Original Article

A physiological assessment of mean QRS axis in an Indian sub-population using two methods of axis calculation

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Abstract

Background and Aim: The interpretation of the electrocardiographic deflection in terms of mean QRS axis (MQRSA) direction and deviation constitutes one of the most important diagnostic aids for the accurate and deductive evaluation of the electrocardiogram. This study was undertaken to assess the MQRSA in an Indian sub-population free of any cardiac illness using the hexaxial reference system and a formula $\tan \theta = (I + 2III)/\sqrt{3}\,I$.

Methods: The present work is a hospital based cross-sectional study. After getting consent, data was collected from 162 subjects (91 males and 71 females). Electrocardiogram of the subjects studied were taken using Marquette 2000 portable electrocardiographs. Chi-square test was used for comparision of data between the two methods.

Results: MQRSA of 162 adult subjects with no any past or present history of cardiac illness was found to be directed within a narrow range between +40° and +60°. Hundred and forty-two had their mean electrical axis between 0° and +90° and 18 had their mean electrical axis between −90° and 0°. Of the 104 subjects >50 years, 16 (15%) have a statistically significant left axis deviation. The results obtained by both the graph and formula methods tallied perfectly.

Conclusion: This investigation confirms that a majority of the subjects had their MQRSA lying in the range 0°–90°, which is the accepted normal range. The formula can be reliably used for a bedside axis calculation.

Key words: Formula method, Graph method, normal range, QRS axis

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INTRODUCTION

The interpretation of the electrocardiographic deflection in terms of mean QRS axis (MQRSA) direction and deviation constitutes one of the most important diagnostic aids for the accurate and deductive evaluation of the electrocardiogram. Interpreters of electrocardiogram routinely face recordings that appear to be abnormal, but may actually be normal. Therefore, this study aims at studying an Indian sub-population free of any cardiac illness to find the range in which their mean QRS axis (MQRSA) lies and to see if it corresponds to the established values. The mean or dominant direction of all these vectors is known as the mean vector and is expressed electrocardiographically as the mean QRS electrical axes (MEA).[1]

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Clinically hexaxial reference system is used to determine MEA.[2] However, this method does not give an exact numeric value of the axis.[3] A method for calculating MEA accurately and quickly would be a useful clinical tool for the objective monitoring of progressive changes in MEA during the course of a disease process, as well as for determining the effects of therapeutic measures.[4]

Although earlier studies[5,6] have described different electrocardiographic criteria for estimating electrically active ventricular mass, these criteria are not sensitive enough to give the exact value of MEA. Further criteria must be designed to improve their sensitivity.[6]

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MEA can also be measured by dropping perpendiculars from the Einthoven's triangle or the triaxial reference frame. The Graph method for estimating frontal QRS orientation has been used for a long time and is accurate to about ± 15°,[7,8] but is too cumbersome for routine clinical use. Therefore, a new formulae incorporating high sensitivity in obtaining an accurate value of MEA are being developed.

In this study, an attempt is made to evaluate the sensitivity of a newly developed formula in MEA calculation and to study its correlation with the Graph method. As the MEA is calculated quickly using the formulae method, it is very convenient for the rapid calculation of a large number of axes in a short time.

MATERIALS AND METHODS

Study population

A total of 162 healthy individuals (91 were male and 71 were female) in the age group of 40–80 years with no past or present cardiac illness or any other major illness, were recruited from the Medical College Hospital area in Kottayam after obtaining their consent. Subjects with history of uncontrolled diabetes mellitus or systemic hypertension/subjects with any past or present history of cardiac illness like valvular heart disease or cardiomyopathy or bundle branch blocks or preceding angina/subjects with any other systemic illness that can modify the electrocardiogram (ECG) outcome were excluded from the study.

Study protocol

The subjects were made comfortable in the supine position and ECG was taken by the same set of experienced technicians in order to prevent any variation that might otherwise occur. Proper earthing of the instrument was checked for. Electrode jelly was applied on the skin at the appropriate lead positions on the four limbs and on the precordium. ECG of the subjects studied were taken using Marquette 2000 portable electrocardiograph standardized at 25 mm/s and 10 mm/mV. Minimum three complexes were recorded in each lead and the ECG was labeled properly after recording.

