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Spatial magnitudes of instantaneous QRS and ST-T Vectors in Nigerians

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Summary

Spatial magnitudes of instantaneous QRS and ST-T vectors were studied in 664 (333 male: 331 female) normal Nigerians aged 15 to 90 (Mean: 39.1 ± 16.7) years. Measurements were made manually using 8 divisions (octets) per QRS or ST-T waves. Not only the maximum amplitude but also several identical points on the QRS, J-point and ST-T curves were higher in males than females. The R wave, J-point and ST-T vectors were oriented leftwards, inferiorly and posteriorly. The ST-segments were not iso-electric. The rates of ventricular depolarization (dV/dt) varied from one octet to another with maximum dV/dt occurring during the third octet. Ventricular repolarization was slower with peak rates during the fifth octet. It is concluded that this technique is simple, informative and practicable at bedside; but further studies are required to explore its diagnostic usefulness in patients with heart disease.

Résumé

Les modifications spaciales instantaneous des vecteurs QRS et ST-T sont etudiees chez 664 personnes (333 hommes et 331 femmes) Nigeriennes normales agées de 15 a 90 ans (moyenne: 39.1 + 16.7). Les mesures sont faites manuellement, utilisant 8 divisions pour chaque complexe QRS ou segment ST-T. Non seulement L'amplitude maximale, mais aussi plusieurs points identiques des complexes QRS, points J et des segments ST-T sont plus eleves chez les hommes que chez les femmes. Les vecteours de l'onde R, point J, et segment ST-T sont orientes a gauche, inferrieurement et posterieurement du troisieme au quatrieme. Les segments ST ne sont pas iso-electriques. La vitesse de depolarisation dV/dt change d'une "Octat" a L'autre avec un maximum durant la troisieme "Octat". La repolarization ventriculaire est plus lente avec maximum durant la troisieme octat. On conclut que cette technique est simple et informative elle est a pratiquer au lit du malade. D'autres etudes sont necessaires pour explorer son utilité diagnostique chez les cardiaques.

Introduction

Most work on scalar ECG usually centres on providing information about the peak or maximum amplitude (Vmax) of ECG variables [1-2]. Indeed, many diagnostic criteria are based upon QRS Vmax[3-7]. However, there are situations which utilize time- amplitude-direction relations as basis for ECG diagnosis. Such is the case in myocardial infarction (MI) [8-9], fascicular blocks, accelerated conduction defects[10] and, to some extent, left ventricular hypertrophy[11-12]. For instance in MI, not only does the QRS vector show low voltage, there is reversal of initial polarity with irregular time-amplitude course. In accelerated conduction, the initial vector is slurred while LVH is characterized by high QRS voltage with prolonged upstroke time. In order to enhance the diagnostic accuracy of such conditions, a preliminary information would be required on normal individuals. This is the purose of this report: to supply some data-base on the time-amplitude relations of the QRS complex, ST-segment and T waves in disease-free Nigerians of both sexes and different age groups. The information will relate to only the scalar ECG of the Orthogonal (Frank Lead) system which, unlike the 12-Lead System provides this unique advantage in its adaptability to supply information on the moment-to-moment magnitude and direction of the cardiac vectors.

Materials and method

The study group was drawn from healthy adult Nigerians of both sexes and age range above 14

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years. Details of the case selection, screening procedure and elimination criteria were as described recently by Araoye[13]. The recording machine was the Marquette MAC I Micro-computer Augmented Cardiograph. Details of this sytem including placement of electrodes and ECG recording were also described recently by Araoye[13]. For this study, the most critical steps were the setting of the 3-channel styli deflections to synchronize and deliver 10 mm/mV in all the three (XYZ) Leads. Tests for synchrony were performed on every working day as instructed in the cardiograph brochure. Finally, each volunteer had the XYZ ECG recording at 100 mm/s for 5 cardiac cycles.

ECG Interpretation

From each volunteer, one best QRS complex with stable UP- line was selected. Using ECG calipers and rulers, the QRS duration was determined and marked out into 8 equal sub- divisions: 0, 1/8, 2/8.....8/8. Each point is called "instantaneous vector" (Vt). 0 corresponds to the beginning of QRS, 4/8 was half-way its duration while 8/8 was the J-point. Subsequently, the amplitude of each Vt was determined thus obtaining 8 Vt per QRS complex per volunteer.

