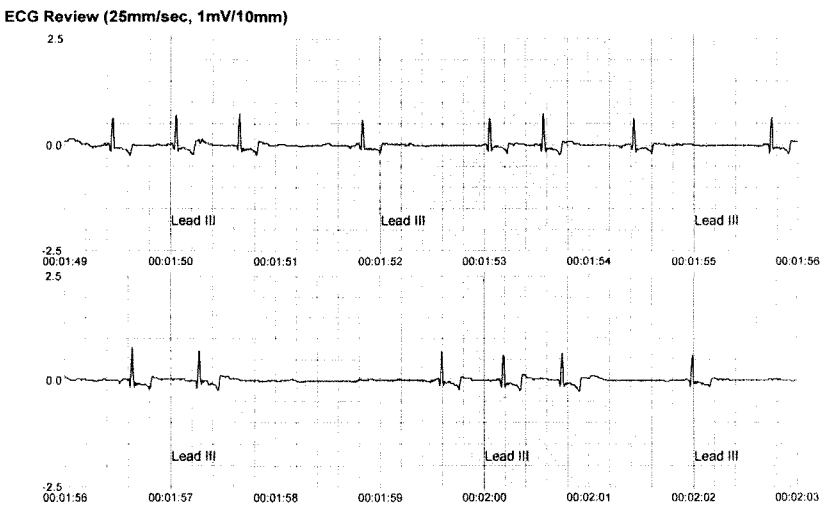

Fig 2. ECG traces caused by sick sinus syndrome. The ECG traces showed bradycardia (60-70 beats/min), sinus pauses of typically 1 to 2s, atrial premature beats and junctional escape beats.

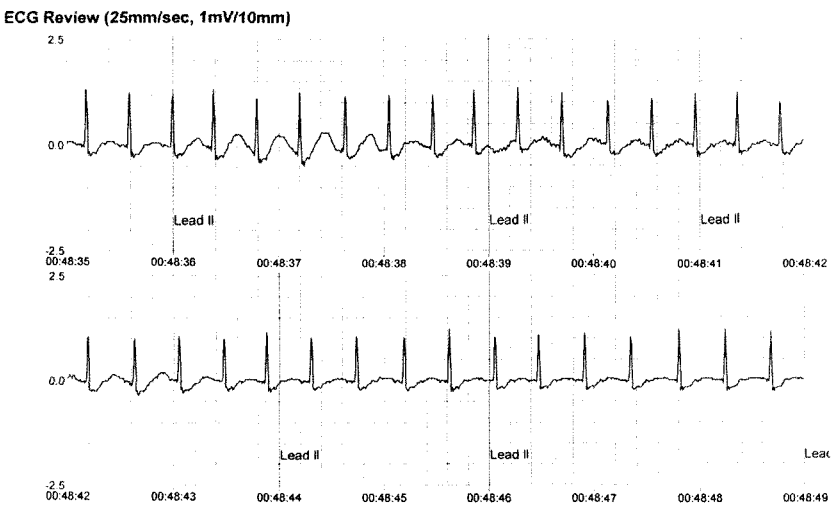

Fig 3. ECG traces of case 1 after atropine administration. The heart rate was 150 beats/min with loss of the sinus pauses and supraventricular tachycardia with occasional junctional beats.

the resting ECG trace. Heart rhythm and rate were not significantly altered even after vagal maneuvers. ECG tracings were recorded again after atropine administration (0.05 mg/kg, IM). The heart rate was 150 beats/min with loss of the sinus pauses. However, supraventricular tachycardia with occasional junctional beats persisted even after atropine administration (Fig. 3).

The ECG characteristics were consistent with sick sinus syndrome, but not originated from abnormal autonomic tone. Since the patient did not show significant sinus pauses with vagal maneuvers and did not return to normal sinus rhythm (although rate was increased to 150 beats/min) by atropine administration, the etiology might be associated with a conduction disturbance rather than excessive parasympathetic tone.