Calculation of the mean QRS electrical axis

The mean electrical axis is graphed using the hexaxial reference system otherwise known as Graph method. The net positive or net negative deflection in any lead is obtained by subtracting the smaller deflection from the larger deflection.[9] To determine how much of the voltage in a vector will be recorded in Lead I, a perpendicular is dropped from the tip of the vector to Lead I axis. This projected vector is drawn along the axis. Thus, the net QRS vector can be calculated from the QRS complex. Once the net vectors in Leads I and III are obtained by plotting these vectors on the co-ordinate axis, the frontal QRS orientation can be found out. This orientation or the angle subtended by the vector on the X-axis is measured and from this the electrical axis is calculated. An error of 10°–15° is not clinically significant.[7] The net voltages are then plotted as vectors on the Leads I and III axes, as shown in the Figure 1. Then, perpendiculars are dropped from the tip of the vectors. At a particular point, the perpendiculars dropped from the two vectors meet. This is the net projected vector, which makes an angle θ with the Lead I axis. Depending on the quadrant in which θ lies, the MEA can be calculated, as represented in Figures 2 and 3. The Formula method makes use of a formula: $\theta = \tan^{-1} [(I + 2III)/Ö3 \times I]$ put forward by Singh and Athar[10] where θ is the angle the net QRS vector makes with the X-axis, and I and III are the mean QRS vectors in ECG Leads I and III, respectively.

Using a scientific calculator having a program memory, the value of θ is obtained within a few seconds by entering the values of the two leads. This considerably simplifies the calculations and is very convenient for rapid calculation of a large number of axes in a short time.

In this study, calculation of the MQRSA is done by both the Graph method and the formula method.

Statistical analysis of data

The data were expressed as number (percentages). GraphPad Instat version (GraphPad Software Inc., San Diego, CA, USA) was used for statistical analysis of data. Chi-square test was used for comparision of data between the methods.

RESULTS

Of the 162 subjects in the control group, 91 were (56.2%) male and 71 were (43.8%) female. The age varied from 31

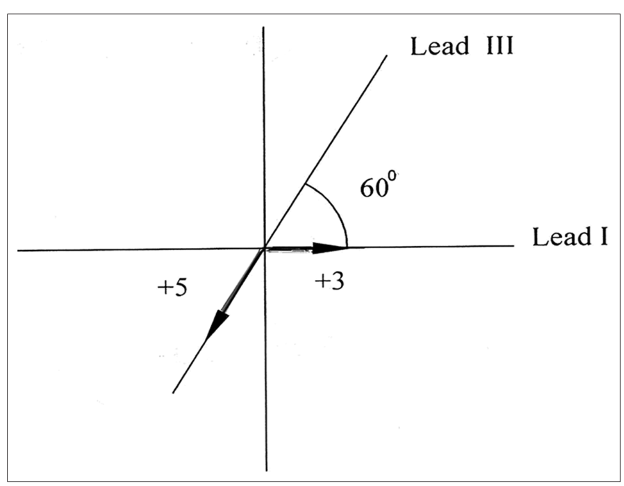

Figure 1: Plotting of net voltages on leads I and III as vectors in the hexaxial reference frame (values +3 and +5 are examples of voltage vectors)

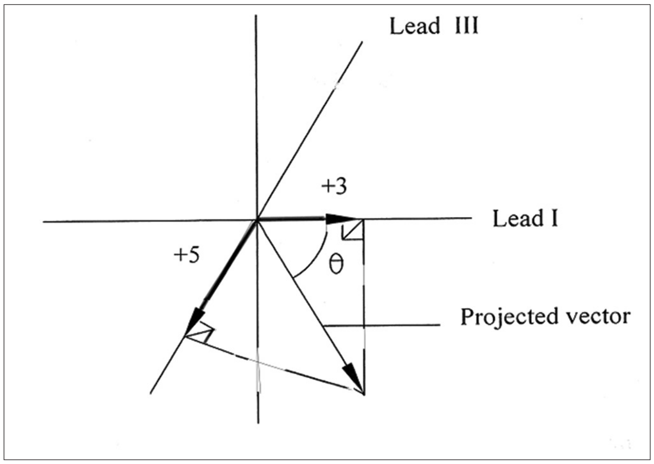

Figure 2: Perpendiculars are dropped from the tip of the vectors in order to calculate the net projected vector θ

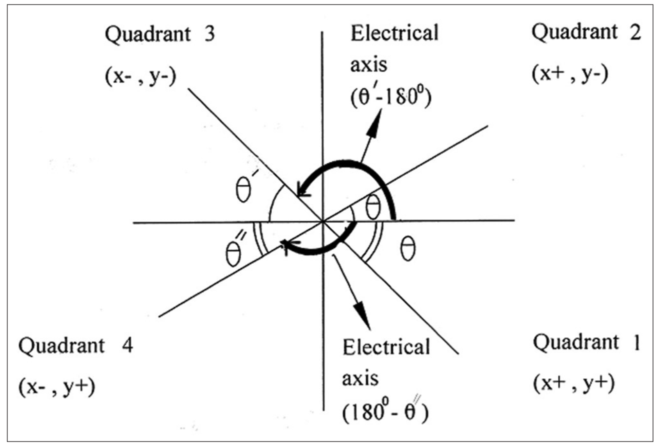

Figure 3: Depending on the quadrant in which θ lies, the mean electrical axis can be calculated (x and y are the values of the vectors)

to 88 years, the mean age was 55.26 years. Hundred and forty two had their mean electrical axis between 0° and +90° and 18 had their MEA between −90° and 0°. The results are shown in Table 1. Comparison of MEA with the age of the subject was also done as depicted in Tables 2 and 3.

