SciMedCentral

Archives of Palliative Care

Research Article

Electrocardiographic Changes in Canine Babesiosis

Shubhamitra Chaudhuri[1]*, Jagdish Prasad Varshney[2], and Bendangla Changkija[3]

[1]*Department of T.V.C.C, West Bengal University of Animal and Fishery Sciences, India*
[2]*Division of Veterinary Medicine, Indian Veterinary Research Institute, India*
[3]*College of Veterinary Science, Guwahati*

***Corresponding author**
Chaudhuri Shubhamitra, Department of T.V.C.C, West Bengal University of Animal and Fishery Sciences, Faculty of Veterinary and Animal Sciences, India, Tel: 919874579755; Fax: 9125571986; Email: drshubhamitra@gmail.com

Submitted: 28 September 2017

Accepted: 30 November 2017

Published: 01 December 2017

ISSN: 2573-1165

OPEN ACCESS

Keywords
- B. gibsoni
- Canine
- Dog
- ECG
- Electrocardiograph

Abstract

Canine babesiosis, a tick- borne haemoprotozoan disease, characterized by both intravascular and extravascular haemolysis leading to regenerative anaemia, anaemic hypoxia, and metabolic acidosis. ECG changes have never been studied in canine babesiosis caused by *B. gibsoni* which is more pathogenic and prevalent in India. However, ECG changes occurred in up to 40% cases of canine babesiosis caused by *B. canis rossi*. The study was conducted to describe the ECG changes in naturally occurring cases of canine babesiosis caused by *B. gibsoni*. Study was performed on 189 clinical cases diagnosed with canine babesiosis, referred at Medical wing of the Referral Veterinary Polyclinic of the Institute during 2005-2006 by using a 12 lead BPL- ECG machine (CARDIART-408). The mean heart rate (151.3 ± 53.3) was found slightly higher than the standard reference value. Population mean of 'P' amplitude (0.17 ± 0.007) and 'QRS' duration (0.04 ± 0.02) were found to be slightly lower. Other parameters like 'P' duration (0.03 ± 0.01), 'R' amplitude (1.05 ± 0.51), 'R-R' interval (0.46 ± 0.15) 'QT' duration (0.15 ± 0.03), 'PR' duration (0.09 ± 0.06) and T: R ratio (0.26 ± 0.26) did not differ much from the standard reference values. The prevalence of electrographic abnormalities were prevalent in 51.3% cases of canine babesiosis with a highest prevalence of tachycardia followed by low voltage complex, sinus arrhythmia, tachy arrhythmia, and atrial fibrillation. The dogs with *Babesia* infection also showed various types of complex changes. From the present study it appears that the ECG changes in canine babesiosis are multifactorial and heart suffers from same pathological process.

ABBREVIATIONS

ECG: Electrocardiogram; B. gibsoni: Babesia gibsoni; E. canis: Ehrlichia canis; E. platys: Ehrlichia platys

INTRODUCTION

Canine babesiosis, a tick- borne haemoprotozoan disease caused by the species of *Babesia* (*B. canis, B. gibsoni* and *B. vogeli*) is well documented in tropical and subtropical regions of the world. In India both *B. canis* [1,2] and *B. gibsoni* [3-6] infections have been reported. Importance of canine babesiosis varies in different regions of the world and in different states of the country, owing to strain or species variations of *Babesia* and various ecological factors [7]

Babesiosis is characterized by both intravascular and extravascular haemolysis leading to regenerative anaemia, anaemic hypoxia, and metabolic acidosis. Parasitaemia, destruction of organism (*Babesia* spp.) and erythrocytes may result in activation of various inflammatory mediators causing pyrexia [8,9]. Molecular mediators of multiple organ dysfunctions including cytokines, nitric oxide and free oxygen radicals are generated by the host tissues in response to parasite rather than directly from parasite itself [9]. Complicated babesiosis is associated with dysfunction of other organs. It is speculated that cardiac changes may develop in canine babesiosis owing to overwhelming inflammatory response and anaemic-hypoxic state [10]. Ischaemia and myocarditis can decrease resting potential of the involved cells leading to a conductional block resulting in arrhythmias [11]. Such changes are well documented in human cardiology and are accompanied by typical electrocardiographic changes. Cardiac changes have been described in human malaria. Its acute phase has many similarities to canine babesiosis [12]. Researchers conducted in Pretoria (South Africa) have indicated that ECG changes occurred in up to 40% cases of canine babesiosis caused by *B. canis rossi*. However, ECG changes have never been studied in canine babesiosis caused by *B. gibsoni* which is more pathogenic and prevalent in India, Malaysia, Korea, Egypt, Japan and United States.

The purpose of this study was to describe ECG changes in naturally occurring cases of canine babesiosis caused by *B. gibsoni*.