Case 2

An 11-year-old intact female Maltese (2.5 kg of body weight) was presented with signs of sudden onset of lethargy with occasional vomiting. The dog was regularly medicated with diuretics and vasodilators due to pre-existing mitral valvular insufficiency. The dog was very lethargic and depressed on physical examination. Thoracic auscultation revealed weak and irregular heart rhythm with occasional pulse deficits and grade IV/VI systolic murmur. In blood cell counts, severe leukocytosis and neutrophillia with left shift were observed. Noticeable serum biochemical profiles were severe azotemia (markedly elevated blood urea and creatitine), hypoabuminemia (2.0 g/dL), hyponatremia (131 mmol/L), hyperkalemia (7.7 mmol/L), marked increase in calcium and phosphorus (Ca:P index was 72), suggesting severe renal failure. The electrocardiographic studies showed sinus rhythm with a remarkable T wave (Tent T wave) and occasional atrial standstill (8th and 13th QRS complexes in Fig. 4). With time, the heart rhythm progressed to 2nd degree sinoatrial exit

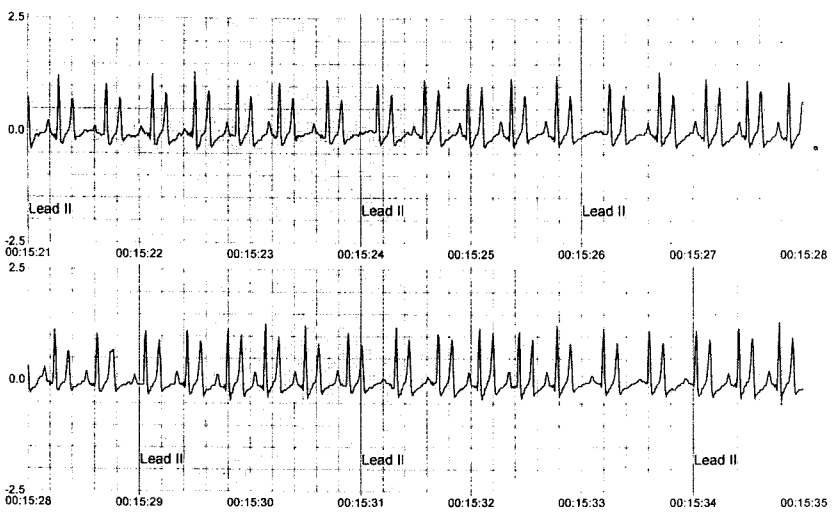

Fig 4. Electocardiographic changes associated with hyperkalemia. The ECG traces showed sinus rhythm (140 beats/min) with remarkable T wave (Tent T wave). There was absence of P wave in 8th and 13th QRS complexes, indicating atrial standstill.

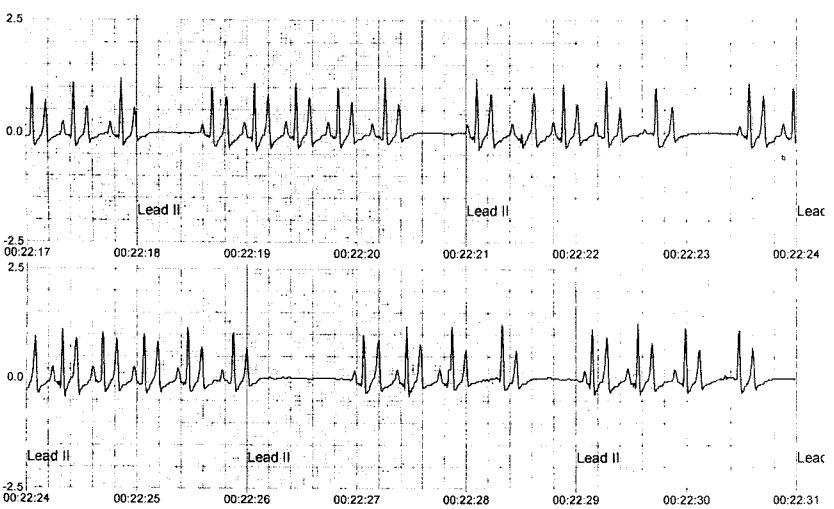

Fig 5. Electocardiographic changes associated with hyperkalemia. The ECG traces showed persisted tent T wave with sinoatrial (SA) exit block.

block with persistent tent T wave (Fig. 5). Those ECG findings strongly suggested increased serum potassium levels in this patient (hyperkalemia).

