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SHORT COMMUNICATION

Analysis of haematological and biochemical blood parameters after electrical cardioversion of atrial fibrillation in dogs

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Abstract

Introduction: Electrical cardioversion is a therapeutic procedure used to convert various types of arrhythmias back to sinus rhythm. It is used to restore the sinus rhythm in dogs with atrial fibrillation. The effect of the electrical energy used during cardioversion on red blood cells (RBC) is not fully understood. Studies on humans reported lysis of RBC following electrical cardioversion. Similar studies have not been carried out on dogs. The aim of the study was to assess the effect of electrical cardioversion on chosen RBC parameters. **Material and Methods:** The study was carried out on 14 large and giant breed dogs weighing from 30 to 84 kg with lone atrial fibrillation (lone AF). Electrical cardioversion was carried out under general anaesthesia by biphasic shock with 70–360 J of energy. Blood was collected at T0 – during atrial fibrillation, prior to cardioversion, and at T1 – 30 min after electrical cardioversion. Complete blood counts as well as total and direct bilirubin concentrations were evaluated. A maximum output of 360 J was used. **Results:** In all cases, electrical cardioversion was effective, and no significant changes in the number of RBC and RBC indices were noted. Similarly, there were no statistically significant differences in the levels of total and direct bilirubin. **Conclusion:** Electrical cardioversion in dogs led neither to statistically nor clinically significant RBC lysis.

Keywords: dogs, heart, atrial fibrillation, electrical cardioversion, red blood cells.

Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia found in canine patients (13, 14). It may be associated with organic heart diseases such as dilated cardiomyopathy, systemic disorders like hypothyroidism, or may be spontaneously occurring lone atrial fibrillation. AF is characterised by chaotic electrical activity of the atrial muscle causing rapid, irregular, and mechanically ineffective contractions. It may be triggered by focal electrical activity originating from the pulmonary veins or atria itself, while the presence of micro- and macro-reentrant circuits are involved in maintaining the arrhythmia (5, 17, 18). Its self-perpetuating nature leads to electrical and eventually structural remodelling expressed as a shortened atrial refractory period, atrial refractoriness dispersion, calcium overload, disseminated tissue fibrosis, and hypertrophy and dilatation of the atria (15). A rapid ventricular response rate, in many cases exceeding 260 bpm, results from very effective conduction within the atrioventricular node in dogs (3). It is often the cause of sudden development of tachycardia-induced cardiomyopathy (TICM) (15, 18). One of the atrial fibrillation treatment strategies and therefore prevention of TICM development is the restoration of sinus rhythm. Both pharmacological and electrical cardioversion is possible, however, the latter

typically has a much higher success rate, even if the arrhythmia duration exceeds 24–48 h, while the pharmacological approach lacks effectiveness this long after onset.

Electrical cardioversion (EC) is an electrotherapeutic procedure, during which a short electrical impulse with energy of 50–360 J is delivered through external electrodes to the heart. Pain sensation under the electrodes, skin burns, thromboembolic episodes, and transient ST segment elevation are described among possible complications in a human patient (5). There is evidence that direct current flow through the patient's body can cause minimal cell injury, which has been intensively studied in the heart muscle. Most reports indicated no cardiac damage or no clinically significant damage as assessed by means of troponin concentrations (2, 7). Only a single report exists regarding the possible injury of other components of the chest such as thoracic muscles (6).

The impact of electrical energy used during the procedure on circulating blood, in particular on erythrocytes, is not fully understood. Blood volume within the chest can obviously be influenced by the electrical field during EC shock. There are reports of red blood cell lysis after electrical cardioversion in humans (9), but similar studies have not been carried out on dogs.

The aim of the study was to assess the influence of electric cardioversion of atrial fibrillation on chosen red blood cell parameters.