MATERIALS AND METHODS

Study design

A prospective study was performed on 189 dogs of different

breeds (Pomeranian, German shepherd, Non-descript, Labrador, Dobermann, Great Dane, Sptiz, Boxer, Bhutia, Dalmatian, Cocker-spaniel, Apso, Rampur hound, Rottweiler, Golden Retriever, Dachschund, Greyhound and Nepolian Mastiff) diagnosed with canine babesiosis. All the dogs were client- owned and were referred at Medical wing of the Referral Veterinary Polyclinic of the Institute.

Inclusion criteria

Ailing dogs found cytologically positive for small *Babesia* simulating to *Babesia gibsoni* on the examination of their capillary blood smears prepared freshly from ear tip and stained with Giemsa stain.

Cytologically *B. gibsoni* positive dogs having no cardiac disease previously diagnosed or treated or suspected at presentation.

Exclusion criteria

Dogs with *B. gibsoni* having concurrent infection of *Ehrlichia canis*, *E. platys*, *Trypanosoma evansi* or *Dirofileria immitis.*

Dogs having chronic heart problem.

Dogs having unusual clinical signs not previously observed in *Babesia* infection.

Each ailing dog was compiled on a 20 point scale having clinical sign as anorexia/partial appetite, dehydration, pyrexia, dullness/depression, diarrhoea/constipation, pale mucosa, ticks on body, hepatolmegaly, vomiting/nausea, splenomegaly, rapid thready pulse, nasal discharge, ataxia/CNS signs, distended abdomen/ascites, dysponea, yellow coloured urine, emaciation/weight loss, epistaxis, occular discharge and edema. Presence of each clinical sign was assigned 01 mark.

ELECTROCARDIOGRAPHIC EXAMINATION

Electrocardiographic recoding was made by using a 12 lead BPL- ECG machine (CARDIART-408). The dogs were restrained in right lateral recumbancy on a table having foam cushion and rubber matting and were made comfortable before taking electrocardiogram. The legs were positioned parallel to each other and vertical to the long axis to the body and keeping the head and neck flat on the table. The skin and electrodes were moistened with the alcohol. The right forelimb (RA) and left forelimb (LA) electrode were placed proximal to the olecranon on the caudal aspect of the respective forelegs. The right hind limb (RF) and left hind limb (LF) electrodes were placed over the patellar ligament on the anterior aspect of the respective hind limbs. Sedation was not used in any dog. Sensitivity and paper speed were set at 1 and 25mm sec^{-1}, respectively Manual Hum filter (notch filter at 50Hz) and EMG filter (cut off frequency of -3dB at 35 Hz) were used to minimize the disturbances. A one minute lead II ECG was recorded in all dogs. The following parameters were evaluated from ECG tracing on lead II:

Arrhythmias, classified according to their origin, named in standard way [13] and their prevalence.

Cardiac rhythm, classified as sinus arrhythmia, regular.

Presence of ST coving

Heart rate was calculated by counting the R-R intervals over 5 non-consecutive 3 seconds intervals multiplied by 4.

The following parameters were measured and averaged for 5 non-consecutive R-R intervals on lead II:

P- wave amplitude and duration

PR- interval duration

R- wave amplitude

QRS- duration

QT- interval duration

T- wave amplitude

ST- segment depression or elevation

DATA ANALYSIS

The numerical parameters were compared to the standard dog ECG [13] and noted as categorical variables. The following parameters were categorized as normal, high or low: heart rate, 'P' amplitude, 'R' amplitude, and 'T' amplitude; following parameters were categorized as normal, prolonged or shortened: 'P' duration, 'QRS' duration, 'QT' duration and 'PR' duration; and R-R interval was classified as regular or irregular. 'T' amplitude was evaluated as a T/R ratio. A ratio of 0.25 was regarded as normal and a ratio below 0.25 as low.

The data was analyzed according to [14]. Each ECG parameters was analyzed for percentage of abnormal and normal observations.

RESULTS

One hundred eighty nine dogs with babesiosis were included in this phase of the study. The main clinical signs were anorexia/partial appetite, dehydration, temperature, dull/depressed, diarrhoea/constipation, pale mucosa, ticks on body, hepatolmegaly, vomiting/nausea, splenomegaly, rapid thready pulse, nasal discharge, ataxia/CNS signs, distended abdomen/ascites, dysponea, yellow coloured urine, emaciation/weight loss, epistaxis, occular discharge and edema in various combinations. An overall mean clinical score, based on 20 point scale, was 8.47 ± 0.27 with an individual score varying from 3 to 14. These dogs were cytologically positive for *B. gibsoni* having parasitaemia ranging from 1.30% to 15.50%.