To reduce serum potassium level, insulin (0.5 U/kg) with 5% dextrose and 10% calcium gluconate solution (2 mL/kg) was slowly administered intravenously. The heart rhythm gradually returned to normal rate of sinus rhythm (Fig. 6). However the dog was hyperkalemic again 2 hour after insulin therapy. Sodium bicarbonate (2 mEq/kg) was administered intravenously. The serum potassium level was maintained under 5.5 mmol/L after bicarbonate treatment. After the heart rhythm was stabilized, the dog was went through more sophisticated diagnostic investigation. Further diagnostic studies revealed pyometra, complicated chronic renal failure and degenerative mitral valvular insufficiency.

Case 3

A 7-month-old intact female Maltese (2.1 kg of body weight) was presented with signs of ascites, exercise intolerance and cyanosis. Owner reported that the dog had several fainting spells recently. In thoracic auscultation, a grade IV/VI to and fro murmur was heard the best at the left basal region. Thoracic radiography revealed dilated pulmonic valves, distended caudal vena cava, undercirculation of the pulmonary vasculature, dorsal displacement of the trachea, an enlarged hepatic shadow, and ascites, suggesting right-sided congestive heart failure. Echocardigraphic studies revealed distended right atrium and hypertrophied right ventricle with severe stenotic pulmonic valve (peak systolic outflow velocity of 5.3 m/sec; calculated pressure gradient 112 mmHg). The electrocardiographic studies showed a sinus rhythm with singlets or doublets of ventricular prema-

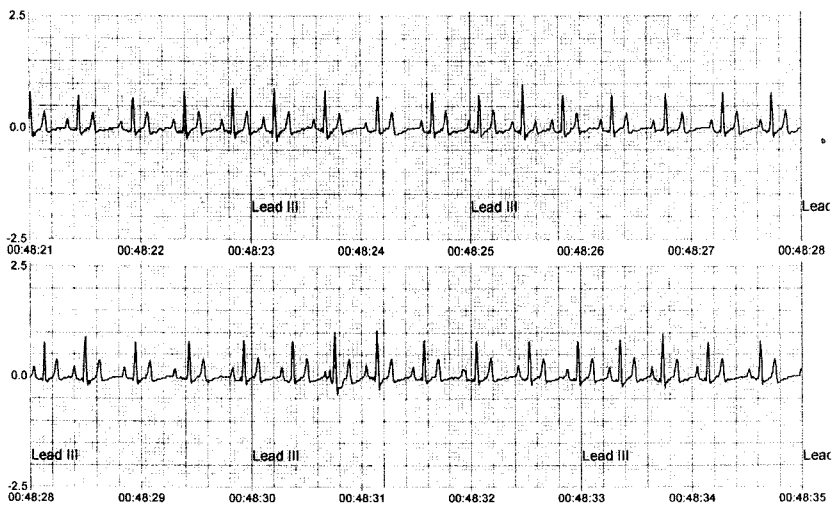

Fig 6. After correcting hyperkalemia with bicarbonate and insulin therapy. The heart rhythm was returned to normal sinus rhythm with the rate of 135 beats/min. The amplitude of T wave is reduced. The heart rhythm was regularly regular.

