ISTANBUL UNIVERSITY CERRAHPASA

Electrocardiographic Studies in Shall Sheep

Muhammadmehdi MIRABAD[1], Ali REZAKHANI[2]

[1]Department of Large Animal Internal Medicine, Tehran University School of Veterinary Medicine, Tehran, Iran
[2]Department of Large Animal Internal Medicine, Shiraz University School of Veterinary Medicine, Shiraz, Iran

Cite this article as: Mirabad, M., Rezakhani, A., 2019. Electrocardiographic Studies in Shall Sheep. Acta Vet Eurasia 45, 96-100.

ORCID IDs of the authors: M.M. 0000-0002-5241-1456; A.R. 0000-0001-9859-8028.

Abstract

The use of sheep in experimental animal models has increased recently. In the present study, we investigated normal electrocardiogram (ECG) parameters of clinically healthy Shall sheep. The animals were divided into two gender and age groups. Electrocardiograms were recorded on a base-apex lead, using limb lead I for at least 2 minutes. The heart rate range was 71–166 beats/min, with an average and standard deviation of 112.47±29.36. Statistical tests did not reveal any significant differences between two genders and ECG parameters. On the other hand, there was a significant difference between different age groups in the heart rate ($p<0.001$), P duration ($p=0.030$), QRS duration ($p=0.005$), and the P–R interval ($p=0.005$), Q–T interval ($p<0.001$), and R–R interval ($p<0.001$). Sheep with sinus arrhythmias had a significantly lower mean heart rate than sheep with normal rhythm ($p=0.007$). Furthermore, an analysis indicated that there was a significant difference between the age groups and the cardiac dysrhythmias ($p<0.01$). The results of this study can be used as a reference in studies on the Shall sheep breed.

Keywords: Age, electrocardiogram, gender, parameter, Shall sheep

Introduction

Electrocardiography (ECG) is a non-invasive, easy-to-use diagnostic technique that evaluates the electrical system of the heart to assess cardiac dysrhythmias and conduction abnormalities. It also provides a meaningful reflection of cardiac size, enlargement of chambers, myocardial damages, and metabolic disorders (Constable et al., 2016). Determination of the electrocardiogram normal values allows investigators to distinguish between pathological and physiological cases. A base apex lead has been shown as an ideal lead system for detecting cardiac dysrhythmias in large animals (Cedeno et al., 2016; Kumar et al., 2015; Rezakhani et al., 2004b). The Shall breed, as a dual-purpose sheep breed, originates from the Ghazvin area in central Iran with the population of over 600,000 heads. The Shall sheep is fat tailed, mostly black or brown, with white spots on the head (Hossein-Zadeh, 2015; Salehi and Taherpour-Dari, 2005). Recently, a number of studies have been carried out to investigate the normal ECG values in different sheep breeds (Chalmeh et al., 2015; Sudhakara and Sivajothi, 2018; Tajik J. et al., 2016). On the other hand, reviewing the literature revealed that no information is available on the normal ECG parameters of clinically healthy Shall sheep breed considering different gender and age groups. Hence, this study was conducted to investigate the ECG values of Shall sheep and to evaluate the effect of gender and different age on the ECG of this breed.

Materials and Methods

This study was carried out on 53 Shall sheep kept at the Aminabad Research Institute of Tehran University (latitude of 35° 34′ N and longitude 51° 29′ E, 1029 m above the sea level). A proportional stratified random sampling method was used to select the study population. A total of 530 shall sheep were

Address for Correspondence: Muhammadmehdi MIRABAD • **E-mail:** mehdi.mirabad@ut.ac.ir
Received Date: 3 July 2019 • **Accepted Date:** 11 November 2019 • DOI: 10.5152/actavet.2019.19018
Available online at actaveteurasia.istanbulc.edu.tr