Measurable data derived from the lead II of the ECG strips of a population of 189 dogs, diagnosed with babesiosis caused by *B. gibsoni*, are summarized in (Table 1). The mean heart rate (151.34 ± 53.36) was slightly higher than the standard reference value. Population mean of 'P' amplitude (0.17 ± 0.007) and 'QRS' duration (0.04 ± 0.02) were found to be slightly lower. Other parameters like 'P' duration (0.03 ± 0.01), 'R' amplitude (1.05 ± 0.51), 'R-R' interval (0.46 ± 0.15) 'QT' duration (0.15 ± 0.03), 'PR' duration (0.09 ± 0.06) and T: R ratio (0.26 ± 0.26) did not differ much from the standard reference values.

Nevertheless, heart rate was high in 51 and low in 4; 'P' amplitude was low in 3; 'R' amplitude was low in 17; 'R-R' interval was irregular in 15; 'QRS' duration was prolonged in 6 and shortened in 9; 'QT' duration was prolonged in 1 and shortened in 5; 'PR' duration was prolonged in 3 and shortened in 7; and 'T' amplitude was low in 39 dogs (Table 2).

Table 1: Electrocardiographic measurements of 189 dogs with babesiosis (Mean ± SD).

Parameters	Standard Reference value	Mean value (±SD)
Heart rate	70-160 (adults)	151.34±53.36
(beat/min)	60-140 (Large)	(50-360)
	≤180 (toy)	
	≤220 (puppies)	
P amplitude (mv)	≤0.4	0.17±0.07
		(0-0.4)
P duration (Sec)	≤0.05 (Large)	0.03±0.01
	≤0.04 (Small)	(0.02-0.08)
R amplitude (mv)	0.5-3 (large)	1.05±0.51
	0.5-2.5 (small)	(0.21-2.7)
R-R interval (sec)	-	0.46±0.15
		(0.208-0.912)
QRS duration (Sec)	0.06 (large)	0.04±0.02
	0.05 (small)	(0.02-0.06)
QT duration (Sec)	0.15-0.25	0.15±0.03
		(0.08-0.28)
PR duration (Sec)	0.06-0.13	0.09±0.06
		(0.04-0.16)
T:R ratio	≤0.25	0.26±0.25
		(0.03-1.0)

The prevalence of electrographic abnormalities was studied in 189 dogs having babesiosis due to natural infection of *B. gibsoni*. The results of abnormalities detected in the ECG strips are given in (Table 3). 51.32% dogs with babesiosis, due to *B. gibsoni*, were found to have either single (47.10%) or multiple (4.23%) abnormalities in the ECG strips. Of the 89 dogs having single ECG abnormality, the prevalence of tachycardia (Figure 1), low voltage complex (Figure 2), sinus arrhythmia (Figure 3), tachy arrhythmia (Figure 4), atrial fibrillation (Figure 5), sinus arrest

Table 2: Prevalence of abnormalities in electrocardiogram among measurable parameters in dogs with babesiosis.

Parameters	No. of case	Standard Reference value
Heart rate (beats/min)		
High	51	70-160 (adults)
Normal	134	60-140 (giant)
Low	4	≤180 (toy)
		≤200 (puppies)
P amplitude (mV)		
High	0	≤0.4
Normal	186	
Low	3	
P duration (sec)		
Prolonged	0	≤0.04
Normal	189	≤0.05 (giant)
R amplitude (mV)		
High	0	0.5-3 (large)
Normal	172	172
Low	17	0.5-2.5 (small)
R-R interval (sec)		
Regular	174	
Irregular	15	
QRS duration (sec)		
Prolonged	6	0.06 (large)
Normal	174	
Shortened	9	0.05 (small)
QT duration (sec)		
Prolonged	1	0.15-0.25
Normal	130	
Shortened	58	
PR duration (sec)		
Prolonged	3	0.06-0.13
Normal	179	
Shortened	7	
T amplitude (mV)		
High	0	≤R/4
Normal	150	
Low	39	

Table 3: Prevalence of electrocardiographic changes in dogs with babesiosis.

ECG Changes	No. of case	Percentage
A. Single Changes	89	47.10
Sinus arrhythmia	12	13.48
Tachycardia	32	35.96
Tachyarrhythmia	06	6.74
Bradycardia	02	2.25
Bradyarrhythmia	01	1.12
Atrial fibrillation	05	5.62
Atrial paroxysmal tachycardia	01	1.12
Sinus arrest	04	4.49
Mobitz type II heart block	03	3.37
Low voltage comples (LVC)	16	17.98
Ventricular premature complex (VPC)	02	2.25
ST depression	03	3.37
ST elevation	01	1.12
ST coving	01	1.12
B. Multiple changes	08	4.23
ST coving and broad QRS	02	25.0
ST elevation with coving	01	12.5
ST depression and atrial fibrillation	01	12.5
ST depression and tachycardia	01	12.5
ST depression and sinus arrest	01	12.5
ST depression, broad QRS, ST coving and increased R wave amplitude	01	12.5
Low voltage complex (LVC) and tachycardia	01	12.5
C. Normal (No change/Sinus rhythm)	92	48.68
Total		189

Figure 1 Showing Sinus Tachycardia.

