The Study of Physiological Variations in Electrocardiogram in Late Adolescent

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ABSTRACT
To assess the prevalence of physiological variations & abnormal changes 100 electrocardiograms were recorded of asymptomatic late adolescents (16-19years). This suggests that physiological variations have basis of alterations in the electrochemical processes occurring during various phases of cardiac cycle.This electrocardiograms were analysed for all waves, intervals, heart rate. There was presence ofearly repolarization syndrome, persistent juvenile pattern, sinus arrhythmia, nonspecific T wave changes. Also with this abnormal recording of right atrial hypertrophy was noted.
KEY WORDS: *electrocardiogram, physiological variation, adolescents*

INTRODUCTION

The 12 lead electrocardiogram is the most commonly used laboratory test in cardiovascular medicine. A patient with an organic cardiac disorder may have a perfectly normal electrocardiogram and a perfectly normal individual may show nonspecific electrocardiographic abnormalities.[1] Modern life style (globalization, food habits & other various stressors) has led to increase in cardiovascular diseases at early age. As per Bayes theorem, in a population with a low prevalence of disease in this case asymptomatic adolescents the number of false positive test (cardiomyopathies, myocardial ischemia) is unacceptably high.[2]Hence, it is very important to know the physiological variation in late adolescents to prevent misdiagnosis.

PRIMARY OBJECTIVE

Assess the physiological variation in electrocardiographic changes in late adolescents.

SECONDARY OBJECTIVE

Assess the incidence of clinically abnormal electrocardiographic findings.

MATERIAL AND METHODS

A cross sectional observational study was conducted in the department of Physiology of a tertiary medical college of Mumbai after approval of Institution's Ethicalcommittee. A prevalidated structured questionnaire with standardized cardiovascular (CV) system-focused history and physical examinationwas used for selecting the subject. Hundred asymptomatic healthy

individuals without any history of cardiovascular disease or surgery in age group of 16 to19 years were selected. Informed written consent was taken. The subject's biographical data, height, weight were recorded. Subject was told to relax on a bed for 15 mins before the procedure. 12 lead Electrocardiogram was taken with frequency response of 0.05 to 100 Hz with a paper speed of 25 mm/sec. Standardization was done before and after each recording. After applying adequate jelly, all the standard limbs leads, augmented unipolar leads and precordial chest leads from V_1 to V_6 with minimum 3 complexes were recorded. Appropriate statistical tests were applied.

RESULT & ANALYSIS:

Age, Height & Weight:

The following table shows the minimum & maximum ranges & the mean values obtained.

	Age(Yrs)	Height(cms)	Weight(Kgs)
Maximum	19	200.66	85
Minimum	15	150	34
Mean	17.78	169.74	56.77

Heart Rate:

The heart rate was determined by taking the measurements of three cycles from each lead & the average was calculated. The distribution of number of cases is given in following table.

Rate/min	48	51-60	61-70	71-80	81-90	91-100	101-110	111-120
No. of cases	1	1	25	32	25	10	3	3

The rate varied from 48 to 115/min. The mean heart rate was 79/min with standard deviation 12.

Rhythm:

Twelve subjects showed sinus arrhythmia. Rest 88 subjects showed normal sinus rhythm. There was no ectopic site of impulse formation or extrasystoles.

P wave:

P wave was observed only in lead II and V_1. In lead II, P wave showed duration less than 0.08 sec except at 4 places where it was 0.12sec. It also showed 3 mm amplitude in 3 subjects with no significant notching /pointed or sharp forms .The negative P wave in 3 subjects with short duration of 0.04 sec. was present only in V_1.

PQ/PR Interval:

The longest duration was taken into account for the calculations. The mean PR interval was 0.1575. The shortest PQ interval was 0.08sec. in 2 subjects and longest 0.32 sec. in one subject .It was also observed that it was 0.2sec.in 4 subjects and in another case 0.28 sec. which is more than normal.

