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Electrocardiogram in left ventricular hypertrophy : with special reference to young adult males

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THE ELECTROCARDIOGRAM IN LEFT VENTRICULAR HYPERTROPHY WITH SPECIAL REFERENCE TO YOUNG ADULT MALES

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1. Introduction

Is cardiac enlargement present? This is an age old question which the physician considers as he examines a patient with possible cardiac disease. In congenital heart disease, essential hypertension, renal disease, etc., the determination of cardiac enlargement is necessary for diagnosis and prognosis.

There are at present, three major methods of determining cardiac enlargement. These are physical examination, chest roentgenography, and the electrocardiogram.

In left ventricular hypertrophy, physical examination may reveal the PMI to be displaced laterally and the impulse sustained. Percussion may reveal an increased area of cardiac dullness. Physical examination is still a basic and useful means of evaluating cardiac enlargement.

Chest roentgenography by fluoroscopy and x-ray films allows the examiner to actually evaluate specific cardiac measurements. Alterations in the normal outline and shape of the heart suggest enlargement. Left ventricalar enlargement is manifested by elongation and bulging of the left ventricular curve, or "the boot shaped heart." Fluoroscopy is usually more sensitive than chest x-ray and alterations in size, shape and outline of the heart are more easily noted. The routine method of estimating cardiac enlargement by x-ray, is the use of the 6-foot PA film of the chest. The transverse cardiac diameter is measured and compared with the normal diameter. Sex, age, height and weight are variables which determine cardiac size. Tables which predict the normal heart size for the particular patient in question, taking into account the above mentioned variables, have been worked out. One such representative table has been presented by Ungerleider and Clark. Other tables and various methods of measuring the heart size may be found in roentgenologic text-books.[2] To quote: "all these methods give strikingly similar results...one which most nearly satisfies our needs should be selected and adhered to."

The introduction of the Electrocardiogram into clinical medicine introduced another avenue of cardiac diagnosis. Einthoven, in 1907, first observed that certain valve lesions when accompanied by great cardiac enlargement, gave electrocardiographs with QRS complexes of distinctive type. Einthoven also noted that these abnormal curves were often of great amplitude.[3,4] Lewis[5] in 1914, confirmed Einthoven's earlier observations but also noted many normal electrocardiographic tracings exhibited Einthoven's signs of right and of left ventricular hypertrophy in minor degree. He found the average values of the individual QRS deflections in a large series of cases of aortic insufficiency and found as compared with the normal subject, a conspicuous increase in the amplitude of the R wave in Lead I, the S wave in Lead III, a decrease of the S wave in Lead I and the R wave in Lead III. The groundwork for use of the electrocardiograph in evaluating cardiac hypertrophy seemed to have been laid.

But, note that Lewis[5] also commented on the fact that many normal persons might show apparent signs of cardiac hypertrophy on their electrocardiographic tracing. In this same vein, Hermann and Wilson in 1922 correlated the electrocardiograph with post mortem observations. They used a relatively large series of 59 cases and concluded that the relative weight of the two ventricles was but one of the many factors which might influence the form of the ventricular complex of the electrocardiogram. They felt this one influence would only predominate when the heart was grossly hypertrophied; and when the ventricular weight was below 250 grams there was no definite relation between the form of the ventricular complex and the relative weight of the two ventricles. Through the years following, attempts have been made to establish criteria which would be more rigid and conclusive in establishing ventricular hypertrophy by electrocardiographic means.

The scope of this paper is intended to review the diagnosis of left ventricular hypertrophy by electrocardiographic means. The criteria used in making this diagnosis will be presented in the discussion. One of the most striking changes is increased amplitude of the QRS complexes. It has been realized by investigators[7,8] that age of the patient (as well as height, weight, sex, etc.) plays a role in determining normal amplitude. For example: Vaquero, Limon, and Limon[8] found the maximum normal amplitude of R-V-5 for adults 50-60 years of age to be 17.0 mm., while for adults under age 40 the normal was 28.4 mm. If amplitude is normally greater in the young adult than in the older age groups, can it be used as a diagnostic criteria for left ventricular hypertrophy in the young adult? This is the primary investigative portion of this paper.