A study of the dispersion of the subjects with respect to their MEA shows that some subjects have their axis lying in extremes. In the age group 51–60 years, the axis ranges between −30° and 97° whereas in the age group 41–50 years, there is again an extreme value of −60° compared to the other axes. Of the 104 subjects >50 years, 16 (15%) have a statistically significant left axis deviation [Table 2]. A study of ECG characteristics shows that the calculation of the mean electrical axis by the two methods gives almost the same value as shown in Table 4.

DISCUSSION

As anticipated, a majority (87.7%) of subjects had their MEA between 0° and +90°; the universally accepted normal range. Table 3 shows the MEA in different age groups of subjects. The normal mean manifest frontal plane QRS axis is usually directed inferiorly and to the left, and its distribution range is usually between 0° and +90° clockwise. Most normal frontal plane QRS axes in the adults are however, directed within a narrow range between +40° and +60°. Axes directed in the region between 0° counter clockwise to −90° reflect left axis deviation. Axes directed to the region between +90° clockwise to +180° in the adult reflect right axis deviation.[1] The limits of left axis deviation and right axis deviation have arbitrary criteria.[11] Of the 104 subjects >50 years, 16 (15%) have a statistically significant left axis deviation, which may occur in the absence of apparent cardiac disease. However, left axis deviation or right axis deviation is not necessarily a sign of significant underlying heart disease.[7] Incomplete

Table 1: Mean electrical axis of subjects calculated graph method

Electrical axis (°)	Graph method (%)
0°-90°	142 (87.7)
−90°-0°	18 (11.1)
90°-180°	2 (1.2)
−180° - −90	-
Total	162

Data are expressed as *n* (percentage)

right bundle branch block left the fascicular block, and first-degree atrioventricular block are the most frequent findings[12] found in a relatively large proportion of young individuals. Our findings here establish the accuracy of this fact in the Indian sub-population studied. Age influences the prevalence of electrocardiographic variations and the diagnostic criterion for abnormality must be based on the sound understanding of the normal electrocardiogram.[13]

Available methods to determine the cardiac axis, like 'at a glance' and 'quadrant-and-degree,' which mostly use Leads I and aVF, could not exactly determine the electrical axis[14-16] and until recently, there was no easy way for accurate determination of the cardiac electrical axis. Earlier researchers[17] have suggested formulae for obtaining an index of ventricular preponderance. However, these formulae do not give the exact values of MEA and are hence faulty.[18] Better formulae have since been propounded, which are more accurate and easier to apply as the one developed by Madanmohan *et al*.[19]

The method applied here is simple and gives accurate values of the electrical axis. Hence, this method can be used to screen large samples of the population for determining the exact values of axes. Since, the calculated values are exact up to many decimal points, it can be used as a simple and objective method for monitoring the progressive changes in MEA. The only additional tool required for the purpose is an inexpensive pocket model scientific calculator.

Table 2: The MEA in different age groups of the subjects

MEA	≤40 years (*n*=17)	41-50 years (*n*=41)	51-60 years (*n*=50)	≥61 years (*n*=54)	Total (*n*=162)
0°-90°	17 (100)	39 (95.13)	42 (84)	44 (81.48)	142 (87.65)
−90°-0°	0 (0)	2 (4.87)	7 (14)	9 (16.67)	18 (11.12)
90°-180°	0 (0)	0 (0)	1 (2)	1 (1.65)	2 (1.23)

MEA: Mean electrical axes. Data are expressed as *n* (percentages)

Table 3: MEA among the subjects in different age groups

Age (years)	Mean axis of the subjects
≤40	54.5°
41-50	45.7°
51-60	43.7°

MEA: Mean electrical axes

Table 4: Comparision of MEA calculated using graph and formula method

Electrical axis (°)	Graph method	Formula method	*P*- value
0°-90° (normal axis)	142 (87.7)	142 (87.7)	< 0.0001
−90°-0° (left axis)	18 (11.1)	18 (11.1)	
90°-180° (right axis)	2 (1.2)	2 (1.2)	

MEA: Mean electrical axes. Data are expressed as *n* (percentages). Chi-square test was used for comparision betwwen the two methods. *P* <0.05 was considered statistically significant.

Limitations of the study

A comparison with computer-generated MQRSA would have provided greater strength to the study, but could not be done as the computer generated MQRSA is not routinely used.

CONCLUSION

On analysis, there is a very high statistically significant (*P* < 0.0001) correlation between the graph and formula methods. The frequency of subjects in each category of axis (normal, left axis, right axis etc.,) was the same in all the subjects by both methods. More than two-third of all subjects had their MQRSA within the normal range.

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