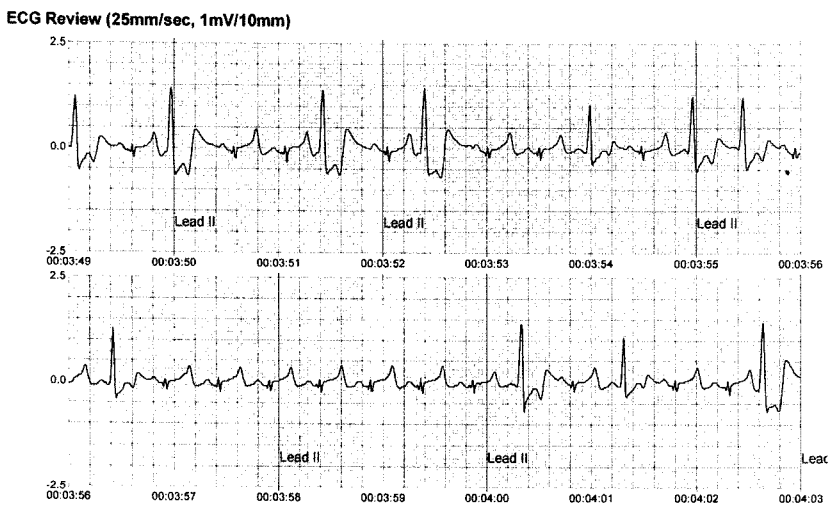

Fig 7. Sinus rhythm with occasional ventricular premature complexes. The sinus rate was 70 beats/min and ventricular premature beat rate was 70 beats/min. The QRS complexes were wide and bizarre. The rate of ventricular premature complexes was 70 beats/min, indicating the dog was required for medical treatment.

ture complexes (VPC, Fig. 7). The mean electrical axis (MEA) was +150° (right axis deviation) with S-waves in leads I, II, III, indicating right ventricular hypertrophy. The VPC was polymorphic and occurred at 70 beats/min. Therefore medical treatment was indicated for this patient.

The dog was medicated with sotalol (2.4 mg/kg, BID, PO) for 2 weeks. The owner reported that the dog was tolerable with sotalol treatment and showed no fainting spells during this period. Overall body condition was not significantly different, but the dog was more lethargic after medical treatment of heart failure (abdominal fluid removal and diuretics; furosemide 3 mg/kg, PO, BID and spirolactone 2 mg/kg PO, BID) and sotalol medication. On the ECG recorded after 2-week of sotalol treatment, the heart rhythm was back to normal sinus rhythm with the rate of 145 beats/min (Fig. 8) There was only 75 VPCs for 1 hr ECG recording (1.25 VPCs/min).

Case 4

A 10-year-old male Jindo dog (15 kg) was presented for evaluation of syncopal episodes. The dog had been generally healthy in the past. Physical examination revealed a dog in good conformation with no obvious abnormalities. Cardiac auscultation revealed no cardiac murmur, but a very irregular rhythm with lengthy pauses. Femoral pulse was strong, yet irregular, with the same pauses noted on auscultation. On the lead II-ECG strips, the atrial rate was 90 beats/min, but the ventricular rate was only 30 beats/min. The rhythm was irregularly irregular with occasional escape beats (Fig 4). Many of the P waves were

