International Journal of Research in Medical Sciences
Mahendrappa SK et al. Int J Res Med Sci. 2014 Aug;2(3):861-865
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: 10.5455/2320-6012.ijrms20140821

Research Article

The normal variations in heart rate and QRS complex of healthy individuals in different age groups

Mahendrappa SK[1]*, Sathyanarayana TB

Department of Medicine, Shimoga Institute of Medical Sciences, Shimoga-577201, Karnataka, India

Received: 17 April 2014
Accepted: 4 May 2014

***Correspondence:**
Dr. Mahendrappa SK,
E-mail: medicogen.doc@gmail.com

ABSTRACT

Background: Electrocardiography is the only practical method of recording the electrical behavior of the heart. It is often an independent marker of myocardial disease and occasionally the only indication of the pathologic process. Therefore the present study has been undertaken to find out the degree of normal variations in healthy individuals in different age groups.
Methods: This study was conducted after the institutional ethical clearance and informed written consent from all the subjects belongs to age group of 18 to 40 years of either sex. All the ECG was taken in resting and supine position using BPL CARDIART 308 machine. The body weight, the QRS duration, QRS axis, P wave duration, P wave voltage, P wave axis in the frontal plane, QTc interval, T wave voltage and QRS-T angle was calculated. The values are expressed as mean and the percentile was calculated in each parameters.
Results: The weight ranges from 56.37 ± 6.53 kg. QRS duration ranged from 0.04 to 0.12 seconds mean of 0.064 seconds. QRS voltage in V_6 varied from 0.30 to 2.1 mv with a mean of 1.14 mv. The QTc interval was 0.31 to 0.47 seconds mean was 0.39 seconds. QRS-T angle varied from 0° to 70° with a mean of 30.9°.
Conclusion: The study provides the frequency distribution and other statistical data when applied to all components of ECG which are commonly assessed during investigations of healthy young individuals. Having knowledge of these normal variants will be helpful in arriving at correct diagnosis.

Keywords: Electrocardiogram, QRS duration, QRS axis, QRS voltage, QTc interval, T wave voltage

INTRODUCTION

Most of the cardiologists would probably define a normal ECG (Electrocardiogram) recording, as one that shows normal sinus rhythm, with no sinus tachycardia, bradycardia or other arrhythmias, in which the important intervals (PR, QRS and QT) are normal and finally in which the importance of the size, direction and form of the P waves QRS complexes and T waves are normal.

It is the only practical method of recording the electrical behavior of the heart. It is often an independent marker of myocardial disease and occasionally the only indication of the pathologic process. As ECG, reflects the electrical activity, it is not surprising that it may be normal in the presence of cardiac disease and abnormal in the absence of cardiac disease. Ranges of normalcy for ECG, components should be based on the analysis of randomly selected routine ECG, recorded in young healthy persons.[1] It is reasonable that only unequivocal ECG, changes should be considered. The normal data for electrocardiographic measurements are determined from studies of large group of clinically normal individuals. If one were to use the 100th percentile range for each measurement, there would be such a large overlap between normal and abnormal conditions as to render

electrocardiographic evaluation futile. As a result, arbitrary limits are used in the range 95th to 98th percentile range. Therefore for any given measurements 2 to 5% normal individuals will be outside the normal value and could be considered abnormal.[2] The physician must be aware this and avoid dogmatic criteria in differentiating between normal and abnormal ECG.

Variability may be due to any causes such as age, sex, body weight and chest (Configuration). Food intake - a high glucose meal can be produce electrocardiographic, changes which mimic abnormality. This is partly due to shift of potassium intracellularly. Ideally, all records should be taken under basal conditions. Since this is impractical, these physiological variations should be kept in mind such as exercise, smoking, and race. There is no doubt that there are differences in the E.C.G. of Caucasians and Negroes. For example the amplitude of R and S waves greater in Negroes than in Caucasians. On the other hand QRS duration of Negro men is shorter than of Caucasians.[3] With the elevation of diaphragm during pregnancy, it is not uncommon for QRS axis to move left wards. In. addition, flattening of right precordial T waves which may occur in normal subjects. Data concerning ECG, of healthy subjects over the age of 60 years are sparse. It has been found that in apparently healthy people over 70 year of age, 30-85% of ECG, measurements are outside the normal limits.

