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THE ELECTROCARDIOGRAM IN PATIENTS OVER 70 YEARS OF AGE
USING UNIPOLAR PRECORDIAL AND AUGMENTED UNIPOLAR LIMB LEADS

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INTRODUCTION

The proper evaluation of the electrocardiogram as an aid to diagnosis of heart disease in the aged has been confused by a lack of generally accepted limits for normal values. Part of this problem has been derived from the debate on certain changes which have been considered as reflections of only the aging process per se. With these uncertainties it becomes apparent the value of knowing what changes occur within the heart anatomically and functionally which need not be considered sufficiently pathological to warrant the diagnosis of heart disease; and how, if at all, these changes are reflected by the electrocardiogram. As a corollary to this concept is the value of tabulating the numbers of clinical and electrocardiographic changes in the aged, thus establishing the relationship of each to itself and to each other.

TECHNIQUE OF STUDY

Selection of Cases

All patients entering Douglas County Hospital on the Medical, Surgical, Orthopedics, and Urology Services during a 5 month period and 70 years of age or older were studied. The total number of cases reported was 75, 20 being excluded because of such a short period of hospitalization that adequate records were not obtained. No attempt to screen this group was made and it represents both ambulatory and bed patients, as well as those with and without known cardiovascular disease. The patients under care at Douglas County Hospital on the services studied are indigent and are not restricted as to sex, race, and color. A record was made on each patient as to age, sex, color, hospital service, and primary diagnosis.

Roentgenological Study

All patients had full size chest films taken in the upright position. Evidence of gross cardiac enlargement or pulmonary congestion on a cardiac basis was used as evidence of radiological abnormality, while those with such findings as ectasia or various degrees of calcification of the aorta were considered within normal limits for the purpose of this survey.

Clinical Study

Careful histories and physical examinations were done on all of the patients with particular reference to the cardiovascular system. This was done either in part or totally by the author.

Electrocardiograms

Electrocardiograms were made on all patients lying in bed with one pillow under their head using a General Electric Cardioscribe direct writing type machine. The leads used were the same on all patients: Standard Leads 1, 2, and 3; Augmented Unipolar Limb Leads aVL, aVR, and aVF; and Precordial Leads V1, V2, V3, V4, V5, and V6.

The author read all of the electrocardiograms using the established normal values for adults (1, 2) and the criteria for reading augmented leads as suggested by Goldberger. (3) In addition to reporting the accepted abnormal findings, premature beats and QRS complexes with low voltage were noted. The cardiac position was recorded by the method of Goldberger, rather than calculating axis deviation.

RESULTS

For the purpose of interpretation of the results this series of cases was divided into four groups. The number of cases in each group, their age, sex, and race is indicated in Table I. The age variation within the series was from 70 to 99.

Definition of the Groups

Groups 1 and 2 had clinical evidence of heart disease. The criteria used for this impression were active or past history of decompensation, angina, pressing substernal sensations, marked exertional dyspnea and the physical findings of abnormally enlarged heart, murmurs including apical systolic murmurs of relative loud intensity, and thrill. Although some of the cases had evidence of only suggestive heart disease it was felt they should be included in this group to allow the so-called normal group to be as free as possible from any clinical evidence of cardiac pathology. Group 1 was not hypertensive, group 2 was. Blood pressures of diastolic 90 mm. mercury and systolic 150 mm. mercury were considered the criteria for hypertension.

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Groups 3 and 4 were considered free from heart disease clinically using the criteria mentioned above. Group 3 was hypertensive, group 4 was not.

A tabulation of the electrocardiographic abnormalities demonstrated is made in Table 2. Further breakdown of the clinically normal groups as to specific ages, blood pressure, and primary diagnosis is available in Table 3.

Table 4 is a tabulation of the cardiac position by the method of Goldberger.

Table 1

Group		No. 1	No. 2	No. 3	No. 4	Total
Sex	Male	15	18	3	16	52
	Female	4	12	3	4	23
Race	White	16	28	5	16	65
	Colored	3	2	1	4	10
Age	70-79	8	24	5	10	47
	80-89	11	6	1	9	27
	90-	0	0	0	1	1
Total Number		19	30	6	20	75

The four interpretative groups tabulated as to sex, race, age and total numbers.