2. Discussion

The criteria of left ventricular hypertrophy which have been noted in the electrecardiograph by various investigators are as follows:

A. Left Axis Shift

B. QRS Pattern

1. Limb Leads

2. Unipolar Leads

C. Intrinsicoid Deflection

D. RST-T Changes

1. Limb Leads

2. Unipolar Leads

E. Amplitude

1. Limb Leads

2. Unipolar Leads

Left Axis Shift

The electrical axis of the heart is determined by observing the degree of positive or negative deflection in the various leads. As the QRS potential in aVL, Lead I, and precordial leads 5 and 6 becomes more positive; in Lead III, and precordial leads

1 and 2 more negative, left axis deviation is said to be taking place. Kaplan and Katz,[9] reported that left axis deviation was present in 80 per cent of cases of left ventricular hypertrophy. They felt if it were not present in left ventricular hypertrophy, it might be due to a neutralizing effect of a concomitant right ventricular hypertrophy or a change in heart position. Goldberger[10] found that in left ventricular hypertrophy the long axis of the heart is usually quite oblique, and left axis deviation is present; however, normal or even right axis deviation may be present, depending on the long axis of the heart. The variable axis of the heart in the human subject makes this criterion difficult to evaluate. Kaplan and Katz found in their report that 25 per cent of their normal patients showed left axis deviation. Chamberlain and Hay[11] found in a series of middle age patients approximately 25 percent showed left axis shift. Factors tending to make heart position more horizontal will produce seeming left axis deviation, among these being body stature, obesity,[12] and pregnancy.[13] Therefore, while left axis deviation is often found in left ventricular hypertrophy, its incidence in the normal subject is too great to make it a sensitive criterion in evaluating left ventricular hypertrophy.

QRS Pattern

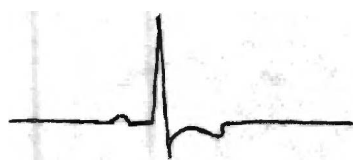
The pattern of tall upright R waves in Lead I, aVL, precordial 5 and 6, with small S waves; of small or absent R waves in in Leads III and precordial leads 1 and 2, with deep S waves, is considered indicative of left ventricular hypertrophy.[14,3,4]

Intrinsicoid Deflection

This is a measure of ventricular activation time. It is the duration of time from the beginning of the QRS complex to the height of the R wave. If intra-ventricular heart block is present, it is of no value. Sokolow and Lyon[15] include it as a criterion and place 0.05 seconds as the upper limit of normal in leads V-5 and V-6. Dimond[16] considers its value questionable and publishes concurring opinions in his textbook.

RST-T Changes

The RST-T changes considered characteristic of left ventricular hypertrophy are a depressed ST segment which is bowed upward, followed by a T wave that is inverted and asymmetric.[15,17,10,9] Diagramatically, it appears as in diagram below.



Sokolow and Lyon[15] point out that this pattern first presents itself in the left precordial leads V-5 and V-6; next in lead aVL, and then in Lead I. It is to be remembered however, that depression of the ST segment and inversion of the T wave is not specific for left ventricular hypertrophy; in fact, in vectorcardiography, the shift of the ST vector to a 180 degree angle with the QRS vector is considered to be merely a reflection of cardiac strain.[18] It may also be seen in digitalis effect, but in this it is more of a flattening of the ST segment to make it merge imperceptibly with the T wave instead of the depressed ST having an upward convexity separating it from the inverted asymmetric T wave.[9] It is the characteristic abnormal contour to which most authors call attention. Littman[19] feels ST-T changes of V-5 or V-6 truly reflect left ventricular strain while abnormal amplitude more nearly reflects hypertrophy, and while they are usually seen together, they may be seen separately. On the negative side Sensebach[20] is of the opinion that many serious mistakes in interpreting electrocardiographs are made by giving too much portent to ST-T changes. He presents a list of 47 conditions, not due to primary heart disease, in which strain pattern may occur as his evidence of the non-specificity of these changes. Notwithstanding, the weight of opinion favors ST-T changes as a sensitive criterion in left ventricular hypertrophy. They were present in 136 of 147 cases of left ventricular hypertrophy in the Sokolow and Lyon series.[15]

Amplitude

Increased amplitude of electrocardiographic tracings in cases of gross left ventricular hypertrophy is often the most outstanding abnormality seen in the tracing. The question as to why hypertrophy of the cardiac muscle should result in increased potential with large amplitude of the QRS complexes has not been fully answered. The following has been considered by Lipman and Massie.[21]

"(1.) The resultant vector is magnified by the increased preponderance of the thickened left ventricular wall; in other words the left ventricular depolarization continues unopposed by right ventricular depolarization for a greater than normal period. This explanation assumes that there is little or no associated hypertrophy of the right ventricle.