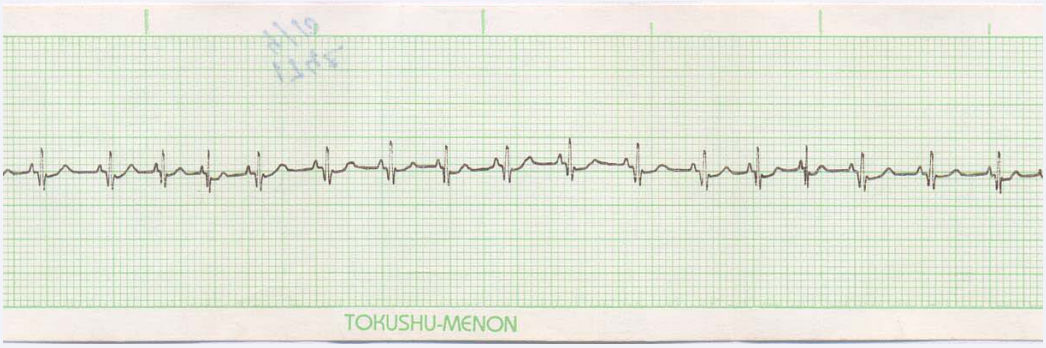

Figure 2 Showing Low Voltage Complex (LVC).

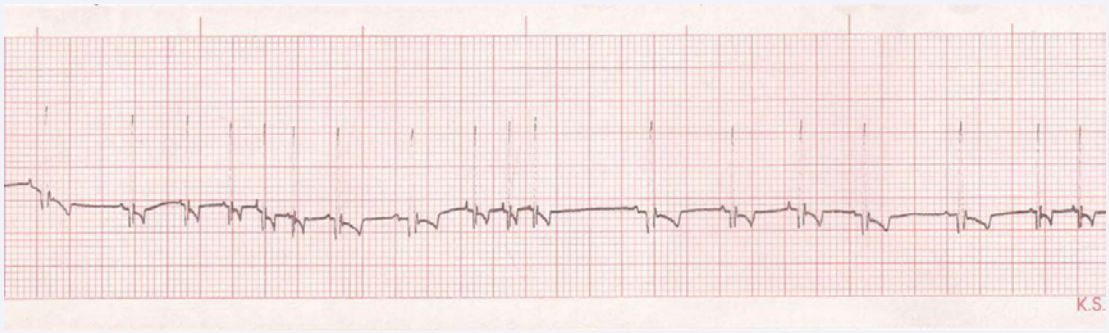

Figure 3 Showing Sinus Arrhythmia.

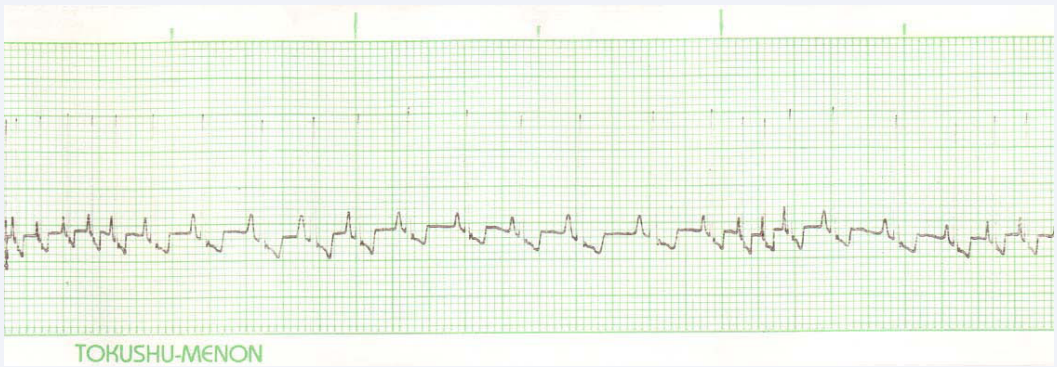

Figure 4 Showing Tachyarrhythmia.