Table 2

Groups	1	2	3	4	Total	Total %
Total cases in groups	19	30	6	20	75	-
Normal electrocardiogram (a)	2	2	6	14	24	32
Normal electrocardiogram (b)	0	0	5	7	12	16
Normal sinus rhythm	12	13	6	15	46	61
Abnormalities of rate, rhythm						
Isolated A premature beats	0	3	0	2	5	6
Isolated V premature beats	5	6	0	1	12	16
Isolated premature nodal beats	2	1	0	1	4	5
Sinus bradycardia	0	0	1	1	2	3
Sinus arrhythmia	0	1	0	0	1	1
Auricular fibrillation	2	6	0	0	8	10
Auricular flutter	0	1	0	0	1	1
Conduction defects						
Prolonged A-V conduction	1	3	0	3	7	9
R Bundle branch block	3	0	0	0	3	4
L Bundle branch block	1	7	0	0	8	10
Intraventricular conduction def.	1	3	0	2	6	8
Ischemic lesions						
Myocardial ischemia	1	4	0	0	5	6
Myocardial infarction						
Acute	2	2	0	0	4	5
Healed	1	2	0	0	3	4
Suspect	4	8	0	0	12	16
Hypertrophy and Strain						
L Ventricular Strain	3	6	0	2	11	14
L Ventricular Hypertrophy	3	3	0	0	6	8
L Vent. hypertrophy and strain	1	1	0	0	2	3
R Ventricular Strain	0	1	0	0	1	1
Digitalis	4	11	0	0	15	20
Low Voltage QRS	3	2	0	7	12	16

The four interpretive groups tabulated as to electrocardiographic diagnosis and the percentage of each.

- (a) Calculated not counting premature beats and low voltage as abnormal.
(b) Calculated counting premature beats and low voltage as abnormal.

Table 3

Group No. 3

Age	Primary Diagnosis	No. of cases	Blood Pressure
71	Fractures	2	154/88
75	Prostatic hypertrophy	1	175/90
76	Diabetes mellitus	1	180/90
77 (2)	Pneumonia	1	180/95
80	Ecthyma	1	168/100
			190/105

Average age 76

Group No. 4

Age	Primary Diagnosis	No. of cases
71	Fractures	5
72	Pneumonia	4
73	Hypochromic anemia	3
74 (2)	Prostatic hypertrophy	1
76	Herpes zoster	1
77	Bronchial asthma	1
78 (2)	Carcinoma of bowel	1
79	Hodgkin's disease	1
80 (2)	Chronic alcoholic	1
82 (2)	Diabetes mellitus	1
83 (3)		
85		
87		
99		

Average age 79

Cases in Groups 3 and 4 tabulated as to the number at each age and as to the primary diagnosis.

Table 4

Group	No. 1	No. 2	No. 3	No. 4	Total
Horizontal	11	20	5	9	45
Horizontal- Intermediate	2	1	0	4	7
Intermediate	4	2	0	4	10
Vertical- Intermediate	0	0	1	0	1
Vertical	0	0	0	1	1
Total					64

Tabulation of the groups according to heart position using the technique of Goldberger, excluding those cases showing bundle branch block.

The Normal Groups

In making an electrocardiographic analysis of the normal hypertensive group 3 and the normal non-hypertensive group 4 the measurements of the various intervals and their amplitudes were tabulated as well as being used in the reading of the individual electrocardiograms. The two cases showing intraventricular conduction defects and the two cases with demonstrable left heart strain were excluded, thus leaving 6 cases in group 3 and 16 in group 4. The material is listed below:

Heart Rate varied from 57 to 93 in group 4, and from 55 to 88 in group 3.

The PR interval was above normal limits in one case after evaluating it with respect to heart rate. In group 4 it varied from .12seconds to .20 seconds with an average of .16 seconds. In group 3 it also varied from .12 seconds to .20 seconds with an average of .16 seconds.

The P waves were notched and slightly irregular in two cases, but in none were there other evidences of auricular pathology.