selected, and the animals were divided into four groups (240 male sheep, 290 female sheep, 250 lambs, and 280 adults) regarding their gender and age. Ten percent of each stratum was randomly chosen based on the ear tag. No signs of failure in the cardiovascular system (edema, jugular distension, or pulsation) of the sheep were observed. Before obtaining the ECG, the health of animals was confirmed by physical examination. A single-channel electrocardiographic machine (Fukuda 501B-III, Japan) with the paper speed of 25 mm/sec and calibration of 10 mm equal to 1 mV was used. The sheep were held in the restraint box, 10 minutes prior to recording the ECG. To avoid stress reactions of sheep separated from the rest of the flock, the restraint box was placed inside the sheep flock. As much as possible, familiar shepherds were used to carry out the study. The connection between the small alligator electrode clips and the sheep's skin were moistened by 70% isopropyl alcohol. The positive electrode (left arm) was positioned in the fifth left intercostal space at the elbow level near the cardiac apex, the negative electrode (right arm) was attached to the left jugular groove at the cardiac base top, and the ground lead was placed on site away from the heart (Constable et al., 2016). To record the electrocardiograms, the base apex lead, limb lead I was used for at least 2 minutes. To analyze and measure the ECG parameters, a magnifying glass was used. By means of this method, the precision of duration and amplitude was 0.02 s and 0.05 mV, respectively. In the next step, the cardiac rate and rhythm, the amplitude of P, Q, R, S, and T waves; the duration of P, QRS, and T waves; and the P–R, Q–T, and R–R intervals were calculated and recorded. The heart rate was determined by measuring the R–R interval. A statistical analysis was carried out using the Statistical Package for the Social Sciences 20 (SPSS IBM Corp.; Armonk, NY, USA), and the data were expressed as the mean±standard deviation. The independent samples t-tests were used to evaluate statistical differences in the heart rate, wave amplitude, and duration, and the duration of the P–R, Q–T, and R–R intervals between the two genders and the two age groups. Pearson's correlation test was used to evaluate the relationship between the heart rate and age. Comparison of dysrhythmias between the two genders and age groups were performed using chi-square tests. The findings of this study were considered statistically significant at a p-value <0.05.

Results

The heart rate range was 71–166 beats/min, with an average and standard deviation of 112.47±29.36. There was a strong negative correlation between the heart rate and age (r=−0.875, p<0.001). The analysis of the ECG waveform and the associated parameters (features) is presented in Tables 1 and 2.

Statistical tests in the studied animals did not reveal any significant differences between the heart rate, amplitude, and duration of ECG parameters and the duration of the P–R, Q–T, and R–R intervals with gender. In contrast, there was a significant difference between different age groups in the heart rate (p<0.001), P duration (p=0.030), QRS duration (p=0.005), P–R interval (p=0.005), Q–T interval (p<0.001), and R–R interval (p<0.001). Further analysis showed that the sheep with sinus arrhythmias had a significantly lower mean heart rate than sheep with normal rhythms (p=0.007). A chi-squared analysis indicated that there was a significant difference between the age groups and the dysrhythmias (p<0.01, df=2, χ^2=10.967). The frequency of cardiac dysrhythmias in different age groups of Shall sheep is shown in the Figure 1.

Sinus tachycardia and sinus arrhythmia were two cardiac irregularities observed in the study. It is interesting to note that the normal cardiac rhythm was not observed in any of the 25 lambs examined in the study. From the Figure 1, it can be seen that the frequency of sinus tachycardia in Group 1 (lambs) is higher than in Group 2 (adults), and the difference is statistically significant (p<0.001, df=1, χ^2=26.323).

Table 1. Heart rate, amplitude, and duration of the electrocardiographic waves in different genders and age groups of Shall sheep

	All sheep	Male sheep	Female sheep	Group 1 (lambs)	Group 2 (adults)
Number of animals	53	24	29	25	28
Heart rate (Beats/min)	112.47±29.36	117.50±29.11	108.31±29.42	139.40±12.89**	88.42±15.56**
P amplitude	0.152±0.038	0.141±0.038	0.161±0.036	0.160±0.032	0.145±0.042
P duration	0.040±0.007	0.039±0.007	0.041±0.006	0.038±0.007*	0.042±0.006*
P–R interval	0.118±0.027	0.117±0.020	0.119±0.032	0.107±0.013†	0.128±0.033†
QRS amplitude	0.670±0.193	0.676±0.223	0.665±0.169	0.689±0.144	0.653±0.230
QRS duration	0.044±0.011	0.042±0.009	0.045±0.012	0.040±0.005†	0.048±0.013†
Q–T interval	0.262±0.049	0.256±0.045	0.266±0.052	0.222±0.015**	0.297±0.040**
T amplitude	0.431±0.234	0.427±0.198	0.435±0.263	0.456±0.153	0.409±0.289
T duration	0.063±0.025	0.063±0.013	0.062±0.031	0.058±0.013	0.067±0.031
R–R interval	0.569±0.151	0.544±0.146	0.589±0.154	0.433±0.039**	0.690±0.102**