The association between the two is shown below

Rate/min	Variations of PR interval (seconds)		
	Range	Mean	No. of subjects
48	0.12	0.12	1
51-60	0.2	0.2	1
61-70	0.08 - 0.2	0.14	25
71-80	0.12 – 0.32	0.22	32
81-90	0.12 -0.28	0.2	25
91-100	0.12 – 0.16	0.14	10
101-110	0.12	0.12	3
111-120	0.12	0.12	3

QRS complex:

Axis: There was no right or left axis deviation. The minimum and maximum axis were 0 and 100 degree respectively, however, electrical positions of heart observed are:

Vertical / Semi vertical	Indeterminant	Horizontal / Semi Horizontal
90%	2%	8%

The correlation between QRS interval with Heart rate is shown below

Heart rate (per min)	QRS interval(sec)		
	Range	Mean	No. of cases
48	0.08	0.08	1
51 – 60	0.1	0.1	1
61 – 70	0.08 -0.12	0.1	25
71 – 80	0.08 -0.12	0.1	32
81 – 90	0.08 -0.12	0.1	25
91 – 100	0.08 -0.10	0.09	10
101 – 110	0.08	0.08	3
111- 120	0.08 -0.10	0.09	3

The mean QRS duration decreases with the increase in heart rate. In range of 48 to 90 beats/min QRS interval was steady & then with increased heart rate showed gradual fall.

There was no subject in whom total voltage of R & S wave was crossing 35mm.

ST Segment:

ST changes were mainly seen in precordial leads. A single subject showed ST depression by 0.5mm whereas eight subjects showed ST elevation. Out of eight cases of ST elevation two each were associated with early repolarisation syndrome & persistent juvenile pattern & rest were nonspecific.

T wave:

T wave showed variable results. The amplitude wasn't exceeding 7mm in standard & unipolar limb leads & 18mm in precordial lead. T wave in V_5 & V_6 was never found to be less than 1mm in height.

T wave inversion was present in single or more than one lead. Out of 100 subjects, 24 subjects showed T inversion in V_1, 11 subjects in lead III & 12 subjects in aVL. T inversion at seven instances was related with Early Repolarisation Syndrome &rests were nonspecific. There was no

correlation between ST elevation or position of heart.

QT interval

QT interval & corrected QT interval was calculated with standard formula.[3] Mean QTc value showed minimal decrease with tachycardia but within a wide range. The following table shows correlation of QTc with heart rate.

Heart rate (beats/min)	QTc interval		
	Range	Mean	No. of cases
48	0.36	0.36	1
51 – 60	0.35	0.35	1
61 – 70	0.34 - 0.42	0.38	25
71 – 80	0.33 - 0.42	0.375	32
81 – 90	0.34 - 0.42	0.38	25
91 – 100	0.34 - 0.42	0.38	10
101 – 110	0.32 - 0.38	0.35	3
111- 120	0.32 -0.38	0.35	3

U Wave:

Upright U waves were recorded only in precordial leads in 26 subjects. The predominance was found in V_3 (24 subjects) followed by V_1 & V_6.

ABNORMAL RECORD & PHYSIOLOGICAL VARIATIONS

Only one subject had right atrial hypertrophy, no other abnormality was detected.

The physiological variations observed are tabulated below

Physiological variation	No of subjects
Early Repolarisation Syndrome	15
Persistent Juvenile pattern	4
Sinus Arrhythmia	12
Nonspecific ST elevation	8
Nonspecific T changes	24

DISCUSSION

The present study not only provides some observations on the range of values found in the electrocardiogram of late adolescents, but also permits certain discussions on the normal variables. It has been noted that the mean heart

rate in this study is showing a higher value. Packard et al (1954) in an electrocardiographic study of 1000 healthy aviators whose age ranged from 20 to 30 years with the mean age of 23.7 years found that only in 20% cases heart rates were greater than 100 beats per min & his mean heart rate was 63.5/min. This could be because of their occupation which requires good physical fitness & cardiovascular endurance. In the present study, anxiety states during examination &lack of proper athletic habits which resulted in increased sympathetic activity[4] can be possible factors for the high value of heart rate.