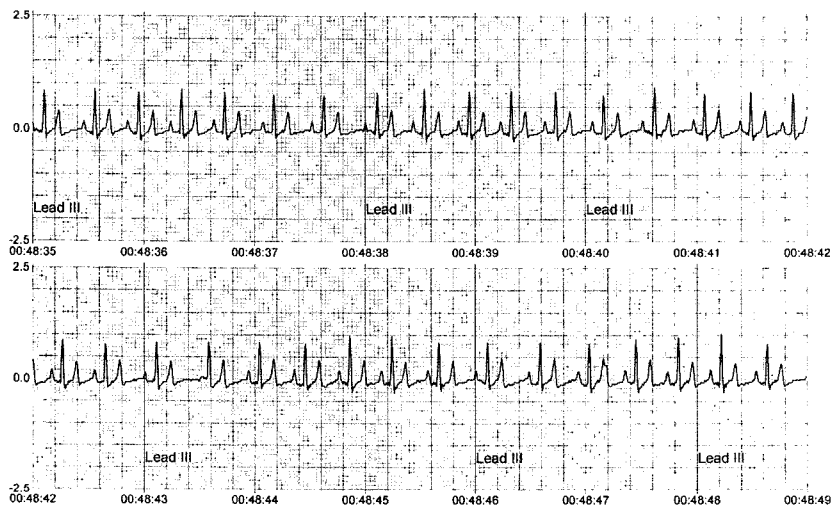

Fig 8. After 2 weeks of sotalol (2.4 mg/kg, BID, PO) treatment. The heart rhythm was returned to normal sinus rhythm at the rate of 145 beats/min. There were only 75 ventricular premature complexes (VPCs) for 1 hr ECG recording (1.25 VPCs/min).

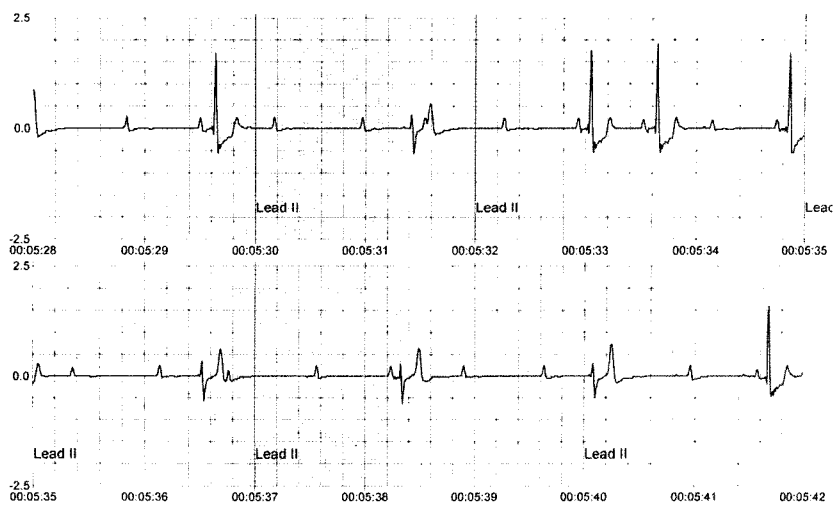

Fig 9. Third degree atrioventricular (AV) heart block with 3 : 1 ratio. The rhythm was irregularly irregular with occasional escape beats (atrial rate, 90 beats/min; ventricular rate, 30 beats/min). Many of the P waves were not followed by QRS-T complexes. The P-R interval was constant on conducted P-QRS complexes. The QRS complexes followed by the P wave were escaped beat, suggesting complete AV block.

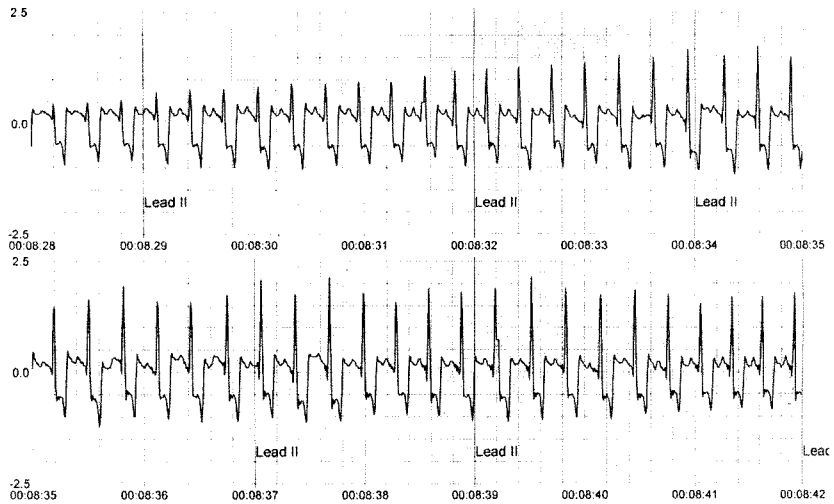

Fig 10. After dopamine (15 ug/kg/min) administration. The rhythm was sinus but the rate was tachycardic with 200 beats/min. Another feature of this ECG was severe ST-segment depression, which might be due to myocardial hypoxia by sudden increase in heart rate.

