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Quantitative Analysis of Normal Electrocardiogram from Tele Minas Saúde Project, Minas Gerais, Brazil

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Abstract

The electrocardiogram (ECG) is a widely used tool to track and to detect heart diseases which are one of the leading causes of death in the world. Some countries have been using the resources of telemedicine to enable health care in situations where distance is a critical factor, including cardiovascular diseases. In Brazil, the State of Minas Gerais has a telecardiology system, the Teleminas Saúde Project, which covers approximadely 70% of the state population. The objective of this article is to quantify and analyze the electrocardiographic information of normal patients from Teleminas Saúde Project. It was observed that ethnicity, gender and age may influence the ECG reference values of normal patients. For the future, it is suggested a study to obtain the normal ECG reference interval using data from Brazilian adults, by gender and age, including patients from all regions of Brazil.

Keywords: Electrocardiogram; Telemedicine; Sampling techniques

Introduction

The electrocardiogram (ECG) is a method to measure and record different electrical potentials of the heart. Willem Einthoven developed the ECG method in the early 1900s [1]. Electrocardiogram signal analysis has received special attention of the researchers in the recent past because of its ability to divulge crucial information about the electrophysiology of the heart and the autonomic nervous system activity in a noninvasive manner [2]. In addition, it is a commonly test used to support in the diagnosis of heart disease. The Tele Minas Saúde Project (TMS Project) consists in the implementation of telecardiology in small cities from interior of the state of Minas Gerais, Brazil. This is a public project that aims to expand medical care with quality and low cost and to reduce unnecessary medical referral. The TMS Project is composed by seven poles which are the responsibility of the following Universities: State University of Montes Claros (UNIMONTES Pole), Federal University of Juiz de Fora (UFJF Pole), Federal University of Minas Gerais (UFMG Pole), Federal University of São João Del-Rei (UFSJ Pole), Federal University of Uberlândia (UFU Pole) and Federal University of the Triângulo Mineiro (UFTM Pole), Federal University of Vales do Jequitinhonha e Mucuri (UFVJM Pole). The TMS Project provides telemedicine services to 780 cities that are connected to one of the seven poles, but in the study period were 665 cities and six poles. Federal University of Vales do Jequitinhonha e Mucuri (UFVJM Pole) was incorporated in 2016. The UFMG pole is the coordinator of the project and it is responsible for the articulation with the other institutions. The database and the hardware structure (servers, backup) are installed in the Telehealth Center of the UFMG Clinical Hospital. It is expected that several peculiarities such as gender, age and ethnicity, may interfere in the electrical impulse conduction and ECG information from normal patients, non-pathologic. An important contribution of this study is that it has considered electrocardiographic information for Brazilian patients. The objective of this article is to quantify and analyze the electrocardiographic information of normal patients from TMS Project.

Materials and Methods

As the heart impulse travels through the heart, electrical currents spread to the tissues surrounding the heart and a small fraction of these currents reach the surface of the body. When electrodes are placed on the skin, the electrical potentials generated by these currents can be recorded. This record corresponds tothe electrocardiogram (ECG) [3]. The normal ECG is formed by P wave, QRS complex and T wave. Most of the time the QRS complex presents Q, R and S waves. Occasionally the U wave can be identified in the electrocardiogram. See Figure 1.