Desiderio Gross has stated in his study, the duration of P wave remains unaltered with the increasing heart rate [5]which is also noted in present study. He has also noted non pointed & unnotched tall P wave, when the person breathes against manometric pressure. Rahimtoola has mentioned in his study about the presence of tall P wave along with sinus tachycardia in tall asthenic individuals with a low diaphragm & a vertical position of the heart.[6]The presence of tall P wave in present study is associated with vertical position of heart.

H.K. Bose(1961) in an electrocardiographic study of 570 young healthy Indian students (age group 16 to 26 years) found that the mean PQ interval was 0.140 sec & never exceeded more than 0.20sec.[1] Packard et al (1954) found PQ interval as 0.154sec in the age group of 20 to 30 years. Savilathi (1946) thought that only a small percentage of normal subjects may reveal PQ interval above 0.20 sec. In this study, the mean PQ interval is 0.14sec & in two records the PR interval has crossed 0.20 sec when it was found to be 0.28sec & 0.32sec. The increase of PQ interval normally with age & bradycardia particularly in young athletic group is well known.[1]Both the subjects with longer PQ interval in this study were underweight & showing bradycardia. The short PR interval is a physiological variation due to accelerated AV conduction as an individual idiosyncrasy.

The Q wave present in all records was neither slurred nor notched which is similar to that of previous studies of H.K. Bose & Packard et al. The slurring or notching of the Q wave can be considered as abnormal.[1]

QRS interval has varied in duration directly with heart rate. The changes with age are significant but not considered in this study due to a very narrow range. Seshadri Balaji had shown the inverse relationship of heart rate with QT interval in adolescents which is similar to the present study.[3]

The T wave inversion is not necessarily a marker of disease but can also be found as a physiological variation. Inverted T waves in precordial leads are common in children which usually become upright during pubertal development. They may remain inverted in young asymptomatic adults in V_1 to V_3 but beyond V_4 are usually abnormal. Also the true inversion of T wave in lead I is uncommon in healthy asymptomatics.[7,8]T waves cannot be differentiated in normal or abnormal conditions, but it is said that T wave is usually shallow & limbs asymmetrical in normal conditions in contrast to symmetrical version of the T wave in abnormal conditions.[6]Hence, clinical correlation is the key to differentiate between benign & malignant T inversion. T wave changes can be seen in physiological conditions like high carbohydrate meal, rotation of heart in clockwise position, impact of the apex against the chest wall, posture, effects of respiration & the influence of local electrical potential. The reasons in adolescent subjects may be presumed to be the anatomic structure of heart, lungs & chest wall which are intermediate between that of child & adult. When negative precordial T waves are recorded from otherwise normal adolescent, the importance of an exaggerated local proximity effect should be considered.[9]The pathological causes areanemia, hyperventilation, electrolyte abnormalities, sympathetic stimulation due to any cause, ischaemia, myocarditis, arrythmogenic right ventricular cardiomyopathy, certain drugs, ventricular hypertrophy. [6,10]

In present study, the T inversion was observed in tall& thin individuals who have a vertical position of heart. Similar observations in upright position

with full inspiration in previous study was considered as physiological variation.[1]This may be mistaken as right ventricular hypertrophy & strain pattern particularly when ST depression & T wave inversion in lead II, III &aVF are associated. Shah & Ranganekar found that low T in lead III, aVL&aVF is common variation whereas in lead II,V_4,V_5 should be taken as borderline finding.[11]They concluded that such T wave changes are the reflex adrenergic activity superimposed on a state of autonomic imbalance with sympatheticotonic preponderance from anxiety. Patel &Damany (1968) found that T wave inversion in precordialleads claimed as juvenile pattern is asymmetrical & the depth of inversion decreases from V_1 to V_3leads in age group between 0 to 30 years.[12]

In the present study, tall T waves were found in 5 cases. In an epidemiological survey of an Indian population, Srikantia& associates (1964) found tall, peaked T waves over 10mm in 41 out of 941 subjects.[13]Maj.Gen.R.S.Hoon et al observed the incidence of tall T waves was 2.5% whereas Dharamdasa & Nadarajah (1968) reported very high incidence (37%) of precordial T waves of 10mm or more in healthy young male subjects of Ceylon.[14,15] Tall T waves were present with vertical or semi vertical position of the heart. Tall T waves did not differ significantly in duration from normal T waves.[14,16] Subjects with isolated T wave changes & no other evidence of any significant disease, showed a significantly increased mortality which is more within first few years after discovery of T wave change.