The cardiac tissue is supplied by the two coronary vessels, which are branches of the aorta and supply blood myocardium and also the conducting tissue through their branches. The heart rhythmically contracts about 70 to 80 times per minute. The pace maker (SA node) generates the impulse which is conducted to AV node and ventricles, through the conducting system. The heart rate is regulated my both Sympathetic and parasympathetic nervous system.[4-6] Sympathetic impulse increases the heart rate and the parasympathetic impulse decrease the heart rate. Therefore the present study has been undertaken to find out the degree of normal variations in healthy individuals in different age groups.

METHODS

This study was conducted at KMC hospital, Hubli, after the institutional ethical clearance and informed written consent from all the subjects belongs to age group of 18 to 40 years of either sex. The recruited subjects were not allowed to smoke before or while recording the ECG. The subjects with no history of symptom of cardiac disease, or any evidence of systemic illness which alter cardiac function, no evidence of previous cardiovascular diseases, no medication which altered cardiac rate and rhythm and resting blood pressure less than 140/90 mmHg were included. Subjects in whom general physical examination showed evidence of systemic diseases were excluded from the study.

All the ECG was taken in resting and supine position ECG using BPL CARDIART 308 machine. Subjects were not allowed to smoke half an hour prior to recording of ECG, height, weight and blood pressure and pulse rate of all the persons were recorded prior to the ECG. In each lead minimum of three complexes were taken. If Q wave were found in lead III, avF, then the ECG was also recorded in deep inspiration. In lead II rhythm strips were taken whenever necessary. 12 Lead ECG was recorded and as analyzed as follows.

Leads - I, II, III, avR, avL, avF. Precordial leads - $V_{1,\ 2,}$ $V_{3,}$ $V_{4,}$ $V_{5,}$ and V_6. Speed of recording was 25 mm/sec. The rate and rhythm was also recorded. The duration and voltage of P wave its axis in Leads - I, II, III, avR, avL, avF, PR interval in lead II, III and V_1 - V_6 was recorded. The QRS duration in precordial leads (V_1 - V_6), QRS axis in Lead I, Lead II, Lead III avR, avL and avF was also recorded. The configuration in all the leads such as voltage in Lead I, II,III, V_2 - V_4, Axis in lead I, II, III, avR avL avF, QT_c interval in V_5 - V_6. Lead I, II, avL.was recorded. ST segment changes in V_4, V_5 and V_6 was recorded. The Voltage and axis of T wave in lead I, II, III, $V_{2,}$ $V_{4,}$ $V_{5,}$ avR, avL, and avF was also recorded.

The heart rate was determined; a lead II, the duration of P wave was measured from that point at which the base line was first interrupted by an upward deflection until it returned to the baseline in lead II. P wave amplitude and all other amplitudes were measured using the upper portion of the base line as the reference point. The axis of P vector in the frontal plane was determined using standard reference system. P-R interval is measured from beginning of the P wave to the beginning of the QRS complex in any of the bipolar or unipolar extremity (V_1) lead, II whether represented by a Q or R wave. QT interval was measured from the beginning of QRS complex to the end of T wave in the lead in which it was longest, ($V_{5,}$ $V_{6,}$ I, II and avL[44]). Usually VQT_c was calculated using the formula, $QTC = QT/\sqrt{R.R}$ in seconds. The QRS complex duration was determined in the lead which demonstrates the largest value. QRS axis in the frontal plane was determined on the basis of hexaxial reference system. ST segment elevation was measured from the ST junction to the beginning of the T wave. It is usually isoelectric. T wave axis was determined by using hexaxial reference system. (I, II, III, avR, avL and avF). T voltage was determined in (I, II and avF).

Statistical analysis

The values are expressed as mean and the percentile was calculated in each parameters.

RESULTS

A detailed analysis was carried out on 150 normal electrocardiograms obtained from healthy young adults between the age group 18 to 40 years and the weight

ranges from 56.37 ± 6.53 kg (Table 1). The heart rate varied from 50 beats per minute to 122 beats per minute. Highest percentage was notice between 60 to 80 beats per minute. Sinus bradycardia (less than 60 per minute) seen in 4 persons (2.67%). Sinus Tachycardia (more than 100) seen in 14 persons (9.33%).

Table 1: Distribution of subjects on the basis of weight of the subjects. N=150.

Weight in kg	No. of subjects	Male	Female	Percentage
41 - 50	25	20	5	16.67
51 - 60	88	79	9	58.66
61 - 70	36	32	4	24
71 - 80	1	1	0	0.67

Note: The mean weight is 56.37± 6.53 kg.