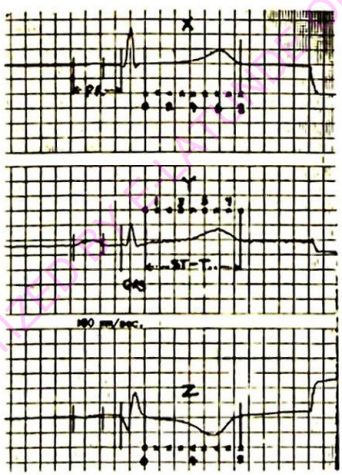

Fig. 1: QRS and ST-T waves at 100 mm per sec. The ST-T is mapped out into eight sub-divisions: 1/8, 2/8 ..... 8/8

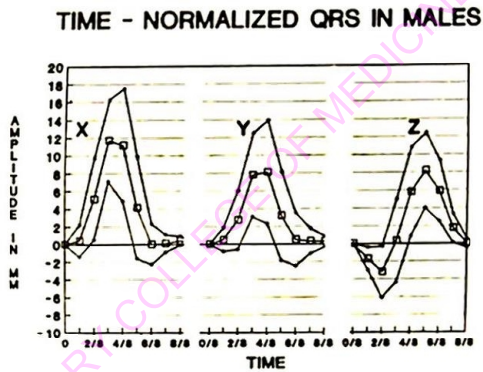

Fig. 2: Time-normalized QRS and ST-T histo electrograms. Note that the mean J-Point is above the UP line in both sexes.

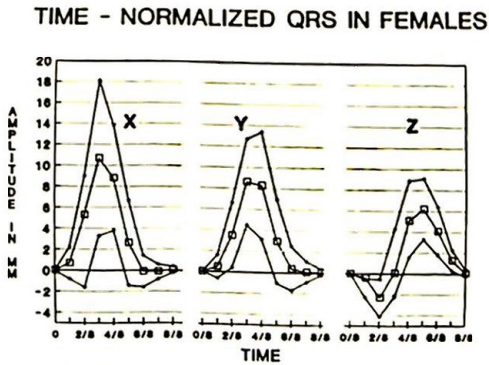

Fig. 3: Time-normalized QRS and ST-T histo electrograms. Note that the mean J-Point is above the UP line in both sexes.

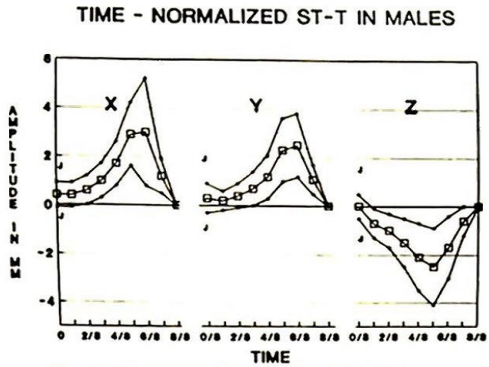

Fig. 4: Time-normalized QRS and ST-T histo electrograms. Note that the mean J-Point is above the UP line in both sexes.

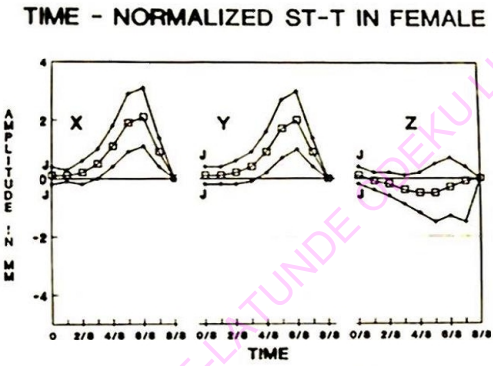

Fig. 5: Time-normalized QRS and ST-T histo electrograms. Note that the mean J-Point is above the UP line in both sexes.

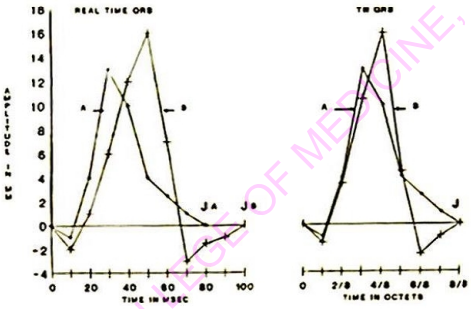

Fig. 6: Real-time and Time-normalized QRS in two normal subjects A and B.