not followed by QRS-T complexes. The P-R interval was constant on conducted P-QRS complexes. The QRS complexes followed by the P wave was an escaped beat (which was originated from ectopic focus) strongly suggesting that the third degree atrioventricular (AV) heart block with 3 : 1 ratio.

Dopamine (15 ug/kg/min) was slowly infused to the patient. The rhythm returned to sinus rhythm with 200 beats/min (sinus tachycardia). However, the ECG showed severe ST-segment depression, suggesting myocardial hypoxia due to sudden increase in heart rate by b–agonist administration. Sinus tachycardia persisted for another 20 min, but the rate was gradually decreased to 120 beats/min. We recommended implantation of artificial pacemaker. However, the owner refused because of substantial cost of pacemaker implantation. The dog was released with a prescription of aminophylline (10 mg/kg BID, PO).

Discussion

In this study, we evaluated the usefulness of digital ECG recorder in clinical settings. There were several advantages over conventional type ECG recorders, including better capability for data storage, better portability and better flexibility in clinical settings. The digital ECG recorder we used in this study could store ECG traces up to 10 hrs.

Better capability for data storage enabled us to identify paroxysmal tachyarrhythmias and occult cardiac rhythm disturbances, since we could analyze longer ECG traces. The standard ECG recorders could provide only 40 to 50 heartbeats representing only for the brief period of heartbeats. Therefore the paroxysmal tachyarrhythmias and occult cardiac rhythm disturbances, which occurred commonly in clinical situations, could be easily missed out.

Most digital ECG recorders are smaller in size and lighter in weight and thus have better portability. They can be also easily and quickly applied to the patient. Therefore the digital ECG recorder can be used in several clinical situations, such as during light surgery, during critically ill-patient monitoring and during cardiac examination. Because the sensitivity and accuracy of ECG tracing in digital ECG recorder are generally better than ECG tracing in patient monitors, the digital ECG recorder can be used as the subsidiary monitor for patient heart rhythm in general anesthesia.

Despite these advantages over the standard paper ECG recorders, the ECG traces recorded in the digital ECG recorder had poorer quality than those in paper ECG. Furthermore, the baseline of ECG tracings was less stable. These drawbacks often led to the misinterpretation of ECG tracings from subtle changes in P waves. In addition, the digital ECG recorder could not filter out electrical activities from skeletal muscles, unlike the ambulatory ECG recorders (i.e. Holter monitor). Therefore the ECG traces recorded while the animal was moving could not be interpretable. However, this was not a big problem in application of digital ECG recorder in clinical situations, since most dog was tolerable to the short period of ECG recording (up to 1 hr).

In conclusion, we evaluated the applicability of digital ECG recorders in clinical situations and presented clinical case studies, which were diagnosed and managed using the digital ECG recorder. This clinical study proved the usefulness of digital ECG recorder in veterinary fields.

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디지털 심전도기의 임상적 적용 예 : 4 증례

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요 약 : 소동물 임상에서 디지털 심전도기가 일반 아날로그 방식의 심전도기를 빠르게 대체하고 있다. 이러한 디지털 심전도기는 일반 아날로그 방식의 심전도기에 비해서 심전도 자료의 저장 능력, 이동성 및 넓은 임상적 적용 범위를 갖는 장점이 있다. 본 연구에서는 소동물 임상에 있어서 이러한 디지털 심전도기의 유용성을 연구하였고, 실제 심장 전도계 장애가 있는 4마리의 개를 진단하고 치료하였다.

주요어 : 심전도, 디지털 심전도기, 부정맥, 심전도장애, 개.