*p≤0.05; **p≤0.001; †p≤0.01

Table 2. Configuration of the electrocardiographic waves in Shall sheep

ECG configuration	p wave	QRS complex		T wave	
ECG patterns	+	rS	QS	+	+/–
Number	53	19	34	47	6
Percentage	100%	35.84%	64.15%	88.67%	11.32%

ECG: electrocardiogram

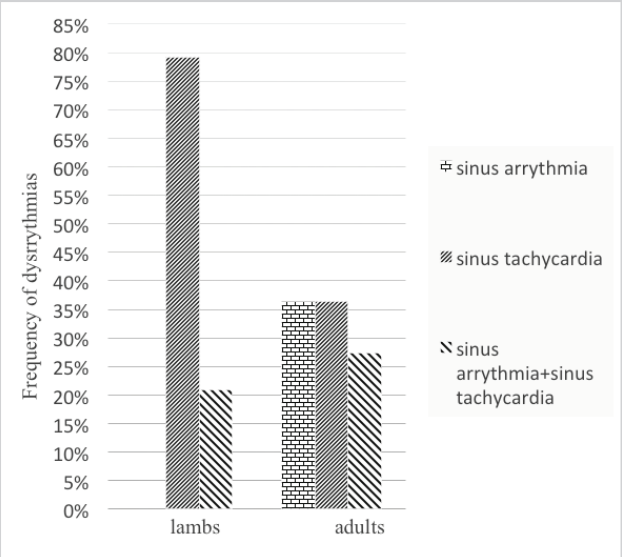

Figure 1. Frequency of dysrhythmias in different age groups of Shall sheep

Discussion

Despite the enormous contribution to human cardiovascular research (Bhatt et al., 2005; Camacho et al., 2016; Milani-Nejad and Janssen, 2014), the studies that have considered normal ECG values and dysrhythmias in sheep are limited. Constant and steady-state configuration in the cardiac parameters, accompanied by negligible effects of animal movement on the ECG quality are the reasons for the use of the base–apex lead system in large animal cardiology (Constable et al., 2016). In reviewing the literature, no data were found on the normal ECG values of the Shall sheep. Hence, the present study was designed to determine the standard values of ECG parameters in clinically healthy Shall sheep based on gender and age.

In our study, the mean heart rate for the Shall sheep was 112.47±29.36. The mean heart rate was found to be higher in the Kermani sheep with 128.9 beats/minute, and lower in the Balouchi sheep with 89.6 beats/minute, Garol sheep with 85 beats/minute, and fat-tailed sheep with 102 beats/minute (Ahmed and Sanyal, 2008; Rezakhani and Edjtehadi, 1980; Tajik J. et al., 2016; Tajik T. et al., 2016). Previous research has documented that the heart rate can be recognized as an indicator of age variation in diverse animals (Ferasin et al., 2010; O'connor et al., 2008; Ohmura and Jones, 2017; Rezakhani et al., 2004a; Santarosa et al., 2016), and especially in sheep (Sudhakara and Sivajothi, 2018; Tajik T. et al., 2016). In the current study, the mean heart rate found for adult Shall sheep was 88.42±15.56, which is statistically significantly lower than the mean heart rate found for lamb Shall sheep (139.40±12.89). There were no significant differences between the two genders and the heart rate. This finding corroborates by Tajik J. (2016) and contrasts with another study (Tajik T. et al., 2016). In this study, the rams had a higher heart rate than the ewes. Certain factors such as animal excitement, age, behavior, and individual identity can affect the heart rate (Baldock et al., 1988; Constable et al., 2016). A significant difference was found between the P-wave duration and age groups of Shall sheep. Nevertheless, this finding is in contradiction with previous reports, which found no apparent difference between the P-wave duration and age groups of different sheep breeds (Chalmeh et al., 2015; Sudhakara and Sivajothi, 2018; Tajik J. et al., 2016; Tajik T. et al., 2016). Also, this result is in agreement with other studies with both human and animal models (Barutçu et al., 2009; Santarosa et al., 2016). The spread of electrical activity through the atria consequently leads to an increase in the heart size with aging. The previous statement matches those observed in earlier studies (Avizeh et al., 2010; Ghadrdan Mashhadi et al., 2016; Reddy and Sivajothi, 2016; Surawicz and Knilans, 2008). Both the PR and QT intervals were longer in adult animals than in lambs, which was statistically significant. The PR interval represents the time impulse transmitted from the sinus node to the atrioventricular node. In addition, the QT interval reflects the ventricular depolarization and repolarization (Muir and Hubbell, 2008; Surawicz and Knilans, 2008). A similar mechanism could explain longer PR and QT intervals in adult animals, as previously described for P duration. The QRS duration was considered a detection criteria in impaired ventricular conduction (Das and Zipes, 2012; Surawicz and Knilans, 2008). Numerous studies have confirmed the age-related changes in QRS duration (Ghadrdan Mashhadi et al., 2016; Mantovani et al., 2013; Rezakhani et al., 2004b). Also, various factors such as hyperkalemia, abnormal or partial impulse formation, and sodium-channel blockers contribute to the QRS complex widening (Muir and Hubbell, 2008; Surawicz and Knilans, 2008). As a hypothesis, it can be argued that in the Shall sheep, the effect of age on the ECG parameters is more prominent than gender. Once again, the reason could be the differences in the size of the heart of the lambs compared to the adult sheep. The influence of gender on ECG parameters has been widely studied (Ghadrdan Mashhadi et al., 2016; Macfarlane, 2018). Furthermore, the effect of sex hormones on ECG parameters has been proven by different authors (Santarosa et al., 2016; Tajik T. et al., 2016; Ziv and Kaufman, 2012). Further studies are required in different sheep breeds to investigate the effects of sex hormones on the ECG parameters.