The QRS duration more than 0.10 seconds in 3 persons who had REIBB pattern in V_1. QRS axis ranged from-35° to +110° mean of 52.84^0 only one person had QRS axis of -35° (Table 2). P wave duration varied from 0.0 to 0.10 seconds with mean of 0.055 seconds. All the persons in this study had P wave duration within normal limits. P wave voltage ranged from 0.05 mv to 0.2 mv with mean of 0.083. All the subjects in this study voltage were within the normal limits of 0.25 mv or less. P wave axis in the frontal plane varied from $+10^0$ to +90° mean was 52.23°. All the persons in this study were within the normal limits of +90°. PR interval range from 0.12 to 0.18 seconds mean was 0.14 seconds so PR interval was seen within the normal range of all the subjects studied.

Table 2: Percentage of subjects on the basis of range of QRS axis in degrees in both male and female subjects. N=150.

QRS axis in Degree	No. of subjects	Male	Female	Percentage
-59 - -30	1	1	0	0.66
-30 - 0	14	11	3	9.34
+1 - +30	16	11	5	10.66
+31 - +60	55	47	8	36.67
+61 - +90	61	59	2	40.67
+91 - +120	3	3	0	2.00

Note: The mean QRS axis as 52.84 ± 23.82 degrees.

QRS duration ranged from 0.04 to 0.12 seconds mean of 0.064 seconds (Table 3). This was beyond the normal limits. QRS voltage in V_6 varied from 0.30 to 2.1 mv with a mean of 1.14 mv (Table 4).

Voltage criteria of LVH without any ST changes were seen in 6 persons. ST segment elevation in mid and left precardial leads suggestive of early repolarization was seen in 2 persons (Table 5). QTc interval was 0.31 to 0.47 seconds mean was 0.39 seconds (Table 6). This returned to the baseline after exercise. T wave voltage varied from 0.01 to 0.7 mv mean of 0.27:3 mv. QRS-T angle varied from 0° to 70° with a mean of 30.9° (Table 7).

Table 3: Percentage of subjects on the basis of duration of QRS complex in both male and female subjects. N=150.

QRS duration in seconds	No. of subjects	Male	Female	Percentage
0.02 - 0.04	33	29	4	22
0.05 - 0.07	66	56	10	44
0.08 - 0.10	49	45	4	32.00
0.11 - 0.13	3	3	0	2.00

Note: The mean QRS duration is 0.064 ± 0.022 seconds.

Table 4: Percentage of subjects on the basis of duration of QRS voltage in both male and female subjects. N=150.

QRS voltage in milli volts	No. of subjects	Male	Female	Percentage
0.1 - 0.5	11	9	2	7.33
0.6 - 1.0	54	46	8	36
1.1 - 1.5	63	55	8	42
1.6 - 2.0	17	17	0	11.34
2.1 - 2.5	5	5	0	3.33

Note: The mean QRS voltage is 1.136 ± 0.438.

Table 5: Percentage of subjects on the basis of duration of T wave voltage in both male and female subjects. N=150.

T wave voltage in milli volts	No. of subjects	Male	Female	Percentage
0.05 - 0.55	25	23	2	16.67
0.20 - 0.30	90	75	15	60
0.35 - 0.45	24	23	1	16
0.50 - 0.60	9	9	0	6
0.65 - 0.75	2	2	0	1.33

Note: The mean T Wave voltage is 0.273 ± 0.12.

Table 6: Percentage of subjects on the basis of duration of corrected QT interval in both male and female subjects. N=150.

Corrected QT interval in seconds	No. of subjects	Male	Female	Percentage
0.30 - 0.35	30	28	2	20
0.36 - 0.41	85	72	13	56.67
0.42 - 0.47	35	32	3	23.33

Note: The corrected QT interval is 0.39 ± 0.04.

Table 7: Percentage of subjects on the basis of duration of corrected QT interval in both male and female subjects. N=150.

QRS-T angle in degrees	No. of subjects	Male	Female	Percentage
0 - 29	78	67	11	52
30 - 59	62	55	7	41.33
60 - 89	10	10	0	6.67

Note: The QRS-T angle is 30.9 ± 18.52.

DISCUSSION

In this study One hundred and fifty electro-cardiograms of different age groups were analyzed. All the subjects in this study were apparently healthy and had no cardiovascular disease and also no other systemic illness which altered the electrocardiographic findings. The tracings in this selected group of subjects provided an unique source from which data on normal electrocardiogram were obtained and also afford on opportunity to determined normal ECG variation at different age level (18 to 40 years).