(2.) The hypertrophied fiber has diminished internal resistance as a result of its increased cross-sectional area. This tends to increase the magnitude of the potential. By the equation, EmF = V/R where V is voltage and R, resistance, as resistance decreases, the EmF increases.

(3.) The enlarged ventricle exposes a greater portion of the heart to the exploring electrode, or expressed in another way, the angle subtended by the electrode is abnormally large by virtue of the hypertrophied ventricle. The effect on the potential recorded by the electrode is much the same as if the electrode were moved closer to the epicardial surface, with the result that the potential is increased and a high amplitude R wave is thereby recorded."

In reality it is probably a combination of all three factors. In left ventricular hypertrophy the QRS in leads over the hypertrophied left ventricle, particularly the precordial leads V-5 and V-6, are large and positive. Large positive QRS complexes are seen in Leads I and aVL. Leads facing the comparatively small right ventricle, such as the precordial leads V-1 and V-2, are negative. It should be realized that perhaps body build, thickness of chest wall, age of patient, may play a part in determining amplitude of QRS complexes.

Amplitude of Standard Limb Leads

If the total voltage of the R wave in Lead I and S wave in Lead III equals 25 mm. or more, left ventricular hypertrophy is suggested.[22,23,7] In normal hearts Gubner and Ungerleider found that only 1 per cent had the sum of the R wave in Lead I and the S wave in Lead III in excess of 24 mm.[23]

Amplitude of Lead aVL

Shack, Rosenman, and Katz reported a maximum normal value of 12 mm. in R-aVL in their series.[24] Goulder and Kissane reported that in 165 patients with left ventricular hypertrophy, 83 per cent were characterized in Lead aVL by an R wave greater than 10 mm.[25]

For the use of the above leads, it was recognized that electrical axis of the heart must be taken into consideration when evaluating amplitude as a criterion for left ventricular hypertrophy. Goulder and Kissane's series[25] included only the horizontal or semi-horizontal hearts. Heine, Sackett and Serber, in a large series 1064) of male veterans, concluded that: the criteria of amplitude R-Lead I plus S-Lead III be 25 mm. or greater, and RaVL be 11 mm. or greater, (which were usually positive in the same patients) were only valid in estimating left ventricular hypertrophy when the heart position was horizontal or semi-horizontal.[7]

Amplitude of Precordial Leads

Heine, Sackett, and Serber in their study[7] found that the criteria based on high amplitude in the precordial leads were more sensitive than those based on high amplitude in the limb leads. Sokolow and Lyon had recognized this in an earlier report,[15] and also felt that the precordial leads, especially V-5 and V-6, showed the same type of abnormality in left ventricular hypertrophy whether the heart was vertically or horizontally placed; however, Heine, Sackett, and Serber[7] felt the highest association between precordial amplitude and left ventricular hypertrophy could be found in the vertical heart and in the patient under 40 years of age. Sokolow and Lyon[15] recognized the value of using more than one criteria in evaluating left ventricular hypertrophy. Their work has been cited earlier in this article regarding intrinsicoid deflection and RST-T pattern. They emphasize the diagnostic significance of the sum of the R wave in V-5 or V-6 and the S wave in V-1. Thirty-two per cent of patients with left ventricular hypertrophy had the sum of these two potentials exceeding 35 mm. In 96 per cent of normal individuals the sum was found to be below 30 mm. They also established 26 mm. as the upper limit of normal for R in V-5 and V-6. Heine, Sackett, and Serber agreed that R in V-5, 6, plus S in V-1 greater than 35 mm. was the most sensitive criterion, being positive in 71 per cent of their 149 cases of left ventricular hypertrophy and only infrequently was this criterion negative when any of the other criteria were positive. They found R in V-5, 6, plus S in V-1 greater than 35 mm., to be positive in only 1.5 per cent of 261 cases without left ventricular hypertrophy.