The same technique was carried out for the ST-T waves as illustrated in Fig. 1. Here, the 0/8 Vt is J-point while the 8/8 Vt marked the end of T wave.

Pooling all the readings together, the Mean ± SD was calculated for each octet of the QR and ST-T wave as shown in Tables 2-5. By plotting Vt (in MM) against time (octet), electro- histograms of the QRS and ST-T wave were obtained. The mean QRS duration and QTc were calculated, and the corrected mean ST-T duration was derived by substracting the mean QRS duration from the mean QTc.

Table 1: Age and sex of study group

Age in Years	Male	Female	Total	% Group
15 - 19	29	39	68	10.24
20 - 29	84	84	168	25.30
30 - 39	75	68	143	21.54
40 - 49	60	57	117	17.62
50 - 59	36	38	74	11.14
> 60	49	45	94	14.16
Total	333	331	664	100.0

Table 2: Time-normalized QRS in Males

Time	0	1/8	2/8	3/8	4/8	5/8	6/8	7/8	8/8 (J)
X Mean	0	0.4	5.1	11.7	11.2	4.1	0	0.1	0.4
SD		1.8	4.6	4.6	6.3	5.7	2.3	1.0	0.5
Y Mean	0	0.5	2.7	7.8	8.1	3.2	0.5	0.3	0.3
SD		1.3	3.3	4.7	5.8	5.0	3.0	1.4	0.6
Z Mean	0	-1.7	-3.2	0.3	5.8	8.2	5.9	1.7	0
SD		1.3	2.9	4.7	5.0	4.2	3.4	1.6	0.5

Table 3: Time-normalized QRS in females

Time	0	1/8	2/8	3/8	4/8	5/8	6/8	7/8	8/8 (J)
X Mean	0	0.7	5.3	10.7	8.8	2.6	-0.1	-0.1	0.1
SD		1.5	3.7	7.4	5.0	4.0	1.5	0.7	0.3
Y Mean	0	0.5	3.5	8.6	8.3	3.0	0.4	0.1	0.1
SD		1.1	3.1	4.1	5.1	4.0	2.1	1.0	0.3
Z Mean	0	-1.4	-2.3	1.0	5.1	6.2	4.1	1.3	0.1
SD		0.9	1.8	3.3	3.5	2.9	2.3	1.0	0.3

Table 4: Time-normalized ST-T in males

Time	0 (J)	1/8	2/8	3/8	4/8	5/8	6/8	7/8	8/8
X Mean	0.4	0.4	0.6	1.0	1.7	2.9	3.0	1.2	0
SD	0.5	0.5	0.6	0.7	0.9	1.3	2.2	0.7	
Y Mean	0.3	0.2	0.4	0.7	1.2	2.3	2.5	1.1	0
SD	0.6	0.4	0.5	0.7	0.9	1.3	1.3	0.6	
Z Mean	0	-0.7	-1.0	-1.5	-2.1	-2.5	-1.7	-0.6	0
SD	0.5	0.6	0.7	1.0	1.4	1.6	1.6	0.6	

Table 5: Time-normalized ST-T in females

Time	0 (J)	1/8	2/8	3/8	4/8	5/8	6/8	7/8	8/8
X Mean	0.1	0.1	0.2	0.5	1.1	1.9	2.1	0.9	0
SD	0.3	0.2	0.4	0.5	0.7	1.0	1.0	0.5	
Y Mean	0.1	0.1	0.2	0.4	0.9	1.7	2.0	0.9	0
SD	0.3	0.3	0.4	0.5	0.7	1.0	1.0	0.5	
Z Mean	0.1	-0.1	-0.2	-0.4	-0.5	-0.5	-0.3	-0.1	0
SD	0.3	0.3	0.4	0.5	0.7	1.0	1.0	0.5	

Result

Table 1 shows the age and sex distribution of the study group. Three hundred and thirty three (50.2%) were male; 331 (49.8%) were female. Three hundred and seventy-nine (57.1%) were below 40 years while 285 (42.9%) were above 40 years. The mean ages were 39.8 ± 17.1 for male, 38.4 ± 16.3 for female (P > 0.1) and 39.1 ± 16.7 for the entire group.

The mean ± SD of the 8 QRS Vt and ST-T are shown in Tables 2-5 with the corresponding electro-histograms in Fig. 2-5. On each histogram, the middle curve (open squares) represents the mean; the lower and upper curves (small closed squares) represent the minimum and maximum limits thus giving the Vt ranges for each octet.

