Left Ventricular Wall Thickness Determined by Ultrasound in 100 Subjects without Heart Disease*

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Left ventricular wall thickness (LVWT) was measured by ultrasound in 100 subjects without heart disease. The data on both diastolic (LVWTd) and systolic (LVWTS) thickness were related to sex, age, weight, height, heart volume (HV), and ECG voltage criteria. LVWTd was greater in men (P<0.01) but LVWTS was of the same magnitude in both sexes. In both sexes LVWTd and LVWTS increased with age (P<0.001). In women LVWTd correlated with HV but not in men (R=0.429; P<0.001 for women, R=0.145; P>0.05 for men). This was caused by an increasing HV with age in women, in contrast to the steady HV in men. There was no correlation between LVWTd and weight in either sex. LVWTd and height was not related in men but in women there was an inverse correlation between LVWTd and height (R=−0.102; P>0.05 for men, R=−0.363; P<0.01 for women). No significant correlation was found between the LVWT and ECG voltage criteria. Irrespective of sex and age the upper normal limit for LVWTd was 12 mm and for LVWTS 18 mm.

The estimation of the absence or presence and degree of left ventricular hypertrophy (LVH) is an integral part of cardiology routine. This estimate has both diagnostic and prognostic significance, and it is one of the commonly used parameters in assessing the results of both therapeutic and surgical procedures. Electrocardiography (ECG), vectorcardiography and recently multiple dipole electrocardiography have been used in estimating LVH. The criteria employed are to a large extent empirical and are based on several assumptions. Accordingly, both false positive and negative data are obtained.1-7

Angiocardiography is more accurate in determining the left ventricular wall thickness (LVWT) but it, too, is subject to many errors.8-13 The ultrasound examination of the heart and its movements was introduced by Edler14 in 1955 and in 1966 Feigenbaum and associates15 and Soulen and associates16 reported data on LVWT. Since that time several reports have described left ventricular wall measurements by ultrasound.17-22 Despite an increasing amount of data on LVWT, the normal range in relation to age, sex, body composition and heart size has not been established. This present report describes normal variations in ultrasonically determined LVWT in subjects without clinically detectable heart disease.

MATERIAL AND METHODS

One hundred subjects with no clinically recognizable heart disease, as judged by clinical findings, ECG and chest x-ray films, were studied ultrasonically to record LVWT.

The material consisted of 58 women, aged 18 to 61 years, mean 35 years, and 42 men aged 17 to 69 years, mean 39 years. The subjects consisted of hospital house staff, medical students and patients admitted for minor surgical procedures, e.g., repair of inguinal hernia. They comprised both manual and sedentary workers with an even distribution in both sexes. The conventional 12-lead ECG was taken as the hospital routine. A direct-writing inkjet ECG machine was used (Elema-Schönander). The calibration was carefully checked and correction was done, if necessary, in calculating the amplitudes. In assessing LVH the QRS criteria of Manning and Smiley (1964)23 were used as follows: R in lead I 13 mm, max R in V5 and V6 33 mm, R in aVL 7 mm, R in aVF 23 mm, R in lead I + S in lead III 16 mm and max R in V5 or V6 + S in V1 53 mm in subjects under 30 years and 13 mm, 24 mm, 9 mm, 15 mm, 17 mm and 37 mm in subjects over 30 years respectively. The heart volume (HV) in erect position without reference to the cardiac cycle was determined from biplane chest x-ray films by the ellipsoid approximation method24 with certain modifications.25 In excluding pathologic hearts, the HV was related to body surface area;26 volumes over 500 ml/M² in men and over 450 ml/M² BSA for women were considered pathologic.27 Ultrasound

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cardiac examinations were made using an ultrasonoscope* utilizing 500 impulses/sec repetition, with a 13 mm diameter, 2.00 megahertz transducer. The transducer was placed at the left sternal border in the fourth or fifth intercostal space to obtain the posterior left ventricular wall echoes as described earlier.28 Measurements were performed by a single observer by repeated measurements. If variation of measurement was found, an average figure was used for each record. The maximal and minimal wall thicknesses as compared with the carotid pulse were taken to represent systole and diastole respectively, and the measurements were made with an accuracy of 1 mm. The ultrasonic data were compared with different parameters as described later. Conventional statistical methods and measures were used. The statistical significances were determined by Student’s t-test. The tables of Geigy (1962) were used.

RESULTS

Table 1 gives an account of the total series (of subjects) including height, weight, HV, left ventricular systolic wall thickness (LVWTs), left ventricular diastolic wall thickness (LVWTd), and the percentage of LVWTd/LVWTs.