Material and Methods

Fourteen privately-owned dogs admitted to the Cardiology Unit of the Department of Internal Medicine and Clinic of Horses, Dogs, and Cats of the Faculty of Veterinary Medicine, Wroclaw University of Environmental and Life Sciences, Poland, were enrolled into the study. They were dogs which had undergone complete physical, echo- and electrocardiographic examinations and been diagnosed with lone atrial fibrillation and none to minimal left atrial enlargement (LA/Ao < 1.7). The dogs were mostly males (10/14), of mean age 5.92 ±1.47 years, weighing from 30 to 84 kg, and of various breeds, including five German Shepherds, three Central Asian Shepherd Dogs, one Giant Schnauzer, one Irish Wolfhound, one Polish Tatra Sheepdog, one Rhodesian Ridgeback, one Newfoundland, and one St. Bernard. The dogs were premedicated with dexmedetomidine (4 μg/kg) and midazolam (0.2 mg/kg) administered intramuscularly. After placing an intravenous catheter, general anaesthesia was induced with propofol (1 mg/kg) and fentanyl (2–5 μg/kg). Electrical cardioversion was performed using biphasic shock with energy of 70–360 J (Lifepak 12, Medtronic, USA) (Fig. 1). Recovery from the procedure was uneventful.

Blood samples were drawn from the cephalic vein using a 21-gauge needle into plain and K3EDTA-coated tubes. The dogs were phlebotomised twice: at T0 – during atrial fibrillation, just before the procedure (this sample was used to perform routine pre-anaesthetic blood tests), and at T1 – 30 min after successful EC, while dogs were still under anaesthesia. All dogs were fasted at least 12 h prior to blood collection. In all cases owners signed a written consent form to allow inclusion of their dog in the study. All tests were performed within an hour of blood collection. Complete blood count was performed using an automated laser haematology analyser (LaserCyte, IDEXX, USA), while total (BLT-T) and direct (BLT-D) bilirubin concentration was analysed using the Konelab Prime 30 ISE clinical chemistry system (Thermo Fisher Scientific, USA).

All collected data were analysed statistically using Statistica for Windows software, version 12.5 (Statistica, USA). Due to the lack of a normal distribution of the assessed variables, Wilcoxon signed-rank test for related samples was applied. Correlations were analysed by Spearman's rank correlation test. For all statistical analyses, $P < 0.05$ was regarded as statistically significant.

Results

Electrical cardioversion was successful in all cases. In the majority of dogs, restoration of sinus rhythm was achieved after one shock. In three patients, two shocks were applied with 70 and 200 J of energy and in one dog three shocks were needed of 200, 300 and 360 J.

No statistically significant changes were noted with respect to erythrocyte count or red blood cell indices. Both total and direct bilirubin concentrations were no different between T0 and T1. No significant correlations were found between any of the variables of total or direct bilirubin concentrations, erythrocyte count after EC, the number of applied shock impulses, or the energy used. Descriptive data are presented in Table 1 as mean ±SD.

Table 1. Erythrocyte count, red cell indices, and total and direct bilirubin concentrations in dogs before (T0) and 30 min after (T1) electrical cardioversion (n = 14)

	RBC x10^{12}/L	MCV (fL)	MCH (pg)	MCHC (mmol/L)	RDW	BIL-T (mg/dL)	BIL-D (mg/dL)
T0	6.42 ±0.74	72.48 ±4.28	24.5 ±1.77	24.9 ±7.3	14.99 ±1.13	3.3 ±0.76	2.5 ±1.07
T1	6.26 ±0.82	72.62 ±4.19	24.27 ±1.87	25.07 ±6.53	15.02 ±1.05	3.2 ±0.77	2.47 ±1.11
P value	N/S	N/S	N/S	N/S	N/S	N/S	N/S

