Left Ventricular Mass in Normal Children and its Correlation with Weight, Height and Body Surface Area

Masa Ventricular Izquierda en Niños Normales y su Correlación con el Peso, Altura y Área de Superficie Corporal

*Piraye Kervancioglu; **Mehmet Kervancioglu; ***M. Cudi Tuncer & ***E. Savas Hatipoglu

SUMMARY: Echocardiographic measurement of left ventricular mass (LVM) is being used for the diagnosis of left ventricular hypertrophy in children with various cardiovascular diseases. The purposes of this study was to establish normal values of LVM according to weight, height and body surface area (BSA) in children and to determine the sex differences. We evaluated 208 children (143 males and 65 females), aged 1 day to 14 years who had no cardiovascular disease. The end-diastolic left ventricular internal dimension (LVIDd), end-diastolic left ventricular posterior wall thickness (LVPWd) and end-diastolic interventricular septum (IVSd) values were determined by M-mode echocardiographic examination. By using these values, left ventricular mass was calculated. The difference between LVIDd, LVPWd and LVM values of boys and girls were not statistically significant. We observed statistically significant differences between the sexes relative to IVSd and LVM/BSA values. The left ventricular mass and its components presented a good correlation with age, weight, height and BSA. The study let us know the lower and upper limits of cardiac dimensions and LVM obtained by echocardiography in normal Turkish children according to BSA. Also, as the LVM/BSA values show gender difference in children, sex should be taken in consideration while evaluating the left ventricular hypertrophy.

KEY WORDS: Echocardiography; Child; Normal values; Gender difference.

INTRODUCTION

Beginning from the embryogenesis period, right after birth, a progressive cardiac development and growth can be seen in newborn and children. In parallel with, an increase in left ventricular mass (LVM) occurs during childhood. Left ventricular mass is an important clinical measure because of its association with left ventricular hypertrophy and its significance as a strong independent risk factor for cardiovascular disease and mortality. The diagnosis of an enlarged or hypertrophied heart has an important effect on the treatment of children with congenital or acquired heart disease (Malcom et al., 1993; Garner et al., 2000; Kampmann et al., 2000; Daniels et al., 1995). Echocardiography is the most commonly used non-invasive method in pediatric cardiology to understand the anatomy and function of heart for the identification of congenital heart disease or exclude cardiac involvement in infectious, neuromuscular, or metabolic disorders. M mode echocardiography makes it possible to assess LVM by measuring the cardiac dimensions and wall thicknesses (Overbeek et al., 2006; Poutanen & Jokinen, 2007). To evaluate the echocardiographic data, the values have to be compared with the normal.

The objectives of this study were to determine normal values for echocardiographic measurements in a sample of healthy children in our country, correlating them with height, weight and body surface area (m²) and to investigate the sex differences.

MATERIAL AND METHOD

The study population consisted of 208 (143 males and 65 females) infants and children aged between one day to 15 years who were retrospectively analyzed. They were selected from the database of the Pediatric Cardiology Department of
Dicle University Medical Faculty, Diyarbakir who were attended between June 2006 and June 2007. Subjects were included if they did not have cardiac disease or a history of heart involvement due to infections, neuromuscular or metabolic disorders and if they presented a normal full-term delivery with adequate weight for date and the absence of any significant illness or of mental or physical retardation. The children were referred for evaluation of a heart murmur which was found to be normal on clinical, electrocardiographic and echocardiographic examinations. The age (in months), weight (Wt) in kilograms (Kg), and the height (Ht) in centimeters (cm) were obtained. The characteristics of the subjects expressed as mean±SD are shown in Table I. The body surface area (BSA) in square meters (m$^2$) was calculated by using the DuBois & DuBois (1916) formula as the following equation:

$$\text{BSA (m}^2) = (0.0001)(71.84)(\text{Wt}^{0.425})(\text{Ht}^{0.725})$$

Transthoracic echocardiographic examination was performed with the patient lying supine or in the left lateral semirecumbent position. No sedation was used during echocardiography. Two-dimensional and M-mode echocardiographic studies were carried out by a single pediatric cardiologist using a commercially available machine (Philips Sonos 7500, with 2.8 MHz transducers). The two-dimensional image was used to obtain the optimum position and angulation of the M-mode line. Standard parasternal, apical, subcostal and suprasternal views were used. End-diastole and end-systole were defined as the beginning of the QRS complex in electrocardiogram and the most thickened phase in left ventricular posterior wall, respectively. Each thickness was measured according to the recommendations of the American Society of Echocardiography (Fig. 1).

