

Left Ventricular Mass in Healthy Subjects of the City of Buenos Aires and its Correlation with Anthropometric Measurements.

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ABSTRACT

Left ventricular hypertrophy is a risk predictor of cardiovascular events. The objectives of this study were to establish reference values for left ventricular mass in an apparently healthy population of the Autonomous City of Buenos Aires, to analyze its correlation with age and anthropometric variables and to define the best way to express the assessed data. Left ventricular mass was estimated using internationally supported echocardiographic methods (American Society of Echocardiography/European Association of Echocardiography) and the adjusted Devereux equation. After applying strict exclusion criteria, 1898 subjects with mean age of 38 ± 11 years, 48.89% of whom were male and 51.1% were female, were included in the study. Left ventricular mass was 155 ± 30 g for men (95th percentile 206 g) with normal distribution, and 112 ± 24 g for women (95th percentile 153 g) with non-normal distribution ($p < 0.001$ between genders). Values were comparable to those reported in studies using a similar methodology. Left ventricular mass index showed a moderate correlation with body surface area and weight, and significant differences between genders. As calculated variables exhibited heterogeneity in data distribution (normal or non-normal), the 95th percentile was assumed as the best way of expressing reference values. In conclusion, estimated reference values of left ventricular mass in a healthy population correlated moderately with body surface area and weight. We propose the use of the 95th percentile to express the upper reference value of the assessed data

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Key words

> Hypertrophy - Echocardiography - Left Ventricle

Abbreviations

> ASE	American Society of Echocardiography	L VH	Left ventricular hypertrophy
BMI	Body mass index	L VM	Left ventricular mass
BS	Body surface	P WTd	Left ventricular posterior wall thickness in diastole
EAE	European Association of Echocardiography	I VSTd	Interventricular septum thickness in diastole
ECG	Electrocardiogram	R WT	Relative wall thickness
LVIDd	Left ventricular internal diameter in diastole	P 95	95th Percentile
LVIDs	Left ventricular internal diameter in systole		

INTRODUCTION

Increased left ventricular mass (LVM) is a nonspecific adaptive response to physiological stimuli or to several heart or systemic diseases. (1) In the latter case, left ventricular hypertrophy (LVH) has proved to be an independent risk predictor, increasing two to four times the probability of fatal and nonfatal cardiovascular events. (2-5) In patients under adequate antihypertensive treatment, LVH regression has been associated with a reduction in the number of cardiovascular

events and improved survival at follow up. (6, 7)

Different techniques such as electrocardiography (ECG), echocardiography, magnetic resonance imaging and angiography have been used to determine LVM. (8-11) Echocardiography is a simple, non-invasive, low cost method, which has shown very good correlation with necropsy in LVM assessment. (9, 12) However, various criteria have been used for echocardiographic measurements, as well as different for-

mulas to assess LVM, generating discrepancies in the cutoff points used for the diagnosis of LVH. (9, 13, 14) This technical variability has been transferred to epidemiological studies which have been carried out to establish reference values for the healthy population.

The aims of this study were, to establish reference values for LVM on a healthy population of the Autonomous City of Buenos Aires (CABA), to analyze its correlation with age and anthropometric variables and to define the best way of expressing these data using an internationally validated echocardiographic method.

METHODS

Study Population

All subjects admitted to a preventive health assessment in the Life Center of Fundación Favaloro were prospectively and consecutively evaluated for a period of eight months.

Subjects were evaluated by a cardiologist who conducted the interview and physical examination. Weight, height, blood pressure and heart rate were measured. Body surface (BS) was calculated using the DuBois & DuBois formula (15) and body mass index (BMI) as: weight in kg/height² in meters. All subjects underwent laboratory tests, ECG, 12-lead exercise stress test and color Doppler echocardiography.

Subjects aged ≥ 16 years with no history of cardiovascular or other systemic diseases were included in the study. Exclusion criteria were: hypertension (defined as blood pressure $\geq 140/90$ mm Hg or on antihypertensive therapy), diabetes (fasting blood glucose ≥ 126 mg/dl or glycosylated hemoglobin > 6.5 %), dyslipidemia (LDL cholesterol > 160 mg/dl), obesity (BMI ≥ 30), alterations in the thyroid profile or the internal environment, anemia or renal failure, known coronary artery disease, history of cardiovascular events, valvular heart disease (except mild mitral, tricuspid and/or pulmonary valve regurgitation), congenital heart diseases, storage disorders, neurodegenerative diseases, myocardial noncompaction, collagen diseases, primary hypertrophic cardiomyopathy and restrictive cardiomyopathy. Athletes and subjects with inadequate echocardiographic window were also excluded.