As shown in Table 2, the configuration of the p waves in all animals were positive. A positive p wave was the most prominent

configuration of p wave in other studies (Rezakhani and Edjtehadi, 1980; Tajik T. et al., 2016; Torío et al., 1997). The dominant QRS configuration in our sheep was QS. The QS morphology has been reported to be the main QRS morphology (in the base-apex lead system) by various researchers (Kamali et al., 2017; Rezakhani and Edjtehadi; 1980, Rezakhani et al., 2004b). The T wave was positive or diphasic (+/–). This finding has been reported by different authors in different sheep breeds (Tajik J. et al., 2016; Tajik T. et al., 2016). There was no normal sinus rhythm in lambs (Figure 1). The impulse initiation and conduction above normal (90 and 120 for adult sheep and lambs, respectively) with origin of the sinus node considered to be sinus tachycardia (Constable et al., 2016). Previous studies have shown that sinus tachycardia is the most prominent arrhythmia in lambs (Chalmeh et al., 2015; Pourjafar et al., 2011). Physiologic sinus tachycardia is mainly rooted in catecholamine, however synergistic inhibition of the vagus nerve plays a role in the formation of this cardiac arrhythmia (Yusuf and Camm, 2005). Sinus tachycardia is frequently associated with excitement, pain, exercise, anemia, hypotension, and the administration of adrenergic agents (Constable et al., 2016; Muir and Hubbell, 2008). As sinus tachycardia is a physiological response to stress, treatment is rarely required (Reed et al., 2018). Another dysrhythmia observed in this study was sinus arrhythmia. The PP interval variability >10% is clearly and unambiguously indicative of sinus arrhythmia (Constable et al., 2016). Physiological reaction to respiration or drug-induced vagal stimulation are predisposing factors for sinus arrhythmia (Das and Zipes, 2012). In the current study, sheep with sinus arrhythmias had a significantly lower mean heart rate than sheep with normal rhythms (p=0.007). This finding has been confirmed in other studies (Rezakhani and Edjtehadi, 1980; Rezakhani et al., 2004a; Tajik T. et al., 2016). Cardiac irregularities are considered a normal physiological phenomenon since there were no clinical signs of cardiovascular disease. Finally, results obtained from this study can be used as a reference for future studies, and one of the more significant findings is the suitability of the base–apex lead system in the Shall sheep.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – M.M., A.R.; Design - M.M., A.R.; Supervision - M.M., A.R.; Resources - M.M., A.R.; Materials - M.M.; Data Collection and/or Processing - M.M., A.R.; Analysis and/or Interpretation - M.M., A.R.; Literature Search - M.M., A.R.; Writing Manuscript - M.M., A.R.; Critical Review - M.M., A.R.