The end-diastolic left ventricular internal dimension (LVIDd), end-diastolic left ventricular posterior wall thickness (LVPWd) and end-diastolic interventricular septum (IVSd) values were determined by echocardiographic examination. Left ventricular mass was calculated by the formula of Devereux et al. (1986) which has been validated for use in children with normal hearts:

$$\text{LVM (g)} = 0.8 \{1.04((\text{IVST}+\text{LVID}+\text{LVPWT})^3 - \text{LVID}^3) + 0.6$$

The children were divided into 6 groups according to their BSA: 0.20-0.25 m$^2$, 0.25-0.50 m$^2$, 0.50-0.75 m$^2$, 0.75-1.0 m$^2$, 1.0-1.25 m$^2$, and 1.25-1.50 m$^2$. The means, ±SD of LVIDd, LVPWd, IVSd, LVM and LVM/BSA values were estimated for all groups (Table II).

Table I. Summary of the clinical characteristics and echocardiographic measurements of total of the children studied (T), and individually per male (M) and female (F). Data are expressed as mean±standard deviation. BSA, body surface area; IVSd, end-diastolic interventricular septum; LVIDd, end-diastolic left ventricular internal diameter; LVPWd, end-diastolic left ventricular posterior wall; LVM, left ventricular mass; LVM/BSA, left ventricular mass/body surface area.

<table>
<thead>
<tr>
<th></th>
<th>T (n=208)</th>
<th>M (n=143)</th>
<th>F (n=65)</th>
<th>Significance $p$ values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>77.13±50.84</td>
<td>77.13±51.71</td>
<td>77.14±49.26</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>22.68±1.80</td>
<td>22.72±1.80</td>
<td>22.60±1.89</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>112.25±30.27</td>
<td>112.33±30.75</td>
<td>112.09±29.43</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>BSA (m$^2$)</td>
<td>0.83±0.34</td>
<td>0.83±0.35</td>
<td>0.83±0.34</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>IVSd (cm)</td>
<td>0.62±0.14</td>
<td>0.63±0.14</td>
<td>0.59±0.14</td>
<td>=0.032</td>
</tr>
<tr>
<td>LVIDd (cm)</td>
<td>3.19±0.70</td>
<td>3.22±0.70</td>
<td>3.12±0.70</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>LVPWd (cm)</td>
<td>0.56±0.13</td>
<td>0.56±0.13</td>
<td>0.54±0.12</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>LVM (g)</td>
<td>47.00±23.05</td>
<td>48.85±23.92</td>
<td>42.95±20.59</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>LVM/BSA (g/m$^2$)</td>
<td>55.56±15.09</td>
<td>57.88±15.90</td>
<td>50.43±11.70</td>
<td>=0.001</td>
</tr>
</tbody>
</table>
Statistical analysis and the calculations were performed using SPSS for Windows, version 17.0. The strength of the associations between echocardiographic measurements and age, weight and BSA was assessed using Pearson’s correlation coefficient (r value). Differences between means of males and females were assessed with Student’s t test. A p value of <0.05 was considered significant.

RESULTS

There were no statistically significant differences between the age (p >0.05), weight (p >0.05), height (p >0.05) and the BSA (p >0.05) of the sexes. Their heights and weights were all within the normal range on standard growth chart.

Table I presents the mean±standard deviations relative to age, weight, height, BSA and echocardiographic measurements and those of their derivatives. It also presents these variables relative to sex. There were no significant differences in LVIDd, LVPWd and LVM values between the sexes. We observed statistically significant differences between the sexes relative to IVSd (p=0.032). IVS thicknesses were greater in boys than girls. Although, LVM (p=0.071) estimates tend to be greater in boys than girls, the statistical significance was achieved only in the values of LVM/BSA (p=0.001). We analyzed the children with the BSA above one square meter, the results were same.

The end-diastolic left ventricular internal dimension, LVPWd, IVSd, LVM and LVM/BSA values presented a good correlation with age, weight, height and BSA. The relationship between the LVM and weight, height and BSA appears in Fig. 2. Table III presents the values of Pearson’s correlation coefficients of echocardiographic measurements relative to age, weight, height and BSA of all the children studied and according to sex. Pearson’s correlation coefficients between the values of echocardiographic measurements and age, weight, height, BSA and sex did not present statistically significant differences.

The means, ±SD values of LVIDd, LVPWd, IVSd, LVM and LVM/BSA relative to the BSA groups were established in Table II.
Discusson

Echocardiography is a non-invasive and a confident method in the diagnosis of congenital and acquired heart disease. M-mode echocardiography is used most widely to measure left ventricular mass because of its wide availability, moderate expense, anatomic and prognostic validation (Rogé et al., 1978; Devereux et al.). As, increased LVM has been established as a strong independent risk factor for cardiovascular morbidity (e.g., arrhythmia, congestive heart failure, and myocardial infarction) and mortality, for management of the treatment and evaluation of the prognosis, the normal values of LVM are also needed (Levy et al., 1987; Epstein et al., 1975). In the 1970s, several studies established the normal limits of M-mode echocardiographic measurements in infants and children (Epstein et al.; Allen et al., 1977; Lundström, 1974). Henry et al. (1980) studied with 105 normal subjects ranging from one day to 23 years of age. They found that echocardiographic measurements of the internal dimensions, thicknesses and mass of the chambers of the heart follow a linear regression upon one of three functions, (direct linear, square root, cube root) of the BSA. There is no agreement in the literature about the anthropometric parameter which presents the best correlation with the echocardiographic measurements. Some studies show a better correlation with BSA, some of them with weight and others with height (Huwez et al., 1994; de Simone et al., 1992; Dai et al., 2009). Bonatto et al. (2006) reported that for normal children there is no difference whether they correlate the values of cardiac measurements assessed by echocardiography with age, weight, height or BSA. Epstein et al. suggested that plotting the echocardiographic measurements against the age is not logical as all age range has a wide body size spectrum. So they chose body surface area to standardize the echocardiographic data of their study. In the present study, no significant differences were observed between the values of Pearson’s correlation coefficients when the values of echocardiographic measurements studied were correlated with age, weight, height and BSA. As the recent studies used BSA to relate their data, we preferred to group the children according to BSA as it is an independent variable.