As noted above Sokolow and Lyon gave the maximum normal amplitude of V-5 and V-6 to be 26 mm. Kossman and Johnston reported amplitudes of R-V-5 up to 33.0 mm. in normal adults.[26] Vaquero, Limon and Limon[8] in a series of 500 normals found the maximum amplitude of R-V-5 for adults under age 40 was 28.4 mm.; in the decade 40-50, it was 20.7 mm.; from 50-60, 17.0 mm. For R-V-6: In adults under 40, 24.4 mm.; 40-50, 19 mm.; 50-60, 15.5 mm. Noth, Myers and Klein[27] found an average amplitude of R-V-6 to be 16.2 mm. in 84 pathologically proved cases of left ventricular hypertrophy, 9.2 mm. in a control series of 52 cases in which the hearts were normal at autopsy, and 10.5 mm. in 50 young male adults with normal hearts by physical and roentgen examination. For R-V-5 they found the average amplitude was 17.0 mm. in 58 autopsy proved cases of left ventricular hypertrophy, 10.7 mm. in 25 autopsy proved normal hearts and 14.1 mm. in the 50 normal adult males. Adequate explanation could not be found for the lower figures found by these workers.

3. Methods used in Present Study

Consecutive tracings were analyzed from the files of the Veterans Hospital, Omaha, Nebraska. The age range of patients was from 19 to 29 years of age. The tracings selected were from patients who had no evidence of heart disease and whose tracings had originally been taken as a portion of examination prior to surgery, electroconvulsive therapy, or some other condition not related to cardiac pathology. The records were analyzed for amplitude of the R wave in leads V-5, V-6, and aVL; for the sum of R-V-5 and S-V-1; for RST-T changes in leads V-5, V-6, and aVL; and for axis deviation. The following data was obtained and is presented in Table 1.

Table 1

Data Obtained from 222 Normal EKG's
of Males 19-29 Years of Age

No.	Age	Amplitude R-V-5	Amplitude R-V-6	Amplitude R-V-5 S-V-1	Amplitude R-aVL	Axis Deviation
1	26	12	9	25	- -	-
2	29	20	14	25	- -	-
3	27	15	12	26	2.5	-
4	22	26	24	34	2.5	right
5	28	16	10	22	1	-
6	24	23	15	34	4	left
7	25	14	12	29	3	left
8	29	19	14	28	4	-
9	29	11	7	21	1	right
10	27	24	18	39	-	-
11	29	10	5	15	-	right
12	21	21	17	29	-	left
13	29	10	7	16	1	-
14	28	16	13	25	7	left
15	26	12	10	20	1	-
16	29	18	12	26	-	left
17	25	13	9	18	-	-
18	26	21	13	37	1	-
19	18	15	13	27	1	right
20	26	15	10	28	1	left
21	22	18	17	33	1	right
22	24	12	11	25	1	right
23	26	18	15	30	2	-
24	28	18	12	30	1	right
25	29	6	5	14	1	left
26	25	13	11	23	4	left
27	28	20	15	20	1	-
28	26	15	12	30	1	right
29	29	19	16	29	2.5	-
30	27	13	10	18	2	left
31	29	10	7	18	1	-
32	27	17	14	24	0.2	-
33	29	25	19	37	3	right
34	24	15	11	26	0.1	right
35	28	15	13	27	0.1	-
36	26	13	9	18	2	-
37	27	26	21	33	4	-
38	26	21	15	26	2	-
39	25	25	17	28	0.5	right
40	29	21	16	29	1	-

No.	Age	Amplitude R-V-5	Amplitude R-V-6	Amplitude R-V-5 S-V-1	Amplitude R-aVL	Axis Deviation
41	24	15	12	17	3	right
42	29	17	15	32	1	-
43	29	13	10	15	2	-
44	26	14	11	28	1	-
45	28	13	11	26	5	left
46	28	19	14	28	-	-
47	24	17	12	21	2	-
48	25	16	12	26	3	left
49	29	28	24	39	0.5	-
50	29	17	12	30	2	-
51	24	23	17	38	5	left
52	27	24	19	29	4	left
53	23	15	11	19	1	-
54	25	12	10	24	0.5	-
55	26	25	16	28	5	left
56	28	13	10	18	4	-
57	24	24	18	38	2	-
58	25	20	14	25	0.5	-
59	26	18	21	22	4	-
60	25	18	21	20	1	right
61	27	24	15	35	5	-
62	18	16	11	21	0.5	right
63	26	12	10	26	1	right
64	26	7	9	10	1	left
65	28	8	5	13	1	right
66	25	13	11	25	1	right
67	26	14	10	22	2	-
68	28	15	11	20	2	-
69	23	13	13	25	-	-
70	26	16	13	24	3	-
71	21	19	12	23	1	right
72	25	16	13	21	3	right
73	24	14	9	27	1	-
74	24	18	13	26	2	-
75	24	13	7	19	2	-
76	21	14	11	21	2	right
77	26	15	12	23	2	-
78	24	22	20	31	1	-
79	26	15	12	22	-	left
80	26	8	7	16	-	-
81	25	20	15	32	1	-
82	29	18	11	23	3	-
84	26	14	11	18	1	-
85	29	20	16	26	-	-
86	20	19	12	32	1	-
87	28	14	14	20	2	-