In the present study, the U wave was seen in 26 cases only in the precordial leads with the predominance in V_3. Similar finding of presence of U wave in V_2 to V_4 was observed by Dharamadasa & Nadarajah.[14]These findings cannot be generalized as specific significant findings. Since occurrence of the U wave in the precordial leads is not consistent therefore the probable cause for occurrence of U wave in given number of cases cannot be explained. Two parallel hypothesis of occurrence of U wave are said to be repolarisation of Purkinje system[17]or

mechanoelectrical hypothesis[18]. Since the individuals in whose electrocardiogram U wave was found were generally tall & thin, these findings in the present study can be considered as normal variation. There is need of further research for hypothesis of U wave genesis as well as relation between built & genesis of U wave. In the present study all U waves observed were upright. U wave should be always analysed in relation with T wave for abnormality. Negative waves are always abnormal & associated with many disorders like valvular heart disease, myocardial infarction, hypokalemia etc.[19]

It is observed that there is a general tendency to vertical position of heart in the young age group as most of the individuals were tall & lean.

The physiological variation as early repolarisation syndrome is well recognized in electrocardiographic findings. It is seen in approximately 1-2.5% of healthy teenagers, young adults, male athletes & is more common in young blacks.[20,21] Some studies conclude that there is no racial variation. Criterion for its diagnosis is the presence, in at least two adjoining leads, of ≥ 1 mm or 0.1 mV ST segment elevation.[21,22,23] The physiological basis for this physiological variation is not well established, but it is considered a result of early onset of repolarisation of the ventricle in a nonhomogeneous mannerpreceded by the epicardial surface vector.

Earlyrepolarisation syndrome & persistent juvenile pattern sometimes closely mimic pericarditis or patterns of epicardial injury. Recent studies show positive association of early repolarization (ER) with the risk of life-threatening arrhythmias in patients with coronary artery disease (CAD).Early repolarisation mainly in inferior leads with a horizontal/descending ST variant was associated with increased risk of cardiac events24 whereas some studies have not obtained association between any component of early repolarisation with cardiac mortality. 25 Normal juvenile symmetrical T wave inversion cannot be differentiated from T wave inversion due to organic disease.6

The only abnormal finding in present study was right atrial hypertrophy. Though this is uncommon finding in asymptomatic individuals but has been noted in previous study.[26]It has been noted that there is increase in sudden cardiac death in young population.[27,28] The correlation between the sudden cardiac death & abnormal findings need to be established.

CONCLUSION

The electrocardiography, presently, is a widely used method for detection of various cardiovascular diseases. It is a rapid, safe & reliable method. The interpretation of most electrocardiographic contour abnormalities involve clinical correlation & thus their diagnostic reliability depends on specificity, sensitivity & predictive accuracy of given pattern.[2]Only after deciding what is normal & its variants, it is possible to discriminate the abnormalities in right way. The present study was undertaken to assess the normal variations in the electrocardiogram of asymptomatic individuals in the age group of 15 to 19 yrs. Aim of the study was to observe the normal & abnormal electrocardiographic changes & its physiological variations in late adolescents. In this study, 100 asymptomatic individuals' electrocardiograms have been analyzed. Average, minimum & maximum values of different waves have been put up in the tabulated form. Stress has been laid on physiological variations & evaluation of borderline findings.The present study is an attempt to assess the normal variations in a small sample size. As these physiological variations may mislead to serious cardiovascular diseases, there is a need to conduct more studies over a wide range of population, so as to minimize possible errors for detection & establishment of physiological variation as risk factor for cardiovascular diseases.

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