Acknowledgement: We gratefully acknowledge the help provided by Dr.Seyed Mahdi Ghamsari, the head of Amin-Abad Research Institute.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

References

Ahmed, J.A., Sanyal, S., 2008. Electrocardiographic studies in Garol sheep and black Bengal goats. Research Journal of Cardiology 1**,** 1-8. **[CrossRef]**

Avizeh, R., Papahn, A., Ranjbar, R., Rasekh, A., Molaee, R., 2010. Electrocardiographic changes in the littermate mongrel dogs from birth to six months of life. Iranian Journal of Veterinary Research 11, 304-311.

Baldock, N., Sibly, R., Penning, P., 1988. Behaviour and seasonal variation in heart rate in domestic sheep, Ovis aries. Animal Behaviour 36**,** 35-43. **[CrossRef]**

Barutçu, İ., Esen, Ö., Kaya, D., Onrat, E., Melek, M., Çelik, A., Kilit, C., Esen, A.M., 2009. The Relationship Between Aging and P Wave Dispersion. Kosuyolu Heart Journal 12**,** 5-9.

Bhatt, L., Nandakumar, K., Bodhankar, S., 2005. Experimental animal models to induce cardiac arrhythmias. Indian Journal of Pharmacology 37**,** 348-357. **[CrossRef]**

Camacho, P., Fan, H., Liu, Z., He, J.Q., 2016. Large mammalian animal models of heart disease. Journal of Cardiovascular Development and Disease 3**,** 1-11. **[CrossRef]**

Cedeno, D.A., Lourenço, M.L., Daza, C.A., Chiacchio, S.B., 2016. Electrocardiogram assessment using the Einthoven and base-apex lead systems in healthy Holstein cows and neonates. Pesquisa Veterinária Brasileira 36**,** 1-7. **[CrossRef]**

Chalmeh, A., Akhtar, I.S., Zarei, M.H., Badkoubeh, M., 2015. Electrocardiographic indices of clinically healthy Chios sheep. Veterinary Science Development 5**,** 99-102. **[CrossRef]**

Constable, P.D., Hinchcliff, K.W., Done, S.H., Grünberg, W., 2016. Veterinary Medicine-E-Book: A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs and Goats. Elsevier Health Sciences, St. Louis.

Das, M.K., Zipes, D.P., 2012. Electrocardiography of Arrhythmias: A Comprehensive Review E-Book: A Companion to Cardiac Electrophysiology. Saunders Company, Philadelphia.

Ferasin, L., Ferasin, H., Little, C., 2010. Lack of correlation between canine heart rate and body size in veterinary clinical practice. Journal of Small Animal Practice 51**,** 412-418. **[CrossRef]**

Ghadrdan Mashhadi, A.R., Kamali, S., Haji Hajikolaei, M.R., Rezakhani, A., Fatemi, S.R., 2016. Determination the Normal Parameters (amplitude and duration) of Electrocardiogram Waves in River Buffaloes (Bubalus Bubalis) of Khuzestan. Iranian Journal of Ruminants Health Research 1**,** 23-31.

Hossein-Zadeh, N.G., 2015. Modeling the growth curve of Iranian Shall sheep using non-linear growth models. Small Ruminant Research 130**,** 60-66. **[CrossRef]**

Kamali, S., Ghadrdan, M.A., Haji, H.M., Fatemi, T.S., Rezakhani, A., 2017. Survey on Frequency of Various Forms of QRS Complex in Khuzestan River Buffalo. Iranian Veterinary Journal 13**,** 91-97.