No.	Age	Amplitude R-V-5	Amplitude R-V-6	Amplitude R-V-5 S-V-1	Amplitude R-aVL	Axis Deviation
88	29	14	10	24	2	-
89	25	13	14	16	4	left
90	27	16	13	25	5	-
91	27	18	15	30	-	right
92	20	15	11	23	1	right
93	20	17	17	28	-	-
94	22	14	11	20	1	-
95	26	14	11	20	1	-
96	23	10	9	25	-	-
97	26	11	10	26	-	-
98	23	12	8	19	2	-
99	26	16	12	25	0.5	-
100	25	15	9	29	2	-
101	28	18	13	27	4	left
102	28	22	15	35	1	-
103	28	19	14	25	0.5	-
104	29	10	9	13	8	left
105	29	20	16	25	5	left
106	29	16	11	30	4	left
107	27	25	16	45	0.1	-
108	24	11	11	31	-	-
109	23	17	15	28	-	-
110	26	13	11	24	-	-
111	28	20	15	28	-	-
112	25	20	14	28	2	-
113	23	10	9	16	1	-
114	20	15	15	37	1	-
115	24	24	20	44	3	-
116	28	20	15	26	1	-
117	23	17	12	32	-	-
118	28	15	12	25	2	-
119	28	17	15	22	1	-
120	25	18	13	27	2	right
121	29	26	17	30	2	-
122	25	18	13	25	1	-
123	28	7	6	15	-	right
124	26	13	11	16	1	-
125	21	18	11	25	3	left
126	26	9	8	12	1	-
127	23	22	18	29	1	-
128	27	17	15	22	5	left
129	25	19	18	30	1	-
130	29	21	14	43	6	left
131	28	15	11	27	-	-
132	29	10	8	15	-	right
133	25	17	16	29	-	-

No.	Age	Amplitude R-V-5	Amplitude R-V-6	Amplitude R-V-5 S-V-1	Amplitude R-aVL	Axis Deviation
134	28	18	13	23	5	left
135	29	17	16	27	1	-
136	25	18	18	33	1	-
137	29	12	8	14	-	-
138	29	13	11	18	-	-
139	29	24	16	34	2	-
140	26	12	12	27	1	-
141	25	14	12	16	1	-
142	26	10	9	18	0.5	right
143	25	13	11	23	-	-
144	18	10	7	20	2	-
145	22	23	16	33	1	-
146	27	26	20	38	0.5	-
147	25	14	10	26	-	-
148	28	9	8	17	0.5	right
149	27	24	16	28	2	-
150	29	20	17	29	1	-
151	23	16	12	23	5	-
152	27	12	12	20	2	-
153	21	17	15	31	2	right
154	22	25	20	25	2	right
155	28	13	11	15	-	-
156	29	17	14	25	-	-
157	24	30	20	39	5	left
158	29	11	8	17	-	-
159	20	13	14	18	1	-
160	29	10	9	20	1	right
161	24	24	20	28	1	-
162	21	11	10	17	1	-
163	28	15	10	23	3	-
164	28	12	8	18	0.5	-
165	29	17	15	23	2	-
166	24	14	15	26	4	left
167	24	10	8	18	1	-
168	25	14	10	18	1	-
169	22	18	13	24	2	-
170	29	15	14	27	2	-
171	19	15	11	20	1	-
172	24	15	13	33	-	-
173	27	19	14	29	1	right
174	27	15	12	17	4	-
175	18	15	11	20	1	-
176	25	13	11	23	0.5	right
177	28	19	11	26	1	left
178	22	16	12	21	2	left
179	26	7	6	18	-	right
180	24	16	13	31	1	right