Echocardiography

Studies of transthoracic color Doppler echocardiography were performed by three operators in two ultrasound Philips EnVisor C HD (Bothell, WA, USA) equipments, according to standard technique. (16) All measurements were performed with a 2-4 MHz probe using second harmonic imaging. The parasternal long axis view was used to determine left ventricular internal diameter in diastole (LVIDd) and in systole (LVIDs) and interventricular septum (IVSTd) and left ventricular posterior wall (PWTd) thickness in diastole. Two-dimensional mode and/or M mode echocardiography was used to perform linear measurements following the recommendations of the American Society of Echocardiography (ASE) to establish edges (tissue-blood interface). (13, 14, 16) End-diastolic measurements were performed at the level of the mitral valve leaflet tips matching the frame following mitral valve closure or the frame in the cardiac cycle in which the cardiac dimension was largest. End-systole was best defined as the frame preceding mitral valve opening or the time in the cardiac cycle in which the cardiac dimension was smallest. (16)

The LVM calculation was performed using left ventricular linear dimensions and the adjusted Devereux formula (ASE cube) according to the joint recommendations of the

ASE and the European Association of Echocardiography (EAE). (12, 16)

$$\text{LVM (g)}: 0.8 \times \{1.04 [(\text{LVIDd} + \text{PWTd} + \text{IVSTd})^3 - (\text{LVIDd})^3]\} + 0,6 \text{ g}$$

Relative wall thickness (RWT) was calculated according to the formula: (16)

$$\text{RWT (\%)} = 2 \times \text{PWTd/LVIDd}$$

Then, LVM indexes were calculated with respect to BS, weight, height and age.

Statistical analysis

Data are expressed as mean \pm standard deviation (SD) and range (R) with a confidence interval of 95% and 95th percentile (P95).

The nonparametric Wilcoxon test was used to compare continuous quantitative variables.

The Anderson-Darling test was applied to evaluate the type of data distribution (normal or Gaussian vs. non-normal or non-Gaussian). (17)

The correlation (r) between variables was calculated using Pearson's method.

A p value < 0.05 was considered statistically significant

The Language and Environment R software version 2.15.1 was used for statistical analysis. (18)

RESULTS

From March to October 2010, 3626 subjects were evaluated, 1728 of whom were excluded. Of the 1898 subjects included in the study, 928 (48.89 %) were male and 970 (51.1 %) were female. The population mean age was 38 ± 11 years (R 16-82 years). Population characteristics and echocardiographic data are shown in Table 1.

The distribution of LVM values was normal (Gaussian) for men ($p = 0.26$) and non-normal (non-Gaussian) for women ($p < 0.001$) (Figure 1). The LVM value was 155 ± 30 g (R 44-248 g; P95 206 g) in men and 112 ± 24 g (R 54-195 g; P95 153 g) in women, with statistically significant differences between the two genders ($p < 0.001$) (Table 2).

The LVM indexes calculated with respect to BS ($p = 0.16$) and height ($p = 0.36$) showed a normal distribution in men, while the calculations with respect to weight ($p = 0.016$) and age ($p < 0.001$) were non-normal. The four LVM indexes showed non-normal distribution in women: BS: $p < 0.001$; height: $p < 0.001$; weight: $p < 0.001$; age: $p < 0.001$. The upper reference value for LVM / BS in men was 79 ± 14 g/m² (R 21-121 g/m²; P95 103 g/m²) and in women it was 68 ± 13 g/m² (R 37-117; P95 91 g/m²). LVM index values are shown in Table 2. Statistically significant differences were observed ($p < 0.001$) between men and women for all variables analyzed.

In both genders, there was a moderate correlation for LVM / BS (men: $r = 0.4$, $p < 0.001$, women $r = 0.44$, $p < 0.001$) and for LVM / weight (men: $r = 0.41$; $p < 0.001$, female: $r = 0.44$, $p < 0.001$) (Figures 2 and 3). The LVM / height index showed a weak though sig-

Table 1. Population characteristics: age, anthropometric and echocardiographic data.