In men the LVWTd varied from 5 to 12 mm and in women from 4 to 12 mm (Table 2). The LVWTs varied from 10 to 17 mm in men and from 10 to 18 mm in women. Considering the total series the LVWTd was greater in men (P < 0.01) but there was no difference in LVWTs (P > 0.05). Both in men and women there was a positive correlation between LVWTd and age (P < 0.001 for both).

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Table 1—The Measured Variables in Three Different Age Groups.

<table>
<thead>
<tr>
<th>Age, yrs</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=28</td>
<td>N=12</td>
</tr>
<tr>
<td>Height, cm</td>
<td>163.95</td>
<td>4.90</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>56.67</td>
<td>7.67</td>
</tr>
<tr>
<td>Heart vol, ml</td>
<td>570.00</td>
<td>114.50</td>
</tr>
<tr>
<td>LV—Syst thickness, mm</td>
<td>11.96</td>
<td>1.26</td>
</tr>
<tr>
<td>LV—Diast thickness, mm</td>
<td>6.11</td>
<td>0.99</td>
</tr>
<tr>
<td>LV, % Diast syst</td>
<td>51.04</td>
<td>5.72</td>
</tr>
</tbody>
</table>

Figure 1. Relation between age and left ventricular wall diastolic thickness.

Table 2—Left Ventricular Wall Thickness in Different Age Groups.

<table>
<thead>
<tr>
<th>Age, Sex</th>
<th>Diastolic Wall Thickness, mm</th>
<th>Systolic Wall Thickness, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>17-29 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>4-8</td>
<td>6</td>
</tr>
<tr>
<td>Men</td>
<td>5-8</td>
<td>7</td>
</tr>
<tr>
<td>30-49 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>5-12</td>
<td>8</td>
</tr>
<tr>
<td>Men</td>
<td>7-10</td>
<td>8</td>
</tr>
<tr>
<td>50-69 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>8-12</td>
<td>9</td>
</tr>
<tr>
<td>Men</td>
<td>7-12</td>
<td>9</td>
</tr>
</tbody>
</table>
ULTRASOUND DETERMINATION OF LEFT VENTRICULAR WALL THICKNESS

FIGURE 2. Relation between body height and diastolic thickness of left ventricular wall.

with both LVWT\(_s\) (P < 0.01) and LVWT\(_d\) (P < 0.001) (Fig 4 and 5).

LVWT\(_d\)/LVWT\(_s\) in percentage was greater in all groups in men (P < 0.005), but it correlated significantly with age in women only (P < 0.001, Fig 6).

DISCUSSION

In ultrasonic studies the diastolic thickness is easier and more accurate to measure than the systolic thickness due to disturbing echoes from papillary muscles, trabeculations and chordae tendineae. Accordingly the diastolic data are more reliable and worth major emphasis in the analysis. Moreover, in the correlation with HV, when x-ray films are exposed without reference to the cardiac cycle, it is more likely that the exposures are in diastole than in the shorter systole. Measurements of LVWT at autopsy vary according to the place and obliquity of the cut, the inclusion of trabeculae or papillary muscles and the state of myocardial tone. The data on normal values from different autopsy series are compiled into Table 3. The information from angiocardiographic studies in normal hearts is collected into Table 4. Table 3 reveals the scarcity in autopsy materials of LVWT evaluations taking age and sex into account. Various textbooks and authors give normal values for LVWT ranging from 10 to 15 mm, however without regard to age or sex. Angiocardiographic observations (Table 4) are limited to small series and give normal values for LVWT\(_d\) ranging from 5 to 15 mm. Kennedy and associates (1966) have related LVWT\(_d\) to age and sex in their series of 22 subjects.

Even if the above listed data are obtained by direct approaches they are subject to errors owing to methodologic difficulties. Analogous problems existing in ultrasonocardiography have recently been the subject of a number of publications.

FIGURE 3. Graph showing no correlation between ECG criteria and systolic thickness of left ventricular wall.

FIGURE 4. Correlation between heart volume and left ventricular wall systolic thickness in women.

FIGURE 5. Correlation between heart volume and left ventricular wall diastolic thickness in women.