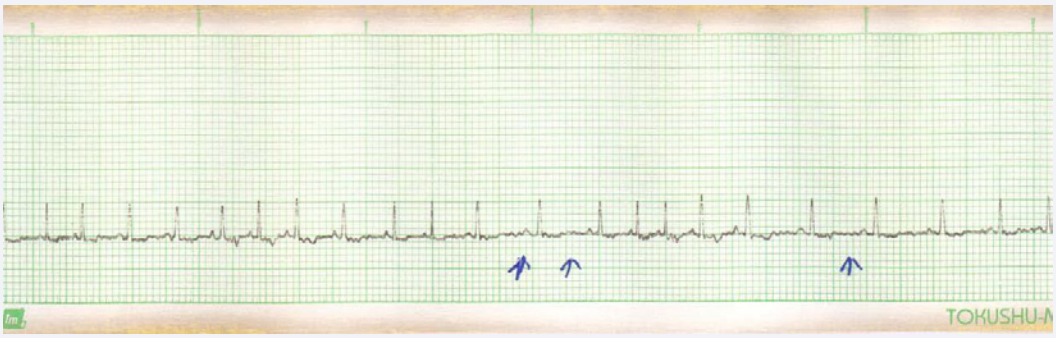

Figure 5 Showing Atrial Fibrillation.

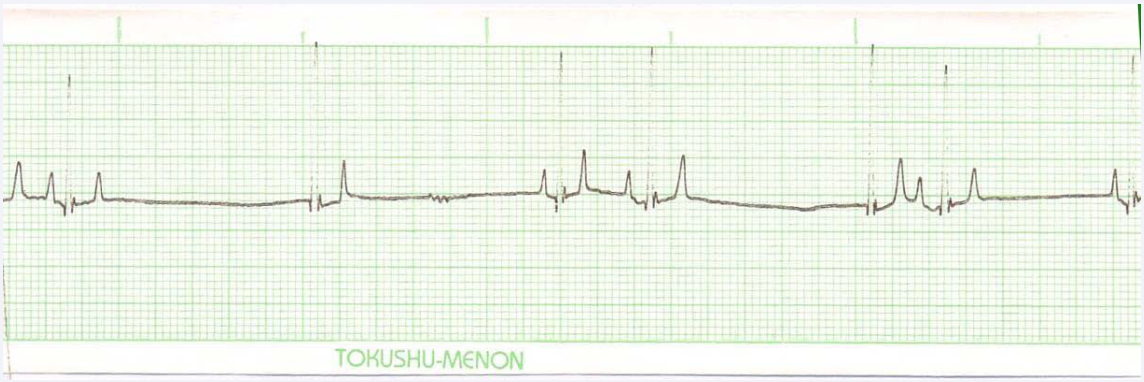

Figure 6 Showing Sinus Arrest.

Figure 7 Showing Ventricular Premature Complex (VPC).

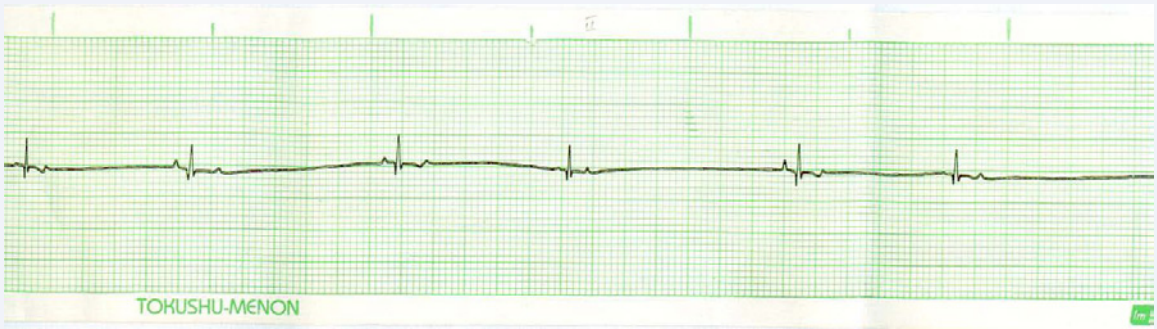

Figure 8 Showing Bradycardia.

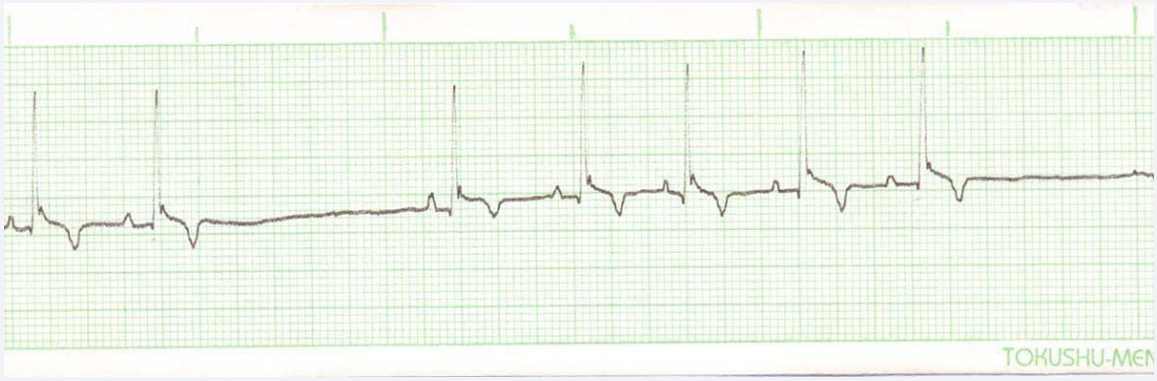

Figure 9 Showing ST elevation.