Kumar, C.P., Sundar, N.S., Reddy, B., Praveena, G., Kumar, R., 2015. Electrocardiogram of small ruminants by base apex lead system. Indian Journal of Small Ruminants 21**,** 141-142. **[CrossRef]**

Macfarlane, P.W., 2018. The influence of age and sex on the electrocardiogram. In: Kerkhof, P.L.M., Miller, VM. (Ed.), Sex-Specific Analysis of Cardiovascular Function. Springer, Cham, pp. 93-106. **[CrossRef]**

Mantovani, M., Tsuruta, S., Muzzi, R., Machado, T., Pádua, M., Coimbra, C., Muzzi, L., Jacomini, J., 2013. Electrocardiographic study in

the American Quarter Horse breed. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 65**,** 1389-1393. **[CrossRef]**

Milani-Nejad, N., Janssen, P.M., 2014. Small and large animal models in cardiac contraction research: advantages and disadvantages. Pharmacology & Therapeutics 141**,** 235-249. **[CrossRef]**

Muir, W.W., Hubbell, J.A.E, 2008. Equine Anesthesia: Monitoring and Emergency Therapy, Saunders Company, St. Louis. **[CrossRef]**

O'connor, M., Mcdaniel, N., Brady, W.J., 2008. The pediatric electrocardiogram: Part I: Age-related interpretation. The American Journal of Emergency Medicine 26**,** 506-512. **[CrossRef]**

Ohmura, H., Jones, J.H., 2017. Changes in heart rate and heart rate variability as a function of age in Thoroughbred horses. Journal of Equine Science 28**,** 99-103. **[CrossRef]**

Pourjafar, M., Badiei, K., Chalmeh, A., Sanati, A., Bagheri, M., Badkobeh, M., Shahbazi, A., 2011. Cardiac arrhythmias in clinically healthy newborn Iranian fat tailed lambs. Global Veterinaria 6**,** 185-189.

Reddy, B., Sivajothi, S., 2016. Electrocardiographic parameters of normal dairy cows during different ages. Journal of Veterinary Science & Medicine 4**,** 5. **[CrossRef]**

Reed, S.M., Bayly, W.M., Sellon, D.C., 2018. Equine Internal Medicine. Elsevier, St. Louis.

Rezakhani, A., Edjtehadi, M., 1980. Some electrocardiographic parameters of the Fat-tailed sheep. Zentralblatt für Veterinärmedizin Reihe A 27**,** 152-156. **[CrossRef]**

Rezakhani, A., Paphan, A., Gheisari, H., 2004a. Cardiac dysrhythmias in clinically healthy heifers and cows. Revue de Medecine Veterinaire 155**,** 159-162.

Rezakhani, A., Paphan, A.A., Shekarfroush, S., 2004b. Analysis of base apex lead electrocardiograms of normal dairy cows. Veterinarski Arhiv 74**,** 351-358.

Salehi, M., Taherpour-Dari, N., 2005. Evaluation of wool characteristics of Iranian sheep breeds 4 _ Arabi breed. Animal Science Research Institute, Final Report, Ministry of Agriculture, Iran. http://agris.fao.org

Santarosa, B.P., Lourenço, M.L., Dantas, G.N., Ulian, C., Heckler, M.C., Sudano, M.J., Gonçalves, R.C., Chiacchio, S.B., 2016. Electrocardiographic parameters of the American Miniature Horse: influence of age and sex. Pesquisa Veterinária Brasileira 36**,** 551-558. **[CrossRef]**

Sudhakara, R.B., Sivajothi, S., 2018. Electrocardiographic studies in different age groups of Nellore cross-breed sheep. International Clinical Pathology Journal 6**,** 30-32. **[CrossRef]**

Surawicz, B., Knilans, T., 2008. Chou's Electrocardiography in Clinical Practice: Adult and Pediatric. Saunders Company, Philadelphia.

Tajik, J., Samimi, A.S., Shojaeepour, S., Jarakani, S., 2016. Analysis of base-apex lead electrocardiogram in clinically healthy Kermani sheep. Acta Vet Eurasia 42**,** 74-79. **[CrossRef]**

Tajik, T., Aslani, M.R., Tajik, J., 2016. Electrocardiographic parameters in clinically healthy Balouchi sheep. Iranian Journal of Veterinary Science and Technology 7**,** 84-91.

Torío, R., Cano, M., Montes, A., Prieto, F., Benedito, J., 1997. Comparison of two methods for electrocardiographic analysis in Gallega sheep. Small Ruminant Research 24**,** 239-246. **[CrossRef]**

Yusuf, S., Camm, A.J., 2005. Deciphering the sinus tachycardias. Clinical Cardiology 28**,** 267-276. **[CrossRef]**

Ziv, O., Kaufman, E.S., 2012. Age and gender modulation of the long QT syndrome phenotype. Cardiac Electrophysiology Clinics 4**,** 39-51. **[CrossRef]**