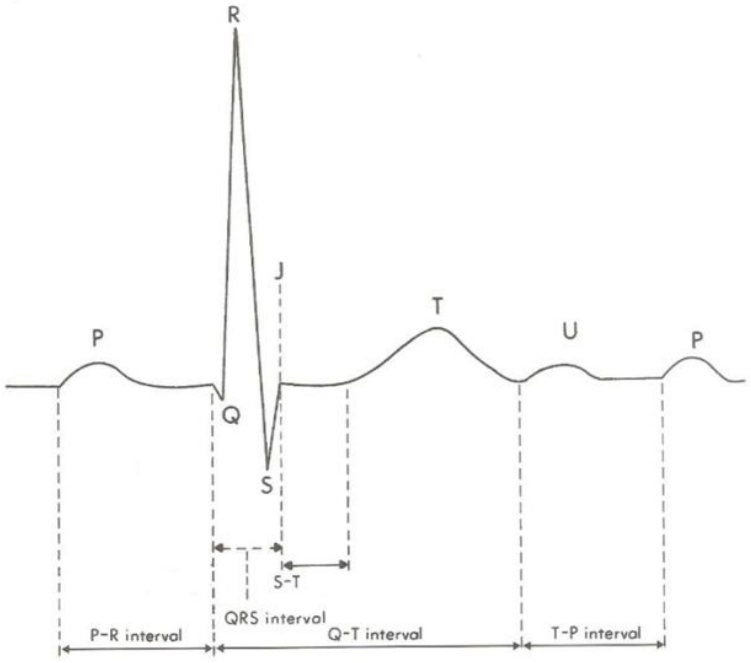

Figure 1: ECG Record

At this work, it was made a retrospective and exploratory study. The database has 318.387 electrocardiogram of patients from TMS Project that were examined in 2011. Therefore, the technique of proportional stratified random sampling was used to select the samples.

The sample size, n, was calculated by solving the equation (1):

$$n \geq \frac{Z_{a/2}^2 \, \hat{p}(1-\hat{p})}{E^2} \qquad (1)$$

Where, $Z_{\alpha/2}$ is a critical value of the normal distribution at α/2, $\hat{p}$ is the sample proportion, E is the margin of error. Here, it was adopted $Z_{0,025}$ = 1,96 and 1,6% of margin of error and it was assumed $\hat{p}=0,5$ for the unknow estimative of p [4]. According to the expression above, the sample size should be $n \geq 3752$. Therefore, it was selected 4000 electrocardiograms. The pole random sample is proportional to the sum of the population of the cities that are served by the respective pole, see Table 1.

Pole	Sample size	Population	Number of cities
UFMG	1.676	3.615.708	124
UFSJ	370	797.775	102
UFJF	525	1.133.193	72
UNIMONTES	836	1.803.834	117
UFU	286	616.150	152
UFTM	307	662.455	98
TOTAL	4.000	8.074.580	665

Table 1: Sample size, Population and Number of cities by pole, 2011

Results and Discussions

The cardiologists from TMS Project analyze the ECG exams of all patients and classify them as normal and pathological. Thus, in the 4000 examinations of the sample, it was found normal ECG (53,40%), pathological ECG (40,23%), inconclusive ECG (6,05%) and unreported ECG (0,33%). In an earlier study, it was considered all exams of the database in 2009 and the 56,87% of the TMS project ECG were normal [5].

In another approach, it was used the Wincardio software to obtain the waves duration and amplitude and segments of the normal ECG of the TMS project sample. The measures obtained were: P wave amplitude and duration, PR segment duration, R wave amplitude, QRS complex duration, RR interval duration, QT segment duration, corrected QT interval (QTc), T wave amplitude

and duration. The electrocardiographic measurements were performed in the DII derivation because it refers the electrical and anatomical axis of the heart (around +60 degrees). Initially, there were 2136 normal ECG. After exclusion of the ECG of patients with heart disease and patients younger than 18 or over 60 years, since the interest here is to study ECG of only adult patients. So, it remained 1113 ECG for the quantitative study. The Table 3 presents the statistical summary for normal ECG measurements, such as minimum value (Min), maximum value (Max), mean ($\overline{X}$), median (Md), first quartile (Q_1), third quartile (Q_3), standard deviation (SD), coefficient of variation (CV) and skewness (Sk).