No.	Age	Amplitude R-V-5	Amplitude R-V-6	Amplitude R-V-5 S-V-1	Amplitude R-aVL	Axis Deviation
181	24	14	13	20	1	right
182	27	10	8	14	2	right
183	26	19	14	31	5	left
184	29	19	15	25	0.5	-
185	27	12	9	18	-	right
186	23	18	16	22	-	right
187	23	18	13	28	0.5	-
188	26	19	14	30	0.5	right
189	28	33	24	38	2	-
190	20	15	10	32	-	-
191	28	19	17	26	-	-
192	28	22	17	22	2	right
193	28	18	16	27	-	right
194	28	9	7	16	5	left
195	24	12	7	20	-	-
196	29	21	12	26	3	right
197	28	14	11	24	0.5	right
198	25	20	10	27	4	left
199	28	12	10	19	2	right
200	26	16	12	27	-	right
201	29	24	22	31	5	left
202	22	15	10	27	1	-
203	24	25	21	31	3	left
204	28	21	17	28	-	right
205	24	17	11	33	4	left
206	26	16	12	23	2	left
207	26	19	14	22	0.5	right
208	23	15	12	24	1	-
209	28	16	11	29	3	left
210	26	10	10	19	2	left
211	24	27	15	36	0.5	right
212	29	16	11	26	1	-
213	23	16	13	20	2	left
214	22	19	11	23	3	left
215	23	13	11	24	-	right
216	29	20	17	32	2	right
217	27	20	17	32	2	right
218	24	17	11	25	2	right
219	29	24	18	29	2	-
220	26	12	10	29	1	right
221	23	15	14	24	-	left
222	29	20	16	26	1	-

4. Analysis and Discussion of Data

Axis Deviation

As noted previously in discussion portion of this paper, axis deviation is a variable dependent on physiologic factors as body build, etc. No attempt was made in this study to correlate these factors with electrical axis of the heart, but rather it was only noted what percentage of male patients, without heart disease, in the third decade of life, showed axis deviation. Of the 222 cases:

-- 125 showed electrical axis within normal limits,

-- 56 showed right axis deviation,

41 showed left axis deviation.

The 125 cases which had normal electrical axis, represent 56.3 per cent of the total. The 56 cases with right axis deviation represent 25.1 per cent. Left axis deviation in 41 cases represents 18.4 per cent of the total.

RST-T Pattern

In none of the records analyzed was there evidence of abnormality of the RST-T pattern.

Amplitude

In lead aVL:

-- 54 had no measurable R wave 24.3%

-- 24 showed R-aVL measuring less than 1 mm. . . . 20.8%

-- 102 showed R-aVL measuring from 1-3 mm. 45.9%

31 showed R-aVL measuring from 3-5 mm. 13.9%

-- 11 showed R-aVL measuring 5 mm. or greater . . .

Previous investigators had found maximum normal values of 10, 11, and 12 mm.[25,7,15,24] In this present series 95.5 per cent of patients had R-aVL measuring less than 5 mm.

<u>Amplitudes of R-V-5</u>

22 had V-5 amplitude of 10 mm. or less 9.9%

83 had V-5 amplitude of 10-15 mm. 37.3%

80 had V-5 amplitude of 16-20 mm. 36.1%

29 had V-5 amplitude of 21-25 mm. 13.1%

7 had V-5 amplitude of 26-30 mm. . . . .

1 had V-5 amplitude of 33 mm. 0.4%

Of the 222 tracings analyzed in this study 96.4 per cent had amplitudes of R-V-5 of 25 mm. or less. Only 3.6 per cent exceeded 25 mm. The average amplitude would be less than 20 mm., but 25 mm., would seem to represent the maximum normal. This may be compared with figures found by previous authors.

-Sokolow and Lyon[15] . . . . 26 mm.

-Kossman and Johnston[26] . . . . 33 mm.

-Vaquero, Limon, and Limon[8]. . . . . 28.4 mm.

-Noth, Myers, and Klein[27] . . . . 14.1 mm.

Amplitude of R-V-6

-- 52 had V-6 amplitude of 10 mm. or less 23.4%

-- 121 had V-6 amplitude of 10-15 mm. 54.5%

-- 39 had V-6 amplitude of 16-20 mm. 17.5%

10 had V-6 amplitude of 21-25 mm. 4.5%

-- There were no amplitudes greater than 25 mm. in lead V-6.