Figure 10 Showing ST coving.

Figure 11 Showing Atrial Paroxysmal Tachycardia.

(Figure 6), Mobitz type II heart block; ST depression (> 0.2 mV), ventricular premature complex (VPC) (Figure 7), bradycardia (Figure 8), brady arrhythmia, ST elevation (> 0.15 mV) (Figure 9) and ST coving (Figure 10), atrial paroxysmal tachycardia (Figure 11) was to the tune of 35.96%, 17.98%, 13.48%, 6.74%, 5.62%, 4.49%, 3.37%, 3.37%, 2.25%, 2.25%, 1.12%, 1.12%, 1.12% and 1.12%, respectively.

The dogs with *Babesia* infection also showed various types of complex changes viz, ST coving with broad QRS; ST elevation with coving; ST depression with atrial fibrillation; ST depression with tachycardia; ST depression with sinus arrest; ST depression, broad QRS, ST coaving with increased R wave amplitude, and low voltage complex with tachycardia accounting for 25.0%, 12.5%, 12.5%, 12.5%, 12.5%, 12.5% and 12.5% among the dogs with complex ECG changes (Table 3).

DISCUSSION

Electrocardiographic recordings of 189 dogs with babesiosis, caused by *B. gibsoni*, were studied. The study showed that ECG changes occurred in up to 51.32% dogs in some parameters. The prevalence of ECG abnormalities in dogs with babesiosis, caused by *B. gibsoni*, are on little higher side as compared to 40% reported in canine babesiosis in Africa, caused by *B. canis* [15]. The more common ECG changes were tachycardia, low voltage 'R' complex, sinus arrhythmia, tachyarrhythmia, atrial fibrillation and sinus arrest. The mean heart rate for the whole population was 151.34 ± 53.36 bpm which is slightly on the higher side of the normal range (Table 1) as reported in septic conditions [16]. Thirty two dogs had tachycardia and six dogs showed Tachy-arrhythmia. Increased heart rate results in increased cardiac output to compensate for the anaemia and metabolic effects of the disease [18]. Population mean for 'P' amplitude (0.17 ± 0.07 mV), 'P' duration (0.03 ± 0.01 sec), 'R' amplitude (1.05 ± 0.51 mV), 'QRS' duration (0.04 ± 0.02 sec), 'QT' duration (0.15 ± 0.03 sec), 'PR' duration (0.09 ± 0.06 sec) was slightly on lower side and for T:R ratio (0.26 ± 0.25) was slightly on higher side than the mean standard reference values (Table 1) but these values did not differ significantly. Bradycardia was seen in two dogs with complicated disease and seems to be a poor prognostic indicator in canine babesiosis [15]. Sinus bradycardia associated with syncope and sudden death has been reported in cardiomyopathies [19]. Bradyarrhythmia observed in one dog had negative clinical impact on exercise due to cerebral hypoxia [20]. There was higher prevalence of cardiac arrhythmia which seems to be due to haemodynamic changes in babesiosis. Five of the dogs had atrial fibrillation, atrial paroxysmal tachycardia was seen in 01, sinus arrest in 04, second degree heart block in 03 and ventricular premature complexes in 02 dogs. Based on ECG findings of conduction abnormalities associated with irregular rhythm, the conduction system could have been involved in this inflammatory process.

Sinus arrest is a failure to form an impulse. Sino-atrial block can be a normal incidental finding in the dog [21]. However, this is probably not the case in the present study as the dogs were sick and stressed. SA block can also be a result of extra cardiac causes viz., vagal irritation or hyperkalaemia [22]. Ventricular premature complex is a very non-specific arrhythmia that has been described in myocarditis owing to various causes [23], myocardial infarcts and ischaemia [24], septic condition [25], anaemia [22], and acid base electrolyte disturbances [26]. All these conditions are well documented in canine babesiosis, caused by *B. gibsoni*.

Three dogs in this study had Mobitz type II heart block. These can be incidental findings in the normal dogs [27], but in the present case, the dogs were sick and stressed. In sick dogs Mobitz type II A V block was seen after inducing ischaemic damage at the area of proximal bundle of His and increased heart rate [28]. This could occur in canine babesiosis. Such changes have also been reported in acute and chronic Chagas disease [17,29] and in other forms of myocarditis [23].