The QT interval was measured and compared to the ideal QT interval calculated by the use of Bazett's formula. (4) In group 4, 7 of the 16 had a ratio greater than 1.09, the usually accepted upper limit of normal, while 3 were .9 or smaller. The range was from .65 to 1.15, with an average of 1.04. In group 3 all 6 of the cases had a ratio greater than 1.09, the average being 1.14 with a range from 1.10 to 1.23.

The duration of the QRS complex was under .10 seconds in all of the cases recorded. Low voltage of the QRS complex was present in 7 of the 20 cases in group 4 and was not present in any of the 6 cases in group 3. The standard for low voltage was a total excursion of the QRS complex of less than 5 mm. in each of the three augmented unipolar limb leads. (3)

No T wave changes such as inversion and alteration of shape were seen which were not correlatable to some known type of tracing.

Premature beats were demonstrated in 4 of the 20 cases in the entire group 4 series and in none of the 6 cases in group 3. Auricular premature beats and ventricular premature beats were the only abnormalities

in two of the tracings. The third showed evidence of defective intraventricular conduction as well as nodal premature beats, while the fourth showed a combination of auricular and ventricular premature beats as well as first degree A-V block.

If low voltage QRS, sinus bradycardia, and premature beats are considered abnormalities then group 4 has 13 cases or 65% with abnormal tracings, and group 3 has 1 or 18% abnormal tracings. However if these are considered not abnormal then the relative number of abnormal electrocardiograms changes to only 30% in group 4 and none in group 3.

DISCUSSION

As in all of medicine, so also in this particular study one of the most difficult questions has been establishing what can be considered the normal change with age. Non-specific aging of the heart functionally without significant structural change has been termed presbycardia by Dock. (5) Unfortunately from a clinical viewpoint as well as from the pathological anatomy this concept has proved more theoretical than technically correct as Boas and other workers have shown. (6,7)

The Pathological Anatomy of the Aging Heart

Many investigators believe that the changes shown in the aged heart are entirely a reflection of disease of the heart. It is known that hypertension is common in this group (8,9) and it, in association with arteriosclerotic heart and vascular changes or alone, is responsible for increased cardiac work with hypertrophy and dilatation. Such changes are also common in association with arteriosclerotic changes alone. Both hypertension and arteriosclerosis with increasing demands on coronary vessels of diminished caliber are influential factors in the production of myocardial ischemic changes. Willius and Smith (10) studied 381

cases over 70 years of age at postmortum and found evidence of coronary sclerosis in all of their cases, being scarcely perceptible in only 2.5% but moderate to advanced in over 75% of the hearts. As well as these more common conditions Congenital, Luetic, and Rheumatic Heart Disease are known to occur in the aged group. (11)

The gross pathological findings in a series of 164 cases between the ages of 80 and 94 have been described by Howell. (12) His series showed normal muscle in 50% with the findings of general fibrosis in 16%, fatty changes in 5%, friable muscle in 17%, and brown atrophy in 12%. This series showed gross evidence of cardiac hypertrophy in 56% of the cases.

Since the electrocardiogram can serve only as an aid in cardiac diagnosis it cannot reflect the etiology of any problem. As the diseased state can interfere with conduction or can cause cardiac dilation, hypertrophy, or strain, then these changes can often be seen as variations from the usual stimulation and recovery pattern of the heart. The electrocardiographic diagnosis of these conditions is thus directly related to the changes caused

by these diseases to the state of the myocardium and the conduction system. (13) The problem of what findings are shown in the electrocardiogram by less specific changes, such as brown atrophy, is answered in part by Katz report (14) on the electrocardiogram in three cases of brown atrophy in which the findings were within normal limits, showing moderate left axis deviation.

That at least from an electrocardiographic standpoint no evidence of cardiac abnormality need be found with increasing age is supported by Gelman's case (15) of a man 122 years old showing an essentially normal electrocardiogram.

A Comparison of Electrocardiographic Abnormalities

A review of the literature demonstrates several approaches to the problem of study of the electrocardiogram in the aged. Three groups of papers have appeared:

- 1.) A survey of non-selected hospital and clinic type patients.
- 2.) A survey of a cross-section group of ambulatory patients from a convalescent home
- 3.) A survey of patients which have been selected on the basis of various criteria to be free of cardiac disease

Table 5 shows the proportion of abnormal electrocardiograms reported by each investigator. The number of abnormal tracings ranges from Hagen's group (16) with 14% to Duthoit's (17) with 97%.