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been reviewed by Ilmurzynska and associates.45 One of the drawbacks is that LVWT is measured only in a relatively localized part of the posterior wall of the ventricle. This has bearing upon the appraisal of LVH, since the thickening of the wall may not be uniform, although it presumably is so in the majority of cases. The limited part of the left ventricular wall delineated by ultrasound as compared to different regions measured by angiocardiography renders the comparison of the data obtained by these two methods less satisfactory but reproducibility of the ultrasonic data is excellent.28

With due emphasis on the above limitations the present data show that LVWt and LVWT, increase in both sexes with age. This has not been found in autopsy studies.20 The increasing thickness cannot be due to changes in body weight, since there is no correlation to weight. The same applies to height, even if there is an unexplained negative correlation in the women, since the only significant difference in the height of women (Table 1) was seen between the age groups of 17 to 29 and 50 to 69 years (P < 0.02), and no change in height in men within the years studied. In women both LVWT, and LVWTd increased with an increasing heart volume (Fig 4 and 5); in men there was no correlation to HV. This apparent discrepancy is explained by the fact that in women the HV increased significantly with age: P < 0.02 between the first and second age groups, and P < 0.05 between the first and third age groups (Table 1), whereas HV did not increase in men with age (Table 1: P > 0.05 in all age group comparisons). Thus age seems to be the only factor relevant to both sexes that affects LVWT independently of other measured variables. No comparison was made between blood pressure readings and UCG measurements as the subjects were normotensive with blood pressure values not exceeding 160/100 mm Hg. The lack of any significant correlation between LVWT and the corresponding ECG criteria is worth emphasizing. Although the usefulness of the ECG in the diagnosis of LVH is established, it is generally agreed that false positives and false negatives tend to be common. The ECG data on LVH have been correlated with postmortem findings but there are many difficulties in assessing the upper limit of a normal left ventricular wall thickness at autopsy. Therefore it is not surprising that there was no significant correlation between LVWT, and the corresponding ECG criteria which presumably are too insensitive to reveal significant differences in normal hearts.

The expression of LVWT, in percentage of LVWT, is a measure of dynamic changes in the wall during a cardiac cycle. The considerable variability found in earlier angiocardiographic studies is discussed by Hugenholtz and co-workers.47 In the present work this ratio did not change with age, but it was significantly higher in men in all age groups (Table 1: P < 0.005) due to a significantly greater LVWTd in men and an equal LVWT, in both sexes. Theoretically it seems, therefore, that the

<table>
<thead>
<tr>
<th>Author</th>
<th>No. Cases</th>
<th>Age, yrs</th>
<th>LVWT, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reiner et al</td>
<td>14</td>
<td>28-94</td>
<td>15,2</td>
</tr>
<tr>
<td>Latimer</td>
<td>19</td>
<td>40-80</td>
<td>14 15</td>
</tr>
</tbody>
</table>

Upper limits of normal LVWT, according to

- Peacock: 12.8
- Linzbach: 10
- Boyd: 10-15
- Hudson: 12
- Schlant: 10
- Liu and De Cristofaro: 14
- Scott et al: 13
- Allenstein and Mori: 10

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dynamic change in LVWT is less in men than in women, i.e., the contractile pattern would be different. This line of reasoning is not supported by the angiographic data, which show no difference between men and women in end-diastolic and endsystolic chamber volumes. Additional data on changes in contractility and chamber geometry would presumably clarify the difference between the sexes.

As the normal upper limit of LVWT, irrespective of age and sex we suggest 12 mm (Table 2). The respective LVWT, is 18 mm (Table 2). The age related LVWT in mm should be derived with the aid of the following formulae: where x denotes age in years and SE the standard error of the estimate.

Men:

\[ \text{LVWT}_a = 0.072x + 11.046, \quad \text{SE} = 1.59 \]
\[ \text{LVWT}_d = 0.056x + 5.95, \quad \text{SE} = 1.16 \]

Women:

\[ \text{LVWT}_a = 0.111x + 9.48, \quad \text{SE} = 1.40 \]
\[ \text{LVWT}_d = 0.096x + 3.83, \quad \text{SE} = 1.24 \]

REFERENCES

3. Brann I: The significance of the electrocardiographic pattern for assessment of the degree and type of left ventricular hypertrophy. Cardiologia (Basel) 46:3, 1965
Food Resources of the Oceans

Food in the form of fish and plants was first of the riches man obtained from the seas. Over the course of countless years many of the world's peoples have made seafood a major element in their diet. Many seafoods are rich in vitally important protein. The Japanese, for example, consume a high proportion of seafood, as do many of the people living in the Mediterranean region. Man's food needs account for a world fish catch of about 110 billion pounds a year. This is an enormous amount measured by any standard. Yet marine biologists say it is really only a fraction of what the ocean is capable of supplying. Out of some 25,000 species of fish, only a handful of different species are actually caught and used for food.

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