Low voltage 'R' complex was found in sixteen dogs. It is a common sign in pericardial effusion [30] and pleural effusion [22]. [15] observed a statistically significant correlation between the presence of small 'R' and pericardial effusion in cases of canine babesiosis caused by *B. canis*. Based on this study it appears that the prevalence of pericardial effusion in babesiosis, caused by *B. gibsoni*, was also higher. Effusion into cavities have been described as rare in canine babesiosis [31-33] but based on the present study the prevalence seems high. Low 'R' wave amplitude has been reported in association with myocardial disease, reduced left ventricular function [34-36] and myocardial infarction [37].

ST deviation (depression and elevation) and ST coving are non specific signs of myocardial ischaemia in dogs [22]. Diagnosis of myocardial ischaemia, based on ST deviation in different leads, is routine in human cardiology [38]. ST depression has been reported in humans with malaria [39], in dogs with 'Chagas' disease [29] myocardial infraction [40] and atherosclerosis [41]. In the present study, it was another sign supporting ischaemic changes within myocardium in canine babesiosis.

In 8 dogs with babesiosis more than one change in ECG strips were recorded (Table 3). 'ST' coving and broad 'QRS' seen in 2 dogs, were suggestive of left ventricular enlargement [22]. 'ST' elevation with coving indicated myocardial hypoxia or ischaemia. 'ST' depression with atrial fibrillation, 'ST' depression with tachycardia, 'ST' depression with sinus arrest, low voltage complex with tachycardia, and 'ST' depression with broad 'QRS', 'ST' coving and increased 'R' amplitude were also suggestive of myocardial ischaemia and/or myocardial involvement [22] in cases of canine babesiosis caused by *B. gibsoni*.

From the study it appears that the ECG changes in canine babesiosis are multifactorial and heart suffers from same pathological process, which has been observed for other organ involvement in canine babesiosis namely inflammatory reaction and ischaemia [9].

REFERENCES

1. Kalra IS, Singh KB. Observations of naturally occurring *Babesia canis* infection in dog. 1984; 61: 98-100.
2. Varshney JP, Kumar A, Hoque M. *Ehrlichia platys* and *Babesia canis* infection in a dog: A clinical report. J Vet Parasitol. 2004; 18: 35-37.
3. Sinha BP, Ghosh P. Treatment of clinical cases of canine babesiosis. IJVM. 1986; 6: 94.
4. Verma SP, Srivastava PS, Sinha SRP, Sinha BP, Sinha VK. An outbreak of canine babesiosis in police dog squad of Patna. Ind J Anim Health. 1989; 28: 47-49.
5. Varshney JP, Dey S. A clinical study on haemoprotozoan infections in referral canines. J Remount Vet Crop. 1998; 37: 83-89.
6. Varshney JP, Varshney VP, Hoque M. Clinico-haematological, biochemical, endocrinolgical and ultrasonographic findings in canine babesiosis. Ind J Anim Sci. 2003; 73: 1099-1101.
7. Purnell RE. Babesiosis in various hosts in Ristic, M, Kreier JP. editors. Babesiosis in New York: Academic Press Inc. 1981; 25-63.
8. Lobetti RG. Canine babesiosis. Compendium on Continuing Education for the Practicing Veterinarian. 1998; 20: 418-430.
9. Jacobson LS, Clark IA. The pathophysiology of canine babesiosis: New appraoches to an old puzzle.1994; 65: 134-135.
10. Reyers F, Leisewitz AL, Lobetti RG, Milner RJ, Jacobson LS. Canine

babesiosis in South Africa: more than one disease. Does this serve as a model for falciparum malaria? Ann Trop Med Parasitol. 1998; 92: 503-511.

11. Boyden PA. Cellular electrophysiologic basis of cardiac arrhythmia. Am J Cardiol. 1996; 78: 4-11.

12. Maegraith B, Gilles HM, Devakul K. Pathological processes in *Babesia canis* infections. Zeitschrift für Tropenmedizin and Parasitologie. 1957; 8: 485-514.

13. Tilley LP. Analysis of the canine P-QRS-T deflections. In: Tilley LP, editor. Essentials of Canine and Feline Electrocardiography Interpretation and Treatment. Lea and Febriger Philadelphia. 1992b.

14. Snedecor GW, Cochran WG. Statistical methods. 8th edn. Ames Iowa, Iowa state University Press. 1989.

15. Dvir E. Cardiac histopathology and electrographic changes in canine babesiosis. M. Med. Vet. (Med) Thesis. Submitted to the Faculty of Veterinary Science, University of Pretoria. 2001.

16. Bone RC, Balk RA, Cerra FB, Dellinger RP, Fein AM, Knasus WA. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. The ACCP/SCCM Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine. Chest. 1992; 101: 1644-1655.

17. Barr SC, Holmes RA, Klei TR. Electro cardiograph and echocardiograph features of trypanosomiasis in dogs inoculated with North American *Trypanosoma cruzi* isolates. Am J Vet Res. 1992; 53: 521-527.