Wosika (18) showed 15 of 20 with normal electrocardiograms were normal clinically, while of his group of 80 with abnormal electrocardiograms 35 were considered free clinically.

Table 5

	Date	Type of Lead	Percent Abnormal EKG	No. of Cases	Lower age of cases
General Group					
Willius	1931	Stand.	54.5	700	75
Warnicke	1939	Stand.	59	70	65
Dolgin	1949	-	68	71	65
Wosika	1950	Agmtd.	80	100	80
Ambulatory Convalescent Home Group					
Duthoit	1936	Stand.	97	116	60
Lohr (19)	1939	Stand.	41	162	51
Fox	1942	St. & IVF	66	300	60
Fox	1948	St. & IVF	49	300	60
Screened Non-Cardiac Groups					
Gelman	1936	Stand.	50	60	61
Levitt	1939	Stand.	26	100	70
Eliaser	1941	St. & IVF	85	100	70
Taran	1944	St. & IVF	64	102	60
McNamara	1949	St. & IVF	61	100	70
Hagen	1950	Agmtd.	14	56	70

Tabulation of the number of abnormal electrocardiograms
found in various series.

In the author's series 68% of the total cases had abnormal electrocardiograms. Of the group clinically free of heart disease 30% had abnormal tracings. Occasional premature beats or low voltage of the QRS complex was the only abnormality in 8% of the group with clinical heart disease.

The types of leads and the manner of interpretation of the electrocardiograms have certainly been factors in the marked deviation of results obtained by the various authors. For the purpose of comparison of results it is difficult to include such variations of opinion as Levitt's (20) that auricular fibrillation and prolonged PR interval are not abnormal findings, to that of Eliaser (21) who listed axis deviation as an abnormality. Because of these interpretive differences the findings are of value only when compared on a very broad scale.

It is Wosika's opinion (18), considering the problem of numbers of leads, that in part the number of abnormal electrocardiograms in the aged group is almost proportional to the number of leads taken.

This probably is an exaggeration of fact, although the value of using more than 3 or 4 leads, particularly the use of augmented extremity leads, has been so thoroughly proved that it will not be discussed here. (3, 18, 22) For a comparative basis, particularly with reference to the position of the heart, only those series which have been taken using augmented unipolar extremity leads have been chosen by the author.

Electrocardiographic positioning of the heart has been done in each of the series, however only in the reports of Wosika (18) and Hagen (16) has this been done using the designations suggested by Goldberger. This technique has avoided the earlier problem of trying to evaluate which abnormalities are indicated by various degrees of axis deviation. In general the same pattern is evident in all of the series, namely the great preponderance of left axis deviation or more specifically horizontal heart. Left axis deviation has appeared in from 62% to 76% of the cases of those authors which have reported their results in that manner. (21, 23)

The numbers of hearts in the various positions as calculated in Wosika's and Hagen's series are compared with those of the author in Table 6.

Table 6

Investigator	Wosika	Hagen	Author's series		
			Total	Gr. 3	Gr. 4
Horizontal	38	35	45	5	9
Intermediate- Horizontal	25	-	7	0	4
Intermediate	20	18	11	0	4
Intermediate- Vertical	7	-	1	1	0
Vertical	4	3	1	0	1
Total No. of Cases	94	56	65	6	18

Tabulation of the position of the heart electrocardiographically using the technique of Goldberger and excluding cases of bundle branch block. Comparison of the results of Wosika (18), Hagen (16) and the author.

One explanation for this preponderance of horizontal position has been suggested by Hagen (16) who found a high degree of correlation between this and ectasia of the aorta. The finding of horizontal positioning of the heart cannot be generally considered as an abnormality however.

Left ventricular hypertrophy was present in 20% of the cases of Wosika and in 10% of those of the author. Left heart strain was found in 11% of Wosika's cases and in 15% of those of the author. These findings were primarily observed in the cases with known heart disease. It is interesting to observe that neither was present in the small series of cases presented by the author which were considered clinically normal for the exception of elevated blood pressure.