Many studies have been conducted to describe the normal electrocardiogram and to delineate the range of variation of a several components.[7-9] Each of these studies has added greatly to the understanding of electrocardiography and has enhanced the utility of ECG as a diagnostic tool in clinical practice the problem of what may be expected as normal variation and what must be viewed with suspicion however is far from settled. In this study the heart rate ranged from 50 to 122 beats per minute. Highest heart rate recorded was 122 per minute, lowest was 50 per minute. Highest percentage of heart rate was in the range of 61 to 80 per minute 47.33%. 40.67% of heart rate was in the range of 81 to 100 per minute. Mean heart rate was 81.97 ± 14.30 min.

In another study 2.67% had sinus bradycardia. This bradycardia may be due to fact that the ECG was recorded early in the morning.[10] In the Graybiel et al. study,[11] of 639 healthy subjects with age group ranged between 30 to 40 years showed 6% of sinus bradycardia (heart rate less than 60). The lower incidence of sinus bradycardia in the present study compared to that of Graybiel study[11] is perhaps due to the small number of subjects in the present study. Sinus tachycardia was observed in 9.33%. It is probably due to anxiety during examination. In the study of Graybiel et al., the incidence of sinus tachycardia was 3%; this incidence of Sinus Tachycardia is almost similar to the incidence in the present study. The slightly higher incidence of the sinus tachycardia in the present study compare to that of Graybiel may be due to the less number of subjects in the present study and anxiety during clinical examination in some of our subjects.[11]

In the present study the range of QRS axis was -35° to 110°. Mean was 52.84° and standard deviation was 23.8213°. 10.02% showed -35° to 0°, 87.98% showed +1° to 90°, 2% showed 91° to 110°. One subject showed left axis deviation of -35° (0.66%). In the study of Graybiel et al. in the age group of 20 to 30 years, students of naval aviators had QRS axis ranging from -36° to +120° and the mean was 64.2°. 1.4% of the subject had axis more than 100°. In the study of Joseph K. Perloff[12] left axis deviation was identified in 1.2%. In this study LAD was observed in 0.66%, this study values are similar to that of Graybiels.[11]

The QRS duration varied from 0.042 to 0.12 seconds and with a mean of 0.064 ± 0.022 seconds in the present study. 98.67% had QRS duration of 0.04 to 0.10 seconds. In the study of Graybiels the QRS duration varied from 0.06 to 0.14 seconds mean was 0.087 seconds. In the study of G.E. Burch and Winsor[13] the QRS duration varied from 0.08 to 0.11 seconds mean was 0.081 seconds. McGinn and White[14] observed 0.10 to 0.11 seconds in 3 persons out of 100 examined. In the study of Shipley and Halloran the QRS duration of 0.11 to 0.12 seconds was seen in 3 out of 200 examined.[15] In the study of Luderitz B et al. the QRS duration ranged between 0.06 to 0.10 seconds in 97.8%, and 0.11 to 0.12 seconds seen in 1.8%.[16]

The QRS voltage ranged from 0.3 mv to 2.2 mv. 43.33% had 0.3 to 1.0 mv, 53.33% had 1.1 to 2.0 mv and 3.34% had 2.00 to 2.2 mv. The mean was 1.14 mv standard deviation was 0.4382. In the study Charles Kossmann[19] the QRS voltage varied from 0.2 mv to 2.26 mv and mean was 0.968 mv. In the study of Graybiels the voltage was 0.10 to 1.65 mv with mean of 0.59 mv. The QRS voltage in this study is within the normal limits of voltage mentioned in the studies of Kossmann and Graybiels.[17]

In this study, the T wave voltage ranged from 0.05 mv to 0.73 mv. The mean was 0.273 mv and standard deviation was 0.1221. In the New York heart association publications, T wave voltage ranged from 0.0 mv to 0.69 mv. Mean was 0.28 mv.[18] In the study of Henry Blackburn et al. mean T wave voltage was 0.36 mv, in an age group of 20 to 39 years, standard deviation was 0.13 mv.[19] This present study values are comparable with New York heart association publications. In this study the QTc interval ranged from 0.31 to 0.47 seconds with a mean of 0.7:9 seconds and standard deviation of 0.0412.