It was suggested that the number of human cardiac myocytes is determined within the first year after birth, when mitotic activity of cardiocytes appears to cease. So, subsequent increases in LVM reflect cellular enlargement (hypertrophy) (de Simone et al., 1995). According to the studies in the normal adults, LVM is larger in men than in women (Levy et al., 1987; de Simone et al., 1992). de Simone et al. (1995) stated that this difference might be due to a gender difference in the number of myocytes that was
provenido en el desarrollo de la hipertrofia muscular de los niños, y otros de ellos. Se buscó evaluar la hipertrofia ventricular izquierda (LVM) en 333 niños y 278 niñas de diferentes edades. No se encontraron diferencias estadísticamente significativas entre los sexos en la LVM obtenida por ecocardiografía en niños normales. Además, como los valores LVM/BSA muestran diferencias entre sexos en los niños, el sexo se debería tomar en consideración al evaluar la hipertrofia ventricular izquierda. Sin embargo, en edades más avanzadas, se encontró que la LVM en menores era del 25% al 38% mayor que la en mujeres, lo que es estadísticamente significativo. Løsp et al. (1987) estudiaron 202 (125 varones, 77 mujeres) niños normales de 25 días a 23 años de edad. Los autores observaron que los valores de las mediciones ecocardiográficas eran significativamente mayores en varones, cuando la superficie corporal (BSA) era mayor que un metro cuadrado. Bonatto et al. analizó los valores de las mediciones ecocardiográficas de acuerdo con el sexo y encontró que los valores de la LVM eran estadísticamente significativamente mayores en varones que en mujeres. En niños con diversas enfermedades cardiovasculares, los niños con varones tuvieron valores de LVM significativamente mayores que los de niñas. Las diferencias de los valores LVIDd, LVPWd y LVM entre niños y niñas no fueron estadísticamente significativas. Observamos una correlación efectiva entre la edad, peso y altura. En niños con BSA mayor de un metro cuadrado, los resultados fueron similares.

En conclusión, como existe una fuerte relación entre la LVM aumentada y el desarrollo de enfermedades cardiovasculares, es importante medir los componentes de la LVM y evaluarla de manera precisa. Los resultados establecidos según BSA en este estudio contribuyen a la determinación de los límites superiores e inferiores de las dimensiones cardíacas y la LVM obtenida por ecocardiografía en niños turcos normales. Además, la LVM/BSA de los niños y niñas muestra diferencias estadísticamente significativas entre sexos, lo que debe considerarse en la evaluación de la hipertrofia ventricular izquierda. Los autores también sugieren que en niños con BSA mayor de un metro cuadrado, los resultados fueron similares.


RESUMEN: La medición ecocardiográfica de la masa ventricular izquierda (LVM) se utiliza para el diagnóstico de la hipertrofia ventricular izquierda en niños con diversas enfermedades cardiovasculares. Los objetivos de este estudio fueron establecer los valores normales de MVI en función del peso, altura y área de superficie corporal (BSA) en niños y determinar las diferencias entre sexos. Se evaluaron 208 niños (143 varones y 65 mujeres), con edades entre 1 día a 14 años de edad que presentaban enfermedades cardiovasculares. Se determinaron los valores interno al final del diástole ventricular izquierdo (LVId), el espesor de la pared posterior (LV PWd) y la hipertrofia ventricular izquierda. Las diferencias de los valores LVId, LV PWd y LVId/LVM entre niños y niñas no fueron estadísticamente significativas. Observe las diferencias estadísticamente significativas entre los sexos en relación con los valores IVSd y LVM/BSA. La masa ventricular izquierda y sus componentes presentaron una buena correlación con la edad, peso y altura. Este estudio nos permitió conocer los límites superiores e inferiores de las dimensiones cardíacas, junto a la LVM obtenida mediante ecocardiografía en niños turcos normales de acuerdo con el BSA. Además, como los valores LVM/BSA muestran diferencias entre sexos en los niños, el sexo se debería tomar en consideración al evaluar la hipertrofia ventricular izquierda.

PALABRAS CLAVE: Ecocardiografía; Niño; Valores normales; Diferencia de sexo.

REFERENCES


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