Auricular fibrillation occurred from 2 to 18% (20, 24) in various series, the highest in any survey of patients screened to exclude those with noticeable heart disease was 4%. The author's series showed 10% in the total group, with none in the groups chosen as clinically normal.

First degree A-V block as a finding in each of the reported series has ranged from 2% to 40% (25, 21) varying in part by a lack of uniform criteria. Wosika (18) in his unselected group found 29 cases out of the 100 patients over 80 years of age, his determination being based on the prolongation of the PR interval over .20 seconds. The majority of the authors analyzing selected groups of essentially non-cardiac patients found the incidence was smaller, namely 3% Gelman (26), 2% Taran (25), 3% McNamara (27), 4% Hagen (16), and 3% Dolgin (28). The author had 9% in his total series, and 11% in the clinically normal groups.

Premature beats have not been considered as an abnormality by most authors. Their frequency in various series has been from 4% (28) to 34.3% (24). The number has been approximately of the same order of magnitude, usually between 15% and 25% in both the carefully controlled and the cross sectional studies. The author had an incidence of 24% in the total group, with 15% in the clinically normal group. Premature beats were the only abnormality recorded in the electrocardiogram of 2 of the 20 patients in the normal group, or 10%.

The recording of the incidence of bundle branch block has varied from 4.2% (24) to 17% (29), the exact figure in several series being difficult to evaluate because of the generalized grouping of their conduction disturbances. The general finding of intraventricular conduction disturbances ranged above 5% in all series. In the author's group bundle branch block was found in 14% of the total group, and evidence suggestive of disturbances in the interventricular conduction system in 10% of the normal group.

The relationship of blood pressure to changes in the electrocardiogram in the aged has been discussed extensively by Fox (30, 23). Although in one of his series he showed that 78% of the patients with abnormal electrocardiograms had increased blood pressure the correlation was not as obvious as it might at first appear. This was demonstrated in part by showing that increased blood pressure, particularly systolic, was present in over 60% of the patients in his study. He showed that in the groups with normal electrocardiograms and those with abnormal electrocardiograms approximately the same per cent were hypertensive.

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In the author's series the findings in the groups without clinical evidence of heart disease, both with and without hypertension, were comparable; in the patients with clinical evidence of heart disease, with and without hypertension, the proportions of abnormal electrocardiograms were comparable.

Fox (23) stated that he believed the abnormal electrocardiogram to be a function more of heart enlargement and disease processes rather than of hypertension, excluding those cases with a marked elevation of the diastolic pressure. This is in keeping with the findings of other authors (13) and is additionally supported by the results of this investigation.

CONCLUSION

In studying the electrocardiogram of the aged, using augmented unipolar limb leads and precordial leads which have been demonstrated to show the most changes, one may expect to find between 68% and 84% abnormal tracings in an unselected group of patients. A group carefully screened to exclude cardiovascular disease shows from 14% to 24% abnormal electrocardiograms, even if such conditions as low voltage of the QRS complex and premature beats are listed as normal findings.

Position of the heart is primarily horizontal in the aged group.

In patients otherwise free of cardiac disease frequent findings have been low voltage of the QRS complex, premature beats, and increase in the QT ratio. Pathological studies do not support the contention that these changes result from the normal aging process of the heart, but suggests that they indicate pathological processes within the heart which are however of such insignificance that they do not remarkably alter its function. There are probably no changes reflected on the electrocardiogram caused

by simple aging of the heart per se. It would not appear that mild elevation of the blood pressure, primarily systolic, without other evidence of heart disease is associated with any more electrocardiographic change than might be anticipated from a similar case free from hypertension.

The electrocardiographic findings of fibrillation, A-V and intraventricular block, acute infarction, coronary insufficiency, and heart strain and hypertrophy are the reflections of the same disease processes which occur in the aged heart as well as in younger ones.

SUMMARY

1. A report is made on 75 patients 70 years of age and older on whom standard, augmented unipolar limb, and precordial electrocardiographic leads were taken, correlating the data with the clinical findings and tabulating the results.

2. A review of the literature is made comparing the proportion of various changes found in previous series with those of the author.

3. The criteria for designating an electrocardiogram normal in the aged group is discussed, this being representative not changes which occur within the heart in the normal aging process but actual pathology which is of insufficient severity to alter the function of the heart.

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