Instantaneous (Vt) and maximum (Vmax) vectors

In males, the QRS Vmax occurred at 4/8 in both leads X and Y, and ranged from 0.49 to 1.75mV in X, and 0.23 to 1.39mV in Y. In lead Z, Vmax was at 5/8 with a range of 0.4 to 1.24mV. In females, Vmax occurred at 3/8 in X, 4/8 in Y and 5/8 in Z with ranges of 0.33 to 1.81 mV, 0.32 to 1.34 mV and 0.33 to 0.91 mv respectively.

In X, Vt - 1/8 was higher in females than males (P < 0.05) but at 3/8 (P < 0.05), 4/8 (P < 0.0000001), 5/8 (P < 0.0001), 7.8 (P < 0.005) and 8/8 or J-point (P < 0.000000001), Vt were higher in males than females. There was no significant difference at 2/8 and 6/8. In Y, Vt - 2/8 (P < 0.005) and 3.8 (P < 0.05) were higher in females than males. There were no significant differences at 1/8 and 4/8 to 6/8. Vt - 7/8 (P < 0.05) and J-point (P < 0.0000001) were higher in males. In Z, Vt - 1/8 (P < 0.001) and 2/8 (P < 0.00001) — both of which were Q wave vectors, were deeper, while 4/8 (P < 0.05), 5/8 and 6/8 (P < 0.000000001) and 7/8 (P < 0.001) vectors were higher in males than females. However, Vt - 3/8 (P < 0.05) and J-point (P < 0.005) were higher in females.

On the ST-T curves, all the 0/8 to 8/8 vectors in all the leads were significantly higher in males than females. In both sexes, the initial 0/8 to 1/8 were parellel to, but above the iso- electric line in X and Y.

Vector direction

Except Lead Z where the mean initial 1/8 and 2/8 (Q wave) vectors were oriented anteriorly, Vt - 1/8-2/8 were above the UP line in X and Y in both sexes. For the rest of the curves, the mean vector direction was leftwards, inferiorly and posteriorly.

Rate of depolarization (dV/dt)

The mean QRS durations were 0.0827 seconds (Male) and 0.08 seconds (Female). Each octet was therefore 0.0103 seconds in male and 0.01 in female, thus permitting the estimation of dV/dt as it changed from one octet to the other. For this report, the maximum dv/dt was estimated from the middle curve. Accordingly, in both sexes, dV/dt - Max occurred during the 3rd octet in X and Y and the fourth octet in Z, and were 64.1; 49.5 and 53.4 mV/s respectively in males; 54.0, 51.0 and 41.0 mV/s respectively in females.

ST-T Curve

Both sexes exhibited a slow-rising curve during the first 3 octets with peak T amplitude at 6/8 in X and Y. In Z, all the ST-T vectors (except J-point) were below the UP line in males. In females, the mean and minimum vectors were all negative while the maximum deflections were above the UP line.

The corrected mean ST-T durations were 0.3917 seconds (male) and 0.4095 seconds in females (P < 0.001). Each octet in the time- normalized ST-T wave thus represents 0.049 seconds in males and 0.0512 seconds in females. Accordingly, dV/dt - max as observed in the fifth octet in X and Y and the 4th octet in Z, were 32.7, 30.6 and 20.4 mV/s respectively. In females, dV/dt - max occurred during the 5th octet and was 21.5 mV/s in both X and Y. In Z, it was 5.9 mV/s without variation from one octet to the other.

Discussion

It is well known that there are variations in QRS duration. Thus, comparison of similar points on the QRS are not without fault when real-time QRS or ST-T curves are being considered. For instance, Vmax may differ in two subjects because of time factor. The technique of "Time-Normalization" (TN) was therefore proposed to solve such problems and facilitate the comparison of ECG Vectors at identical points in time[11].

As described above, the beginning and end of the QRS (or any variable under consideration) are lined up in time and sub-divided into equal parts regardless of its duration. Each point represents an instantaneous vector which can be characterized in time, magnitude (Vt), direction and rate of change. In this study, 8 subdivisions (each sub-titled "octet") were adopted because the QRS was 0.08 sec. thus

facilitating easy sub-divisions into 8 equal parts without using a computer. Thus, TN is practicable even at bedside; and as shown by Pipberger *et al.* [12], it does not devalue the diagnostic power of ECG.