	UFU		UFTM		UFJF		UFJF		UNIMONTES		UFMG		TMS Project	
Report	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Unreported	3	1,05	1	0,32	2	0,54	0	0	3	0,36	4	0,24	13	0,33
Inconclusive	16	5,59	21	6,84	23	6,22	30	5,71	33	3,95	119	7,10	242	6,05
Normal	148	**51,75**	162	**52,77**	199	**53,78**	291	**55,43**	454	**54,31**	882	**52,62**	2136	**53,40**
Pathology	119	41,61	123	40,06	146	39,46	204	38,86	346	41,39	671	40,03	1609	40,23
Total	286	100,0	307	100,0	370	100,0	525	100,0	836	100,0	1676	100,0	4000	100,0

Table 2: Classification of the electrocardiogram reports by pole, 2011

EEG records	Min	Max	$\overline{X}$	Md	Q_1	Q_3	SD	CV	Sk
P (mV)	0,02	0,27	0,13	0,12	0,09	0,16	0,05	38,11	0,37
ST (ms)	43,33	186,67	107,33	106,67	90,00	123,33	25,66	23,91	0,16
R (mV)	0,13	2,64	1,00	0,97	0,70	1,23	0,41	40,85	0,64
P (ms)	60,00	156,67	107,41	106,67	96,67	120,00	17,31	16,12	0,04
PR (ms)	80,00	213,33	146,64	146,67	130,00	163,33	23,01	15,69	0,22
RR (ms)	516,67	1373,33	868,55	860,00	760,00	963,33	146,59	16,88	0,38
QT (ms)	293,33	493,33	389,49	386,67	366,67	410,00	32,82	8,43	0,22
QRS (ms)	63,33	146,67	100,72	100,00	90,00	110,00	15,62	15,50	0,33
QTc (ms)	283,27	557,78	420,41	420,34	401,44	438,75	28,97	6,89	0,17
T (mV)	0,04	0,71	0,29	0,27	0,19	0,36	0,12	41,63	0,64
T (ms)	96,67	270,00	181,94	180,00	160,00	203,33	31,09	17,09	0,21

Table 3: Statistical summary for normal ECG records

The Table 3 presents the statistical summary for R wave amplitude, mV, by age and gender. It shows that for all normal ECG, the minimum R wave is 0,13 mV and the maximum R wave is 2,64 mV, the mean ($\overline{X}$) is 1,0 mV and the median (Md) is 0,97 Mv. The variability is high (CV=40,85%) and the distribution is smooth asymmetrical on the right (Sk=0,64). According to age, male and female patients under 29 have the highest R wave amplitude values. The study by Wu et al. (2003) also suggests that the amplitude of the R wave decreases with increasing age for both genders [6].

Grupos	*n*	Min	Max	$\overline{X}$	Md	Q_1	Q_3	SD	CV	Sk
All	1113	0,13	2,64	1,00	0,97	0,70	1,23	0,41	40,85	0,64
Male (M)	399	0,13	2,64	1,01	0,99	0,68	1,25	0,45	44,69	0,78
Female (F)	714	0,17	2,39	0,99	0,96	0,73	1,21	0,38	38,46	0,49
M, 18-19	18	0,49	1,82	1,16	1,16	0,85	1,50	0,38	32,98	-0,05
M, 20-29	84	0,29	2,64	1,24	1,18	0,92	1,48	0,49	39,76	0,94
M, 30-39	91	0,15	2,36	1,02	1,01	0,66	1,28	0,45	44,55	0,64
M, 40-49	114	0,20	2,12	0,92	0,86	0,62	1,21	0,41	44,81	0,66
M, 50-59	86	0,13	1,73	0,85	0,82	0,60	1,04	0,35	41,83	0,34
M, 60	6	0,48	1,95	1,01	0,91	0,85	0,99	0,49	48,65	1,66
F, 18-19	15	0,92	2,21	1,33	1,18	1,12	1,47	0,36	26,91	1,51
F, 20-29	148	0,22	2,39	1,10	1,08	0,82	1,38	0,39	35,25	0,43
F, 30-39	184	0,28	2,01	1,01	0,98	0,78	1,21	0,37	36,65	0,58
F, 40-49	205	0,25	2,05	0,91	0,88	0,65	1,14	0,38	41,20	0,52
F, 50-59	152	0,17	1,90	0,92	0,91	0,67	1,15	0,35	37,84	0,40
F, 60	10	0,33	1,57	1,04	1,04	0,83	1,46	0,39	37,55	-0,27