Of the 222 tracings 95.5 per cent had amplitudes of less than 20 mm. This would appear to represent the maximum normal amplitude while the average amplitude would be in the 10-15 mm. range. Previous investigators have found these figures:

-Sokolow and Lyon[15] . . . . 26 mm.

-Vaquero, Limon and Limon . . . . 24.4 mm.

-Noth, Myers and Klein[27] . . . . 10.5 mm.

Amplitude of R-V-5 plus S-V-1

00 had sum of 10 mm. or less . . . .

14 had sum of 10-15 mm. 6.6%

43 had sum of 16-20 mm. 14.8%

65 had sum of 21-25 mm. 24.7%

64 had sum of 26-30 mm. 28.8%

24 had sum of 31-35 mm. 10.8%

9 had sum of 36-40 mm. 4.1%

1 had sum of 43 mm. 0.4%

1 had sum of 44 mm. 0.4%

1 had sum of 45 mm. 0.4%

The results are somewhat scattered, but agree roughly with figures found by previous authors.[15,7] Of the 222 cases 74.9 per cent had amplitudes of 30 mm. or less, and 94.7 per cent had amplitudes of 35 mm. or less. The remaining 5.3 per cent represent those patients which would be suspected of having left ventricular hypertrophy by the criterion R-V-5 plus S-V-1 equals 35 mm. or less.

5. Summary

The need for evaluation of cardiac hypertrophy has been discussed. The methods by which this may be done have been presented. These methods are: physical examination, evaluation of cardiac size and contour by means of the chest x-ray, and evaluation by electrocardiographic analysis. Analysis by electrocardiographic means has been discussed in more detail. The findings in the electrocardiographic tracing which suggest left ventricular hypertrophy are:

A. Left Axis Shift

B. QRS Pattern

(1) Tall R waves in Leads I, aVL, V-5, and V-6.

(2) Deep S waves in Leads III and V-1.

C. Intrinsicoid deflection in leads V-5 and V-6.

(1) Intrinsicoid deflection greater than 0.05 seconds suggests left ventricular hypertrophy.

D. RST-T Changes

(1) These consist of a depressed, upward bowed, ST segment with asymmetric inversion of the T wave. These changes appear first in the precordial leads, next in lead aVL, then in Lead I.

E. Increased Amplitude

(1) Increased amplitude of QRS complexes is noted in all leads.

(2) The R waves are increased in leads I, aVL, V-5, and V-6. Normal amplitudes for these leads have been established.

(3) The S wave is increased in leads III and V-1. Normal values have been established for the sum of amplitudes of R wave in Lead I plus S wave in Lead III; also for the sum of amplitudes of R wave in lead V-5 plus S wave in lead V-1.

The relative frequency and accuracy of these criteria as obtained by investigators in the field has been discussed. A series of 222 electrocardiographic tracings, of young adult male patients in the third decade of life without evident heart disease were analyzed for axis deviation; RST-T changes in leads V-5, V-6, and aVL; amplitudes of R waves in leads V-5, V-6, and aVL; and the sum of the amplitudes of R-V-5 and S-V-1.

6. Conclusions

A. Left axis deviation in the young adult male is too variable to be of specific diagnostic value in left ventricular hypertrophy.

B. RST-T changes may be used as diagnostic criteria in the evaluation of left ventricular hypertrophy in the young adult male.

C. In this series the amplitude of R-aVL in 95.5 per cent of 222 young adult males without evident heart disease was less than 5 mm., and amplitude in excess of 5 mm. is thought to be suggestive of left ventricular hypertrophy in the young adult male.

D. In this series, 96.4 per cent of patients had R-V-5 amplitudes of 25 mm. or less. Amplitude in excess of this figure is thought to be suggestive of left ventricular hypertrophy in the young adult male patient.

E. In this series 95.5 per cent of patients had R-V-6 amplitudes of 20 mm. or less. Amplitude in excess of this figure is thought to be suggestive of left ventricular hypertrophy in the young adult male patient.

F. In this series, the sum of R-V-5 plus S-V-1 was 35 mm. or less in 94.7 per cent of 222 records examined. It is felt that if the sum is in excess of 35 mm., it may be used as a criterion of left ventricular hypertrophy in the young adult male patient.

G. The electrocardiographic criteria of left ventricular hypertrophy apply to the young adult male.

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