The usefulness of TN is well illustrated in Fig. 6 which compares the real-time with TN instantaneous QRS vectors in X in two normal volunteers A and B. The QRS durations were 0.08 and 0.1 sec respectively. In A, Vmax' was 1.3 mV at 0.03 sec while B was 1.6 mV at 0.05 sec. Following TN, VT - 3/8 were 1.3 mV for A and 1.05 mV for B. In both cases, dV/dt was maximal during the 3rd octet and were 90 and 56 respectively. Thus, although Vmax-b was greater than V max-a, dV/dt-max was faster in A than in B.

This study shows that not only Vmax but also several identical points on the QRS curve were significantly higher in males than females especially in X and Z. dV/dt also showed sex difference in these leads; but there were no significant differences in Y. One explanation for this is the higher incidence of LAD with attendant S in Y observed in males than females. In terms of vectorial direction, both sexes showed initial 1/8 - 2/8 (Q wave) vectors directed anteriorly, leftwards more than rightwards and inferiorly more than superiorly. All the 3/8 and 4/8 (R wave) vectors were located to the left, inferiorly and posteriorly. The J-point vectors were non-iso-electric but were located mostly to the left, inferiorly more than superiorly and posteriorly more than anteriorly. This report cannot compare strictly with that of Pipberger *et al.* [12] because their 252 cases were of mixed races. Besides, their initial work dealt with 10 subdivisions and were based upon computer interpretation. However, they observed dV/dt of 40-190 mV/s and Vmax of 0.72 to 2.49 mV at 4/10.

In conclusion, this study describes the spatial magnitude of instantaneous QRS and ST-T vectors in a large sample of normal adult Nigerians of both sexes. It simplifies the technique of measurements done manually without the use of computers, thus projecting the feasibility of its use in any hospital setting. It demonstrates that not only Vmax but also several other points on the time-normalized QRS or ST-T curves can be explored as diagnostic tools. It gives a range of normal limits for these points thus establishing a firm basis for statistical comparison with future research work on ECG in Negroes.

References

1. Araoye MA. The 12-Lead Scalar ECG in Nigerians: I-Normal Values. Nig. Med. Practit. 1984; 7: 59-65.
2. Araoye MA: The Orthogonal (Frank Lead) ECG in adult Nigerians; Wave amplitude. W. Afr. J. Med (In press).
3. Sokolow M, Lyon TP. The ventricular complex in left ventricular hypertrophy as obtained by unipolar precordial and limb leads. Am. Heart J. 1949; 37: 161-186.
4. Grubschmidt HA, Sokolow M. The reliability of high voltage of the QRS complex as a diagnostic sign of left ventricular hypertrophy in adults. Am. Heart J. 1957; 54: 689- 694.
5. Romhilt DW, Estes Jr EHX. A point-score system for the diagnosis of left ventricular hypertrophy. Am. Heart J. 1968; 75: 752-758.
6. Pipberger HV, Simonson E, Lopez Jr. EA, Araoye MA, Pipberger HA. The electrocardiogram in epidemiologic investigations. A new classification system. Circulation 1982; 65: 1456-1464.
7. Murphy ML, Thernabadu PN, Soyza ND, *et al.* Re-evaluation of electrocardiographic criteria for left, right and combined cardiac ventricular hypertrophy. Am. J. Cardiol.
8. Starr JW, Wagner GS, Behar VS, Walston A, Greenfield JC. Vector cardiographic criteria for the diagnosis of inferior myocardial infarction. Circulation 1974; 49: 829-836.
9. Starr JW, Wagner GS, Draffin RM, Reed JB, Walston A, Behar VS. Vectocardiographic criteria for the diagnosis of anterior myocardial infarction. Circulation 1976; 53: 229-234.
10. Witham AC. Technique of vector-cardiography. In: Hurst JW, Logue RB, Rackley CE, *et al.* The heart 6th Edition McGraw-Hill Book Co. 1985: p 1687-1690.
11. Yano K, Pipberger HV. Spatial magnitude, orientation and velocity of the normal and abnormal QRS complex. Circulation 1964; 29: 107-117.
12. Pipberger HV, Stallmann FW, Yano K, Draper HW. Digital computer analysis of the normal and abnormal electro-cardiogram. Prog. cardiovasc. Dis. 1963; 5: 378.
13. Araoye MA. The orthogonal electrocardiogram in adult Nigerians: A preliminary report. W. Afr. J. Med. 1992; 11: 48-54.