Table 4: Statistical summary for R wave amplitude, mV, by age and gender

Table 5 presents the references contained in the Guidelines of the Brazilian Society of Cardiology (BSC) on the Analysis and Issuance of Electrocardiographic Reports, which is based on about 85 papers published in the international literature between the years 1947 to 2009 [7]. Therefore, these guidelines do not take into account the characteristics of the Brazilian population. When comparing patients' information from the TMS project with the BSC guidelines, 0.45% of the patients were outside the reference range for P wave amplitude, 10.87% of patients were outside the reference range for the R wave amplitude, 38.81% of the patients were outside the reference range of the P wave duration, 10.7% of patients were outside the reference range of the PR interval, 10.7% of the patients were out of range of the QRS complex, 3.6% of the male patients were outside the reference range of the respective QTc, 2.97% of the female patients were outside the reference range of the respective QTc.

	BSC Guidelines		TMS Project Guidelines	
Variáveis	**Min**	**Max**	**Min**	**Max**
P (mV)	-	0,25	-	0,21
R (mV)	0,5	2	0,38	1,80
P (ms)	-	110	-	136,85
PR (ms)	120	200	112,15	188,11
QRS (ms)	-	120	-	129,56
M, QTc (ms)	-	450	-	466,61
F, QTc (ms)	-	470	-	475,15

Table 5: BSC Guidelines e TMS Project Guidelines

Table 5 proposes reference intervals using TMS Project data similar to the SBC Guidelines, that is, age was not taken into account and gender was considered only for the QTc reference interval. The TMS Project Guide used the mean of 10% of the smaller values to establish the minimum value of the reference interval and the mean of 10% of the larger values to establish the maximum value.

Conclusion

According to this study, the prevalence of normal ECG of the TMS project, in 2011, is 53.4%. In particular, the amplitude of the R wave, in mV, was analyzed. It was observed that the amplitude of the R wave decreases with increasing age. Analogously, other measures of the ECG trace such as P wave amplitude, P wave duration, ST interval, can be analyzed. In addition, it has been observed that ethnicity, gender and age may influence the ECG reference values of normal patients. Therefore, a study is proposed for future studies to obtain the normal ECG reference interval using data from Brazilian adults, by gender and age. Patients from all regions of the country should also be considered.

References

1. Biel L, Pettersson O, Philipson L, Wide P (2001) ECG analysis: a new approach in human identification. IEEE INSPEC 50: 808-12.

2. Nayak Sk, Bit A, Dey A, Mohapatra B, Pal K (2018) A Review on the Nonlinear Dynamical System Analysis of Electrocardiogram Signal. J Healthc Eng 2018: 1-19.

3. Guyton AC, Hall JE (2006) Textbook of Medical Physiology (11th Edn.) Elsevier Saunders, Philadelphia, United States.

4. Montgomery DC, Runger GC (2014) Applied Statistics and Probability for Engineers (6th edn), John Wiley and Sons, Hoboken, New Jersey, United States.

5. Alkmin MBM, Abreu MP, Figueira RM, Cunha LR, Neme ES et al. (2010) Teleassistência para municípios remotos do Estado de Minas Gerais: ampliando a atuação geográfica dos Hospitais Universitários. Minas, Brazil.

6. Wu J, Kors JA, Rijnbeek PR, Herpen G, Lu Z, et al. (2003) Normal limit of the electrocardiogram in Chinese subjects. Int J Cardiol 87: 37-51.

7. Pastore CA, Pinho C, Germiniani H, Samesima N, Mano R, et al. (2009) Sociedade Brasileira de Cardiologia. Diretrizes da Sociedade Brasileira de Cardiologia sobre Análise e Emissão de Laudos Eletrocardiográficos Arq Bras Cardiol 93: 1-19.