In the study of G.E. Burch and Winsor the QTc interval ranged between 0.30 seconds to 0.486 seconds mean was 0.382 seconds.[13] In the study of Stewart and Manning the QTc interval varied from 0.29 seconds to 0.47 seconds.[7] The upper limit of QTc was 0.43 seconds in White Kossmann study and 0.59 seconds in Graybiel Donald Gates Webster study. However in view of difficulty in measuring exact OT interval one should be cautious in utilizing this as a diagnostic sign. The QTc interval of

this study was similar to that of G.E. Burch and Winsor and Stewart and Manning studies.[13]

In this study the QRS-T angle ranged from 0° to 70° 97.73% showed 0° to 60° and 2.67% showed 61° to 70°. The mean was 70.9° and standard deviation was 18.5213. In the study of Hiss and Lamb[20] 96% subjects had QRS-T angle less than 70°, they have suggested extending the upper limit to70°. In the study of Graybiel et al. 98% showed QRS-T angle 60° and less. In the present study 100% of cases showed QRS-T angle of 70° or less.

CONCLUSION

Deciding whether an electrocardiogram is abnormal or normal is one of the most difficult exercises in electrocardiography. The purpose of this study is to find out the degree of normal variations in healthy individuals in different age groups (10 to 40 years). This study is also provides the frequency distribution and other statistical data when applied to all components of ECG. These are commonly assessed during investigations of healthy young individuals. Having knowledge of these normal variants will be helpful in arriving at correct diagnosis.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Waller AD. A demonstration on man of electromotive changes accompanying the heart's beat. J Physiol. 1887;8(5):229-34.
2. Bachman Sara, David Sparrow, Smith. LK. Effect of aging on the ECG. Am J Cardiol. 1981;48:513.
3. Brody JI, Golden LH, Tobin JL. A review of 3369 electrocardiograms in young male hospitalized patients. Am Heart J. 1957;53(6):821-4.
4. Blackbern HW, Junior Simonson E. The total QRS duration. Am Heart J. 1957;1953:699.
5. Bahl OP, Walsh TJ, Massie F. LAD on ECG study with postmortem correlation. Br Heart J. 1969;31:45.
6. Blakman MD, Kuskin MD. Inverted T wave in the precardial E.C.G. of normal adolescents. Am Heart J. 1964;67:304.
7. C. B. Stewart, W. V. Manning. E.C.G. of 500 R.C.A. Am Heart J. 1944;27:502.
8. Charles Fisch. Abnormal E.C.G. in normal individuals. J Am Med Assoc. 1984;9:250.
9. Cumminci GR, Prvidif WF. High voltage QRS complex in the absence of LVH. Circulat. 1959;19:406.
10. Turakhia DP. Transient ST segment elevation following DC cardioversion - merely an observation today. J Assoc Physicians India. 1989;37:803.
11. Graybiel A, McFarland RA, Gates DC, Webster FA. Analysis of the electrocardiogram obtained from 1000 young healthy aviators. Am Heart J. 1944;27:524.
12. J. K. Perloff. Left axis deviation: a reassessment Circulat. 1979 Jul;60(1):12-21.
13. G. E. Burch, T. Winsor. Bases of the theory of electrocardiography. In: G. E. Burch, T. Winsor, eds. A Primer of Electrocardiography. 5th ed. Czechoslovakia: Lea & Febiger publishers; 1966: 18-25.
14. Mac Ginn, Scherf D, Dix JH. The effects of posture on A-V conduction. Am Heart J. 1952;43(4):494.
15. Shipley, Hallorau, Johnson RL, Averill KH, Lamb L. Electrocardiographic findings in 67375 asymptomatic subjects. VII. Atrioventricular block. Am J Cardiol. 1960;6:153.
16. Luderitz, Viitasalo MT, Kala R, Eisalo A. Ambulatory electrocardiographic recording in endurance athletes. Br Heart J. 1982;47(3):213.
17. Kannman, Packard JM, Graettinger JS, Graybiel A. Analysis of the electrocardiograms obtained from 1000 young healthy aviators; ten year follow-up. Circulat. 1954;10(3):384.
18. The Criteria Committee of the New York Heart Association. Nomenclature and criteria for diagnosis of diseases of the heart and great vessels. In: New York Heart Association Report. 9th ed. Boston: Little, Brown & Co.; 1994: 253–256.
19. Blackbern HW, Junior Simonson E. The total QRS duration. Am Heart J. 1957;1953:699.
20. R. Hiss, L. Lamb, M. Allen. Electrocardiographic findings in 67375 asymptomatic subjects. Am J Cardiol. 1960;6:200-31.

DOI: 10.5455/2320-6012.ijrms20140821
Cite this article as: Mahendrappa SK, Sathyanarayana TB. The normal variations in heart rate and QRS complex of healthy individuals in different age groups. Int J Res Med Sci 2014;2:861-5.