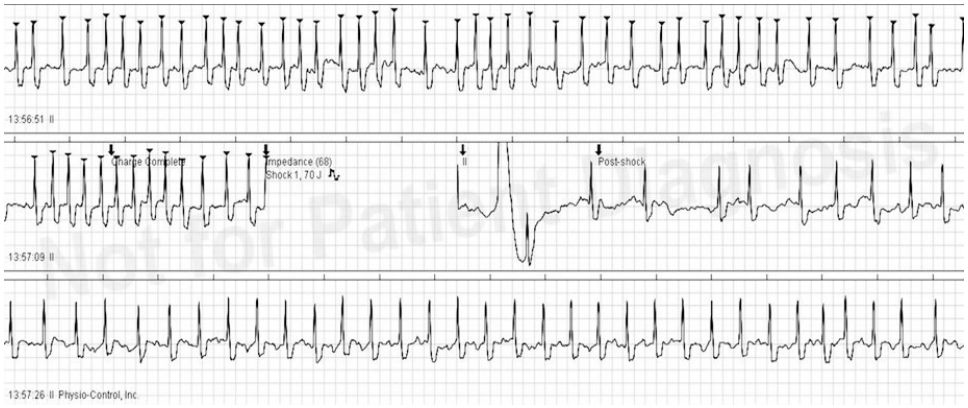

Fig. 1. Successful electrical cardioversion of atrial fibrillation using biphasic shock with energy of 70J

Discussion

This paper reports the influence of electrical cardioversion of atrial fibrillation in dogs on red blood cell indices and haemolysis. EC is a routine procedure both in human and veterinary medicine used to convert atrial fibrillation back to sinus rhythm, therefore treating or preventing the development of chronic heart failure. The influence of biphasic electric current used during the EC on erythrocytes has not yet been studied in dogs.

Haemolysis, *i.e*. disintegration of red blood cells, is induced by loss of erythrocyte haemolytic resistance. Both intra- (structure and function of cell membrane, intracellular metabolism, cell age) and extracellular (biological, chemical, and physical) factors can influence haemolytic resistance of red blood cells. Numerous cardiovascular procedures can result in either subclinical or clinically significant red blood cell lysis. It has been documented that prosthetic heart valves can contribute to haemolytic disease by two mechanisms: direct mechanical trauma to erythrocytes and paraprosthetic valvular regurgitation (11). Additionally, life supporting pump devices used in intensive care environments are associated with pump-induced haemolysis. Mechanical forces generated by implanted continuous-flow left ventricular assist devices (LVADs) may lead to red blood cell lysis regardless of a patient's baseline osmotic red cell fragility (8). This phenomenon is also observed in patients on extracorporeal membrane oxygenation (ECMO), with centrifugal pumps being superior to roller pumps in terms of haemolysis induction (1, 16). Haemolysis is a significant complication in paediatric patients during cardiopulmonary bypass and is associated with the postoperative development of acute kidney injury (10). Electrical cardioversion, as a life-saving procedure, may be required during all of the aforementioned procedures. It is therefore crucial to identify whether EC will cause additional red blood cell lysis and to what extent.

Tissue injury has been intensively studied; however, only with regard to the cardiac myocytes. Several studies on cardiac troponin levels indicated no or only minimal, clinically insignificant cardiac damage (2, 7). A small single study reported a transient creatine kinase increase, pointing to skeletal muscle involvement, while another study confirmed a generalised inflammatory response, which could possibly exacerbate the thrombotic risk of EC (4, 6).

There is only scarce evidence of erythrocyte haemolysis after EC based on preliminary reports in human medicine. Makowski *et al.* (9) showed that 30 min after electrical cardioversion with a mean energy of 170 J, red blood cells, HCT, and haemoglobin were significantly lower, whereas direct bilirubin concentration after 6 h was significantly higher. The authors suggest that this process might influence patients' overall outcomes (9). An experimental study conducted on a suspension of human erythrocytes confirmed that red blood cell electroporation accelerates haemolysis. Significant changes, however, occurred after application of energy higher than 200 J and the results were no different from those of the control with energy below 100 J (12).

Our results suggest that electrical cardioversion in dogs does not affect red blood cells either clinically or statistically. It is therefore safe to perform electrical cardioversion of atrial fibrillation in anaemic dogs.

This study has several limitations. The study group was small and may not reflect the real population. Blood samples were drawn only once post treatment, shortly after successful resolution of an arrhythmia, so the results might be different after a longer period. Furthermore, the energy used in most cases was low and therefore might not be sufficient to cause any erythrocyte lesions. This did, however, reflect the real clinical scenario.

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