18. Tilley LP. Pathophysiologic basis and hemodynamic effects of cardiac arrhythmias. In: Tilley LP, editor. Essentials of Canine and Feline Electrocardiography Interpretation and Treatment. Lea and Febriger, Philadelphia. 1992c.

19. Calvert CA, Jacobs GJ, Pickus CW. Bradycardia-associated episodic weakness, syncope, and aborted sudden death in cardiomyopathyc Doberman pinchers. J Vet Int Med. 1996; 10: 88-93.

20. Rishniw M, Thomas WP. Bradyarrhythmias. In: Bonagura JD, editor. Kirk's Current Veterinary Therapy XIII Small Animal Practice. Saunders WB, Philadelphia. 2000; 719-725.

21. Kittleson MD, Schukei TW. Sinoatrial block in a dog. JAVMA. 1980; 177: 332-334.

22. Tilley LP. Analysis of the common on canine cardiac arrhythmias. In: Tilley LP, editor. Essentials of Canine and Feline Electrocardiography Interpretation and Treatment. Lea and Febriger. Philadelphia. 1992a.

23. Patterson DF, Detweiler DK, Hubben K, Boots RP. Spotaneous abnormal cardica arrhythmias and conduction disturbances in the dog a clinical and pathologic study of 3000 dogs. Am J Vet Res. 1961; 22: 355-369.

24. Driehuys S, Van Winkel TJ, Sammarco CD, Droatz KJ. Mycoardial infarction in dogs and cats: 37 cases (1985-11994). JAVMA. 1998; 213: 1444-1448.

25. Lunney J, Ettinger SJ, Ettinger, S.J, Feldman, E.C. Textbook of Veterinary Internal Medicine. W.B. Saunders, Philadelphia. 1995; 959-995.

26. Keim S, Ayers ST, Grenvik A, Holbrook, and Shoemaker, Conduction disturbances in the critically ill. Critial Care. 1995; 3: 497-502.

27. Branch CE, Robertson BT, William JC. Frequency of second-degree atrioventricular heart block in dogs. Am J Vet Res. 1975; 36: 925-929.

28. Gonzalez MD, Scherlag BJ, Mabo P, Lazzara R. Functional dissociation of cellular activatoin as a mechanism of Mobitz type II atrioventricular block. Circulation. 1993; 87: 1389-1398.

29. Andrade ZA, Andrade SG, Maguire JM. Experimental Chaga's disease in dogs. Arc Pathol Lab Med. 1981; 71: 14-20.

30. Berg RJ, Wingfield W. Effect of graded pleural effusion on QRS in the dog. JAVMA. 1984; 178: 574-579.

31. Moore DJ, Williams MC. Disseminate intravasular coagultion: A complication of *Babesia canis* infection in the dog. JSAVA. 1979; 50: 265-275.

32. Gilles HM. Pathological processes in *Babesia canis*. 1951.

33. Breitschwerdt EB. Infectious diseases of the dog and cat. Saunders Co, Philadelphia. 1990; 796-803.

34. Liu S, Fox PR. Myocardial ischemia and infarction. In: JD. Bonagura, Kirk's Current Veterinary Therapy XI Small Animal Practice. W.B. Saunders, Philadelphia. 1992; 791-795.

35. Parker MD, Ayers ST, Grenvik A, Holbrook P.R, Shoemaker W C. The heart in sepsis. Critical Care. W.B. Saunders Co, Philadelphia. 1995; 596-604.

36. Parker MD, Shelhamer JR, Natanson C, Alling DW, Parrilo JE. Serial cardiovascular variables in survivors and nonsurvivors of human septic shock: Heart rate as an early predictor of prognosis. Critical Care Medicine. 1987; 15: 923-930.

37. Rakita L, Vrobel T, Kaufman ES. Electrocardiography. In: Ayers ST, Grenvik A, Holbrook PR, Shoemaker WC, editors. Critical Care. Saunders WB. Philadelphia. 1995; 492-497.

38. Finch C. Electrocardiography and vectorcardiography. In: Braunwald E, editor. Heart Diseases A Textbook of Cardiovascular Medicine. W.B. Saunders, Philadelphia. 1988; 180-222.

39. Franzen D, Curtius JM, Heitz W, Hoof HW, Diehl V, Hilger HH. Cardiac involvement during and after malaria. Clinical Investigator. 1992; 70: 670-673.

40. Fregin GF, Luginbuhl H, Guarda F. Myocardial infarction in a dog with bacterial endocarditis. JAVMA. 1972; 160: 956-963.

41. Liu Sk, Tilley LP, Tappe JP, Fox PR. Clinical and pathological findings in dogs with artherosclerosis: 21 cases (1970-1983). JAVMA. 1986; 189: 227.

Cite this article

Chaudhuri S, Varshney JP, Changkija B (2017) Electrocardiographic Changes in Canine Babesiosis. Arch Palliat Care 2(2): 1014.