Variable	Men Mean \pm SD	Women Mean \pm SD	p
Age, years	37.7 \pm 11 (R 16-82)	38.9 \pm 11 (R 16-80)	0.042
Weight, kg	78.4 \pm 9	60 \pm 8	< 0.001
Height, cm	175.8 \pm 6.5	162 \pm 6	< 0.001
BMI	25 \pm 2.4	22.7 \pm 2.7	< 0.001
BS, m ²	1.95 \pm 0.14	1.64 \pm 0.13	< 0.001
LVIDd, mm	48.6 \pm 3.5	44 \pm 3	< 0.001
LVIDs, mm	29.4 \pm 3.3	26 \pm 2.9	< 0.001
IVSTd, mm	9.4 \pm 1	8.3 \pm 2.1	< 0.001
PWTd, mm	8.8 \pm 1	7.7 \pm 1	< 0.001
LVEF, %	61.7 \pm 2.4	61.8 \pm 2.5	0.34
LA area, cm ²	16.5 \pm 2.2	14.7 \pm 2	< 0.001
Aortic root, mm	30.4 \pm 3.4	26.4 \pm 2.8	< 0.001
Mitral E velocity, cm/s	0.61 \pm 0.17	0.65 \pm 0.21	< 0.001
Mitral E/A relationship	1.47 \pm 0.37	1.51 \pm 0.41	0.053

SD: Standard deviation. R: Range. BMI: Body mass index. BS: Body surface. LVIDd: Left ventricular internal diameter in diastole. LVIDs: Left ventricular internal diameter in systole. IVSTd: Interventricular septum thickness in diastole. PWTd: Left ventricular posterior wall thickness in diastole. LVEF: Left ventricle ejection fraction. LA: Left atrial.

nificant correlation in both groups (male: $r = 0.25$, $p < 0.001$, female: $r = 0.24$, $p < 0.001$) (Figure 4). The worst correlation was between LVM and age: 0.08 ($p < 0.02$) in men and 0.15 ($p < 0.001$) in women (Figure 5).

The RWT showed a non-normal distribution in men ($p < 0.001$) and in women ($p < 0.001$). The value for men was 0.37 ± 0.05 (R 0.22-0.52; P95 0.45) and for women 0.35 ± 0.05 (R 0.22-0.63; P95 0.45), with statistically significant differences between genders ($p < 0.001$) (see Table 2). A weak though significant correlation was found between RWT and age in both men ($r = 0.16$, $p < 0.001$) and women ($r = 0.19$, $p < 0.001$). The correlation of RWT with BS, weight and height was not statistically significant for either gender.

DISCUSSION

In our local population, LVM values showed significant differences between genders: 155 ± 30 g for men (P95 206 g) with normal distribution (Gaussian) and 112 ± 24 g for women (P95 153 g) with a non-normal distribution pattern (non-Gaussian). The LVM showed a moderate correlation with BS and weight, heterogeneity in data distribution patterns (normal and non-normal) and significant differences between genders.

Current recommendations were followed for linear echocardiographic measurements ASE/EAE (13, 16), according to which wall thickness and diameter are defined by the blood-tissue interface. It is important to notice the use of this methodology, different from that initially used in echocardiographic LVM measurement, such as the Penn Convention which applied other criteria for linear measurements. (9) According

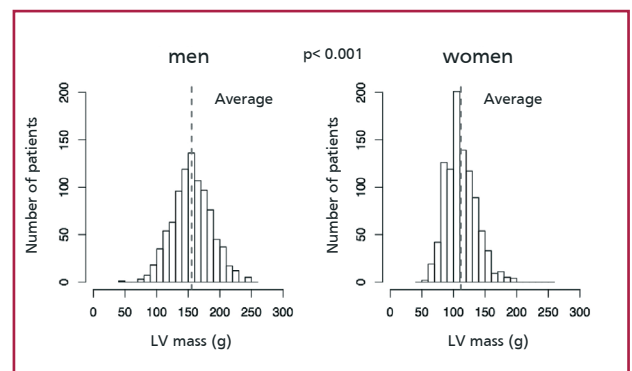


Fig. 1. Left ventricular (LV) mass distribution in the study population

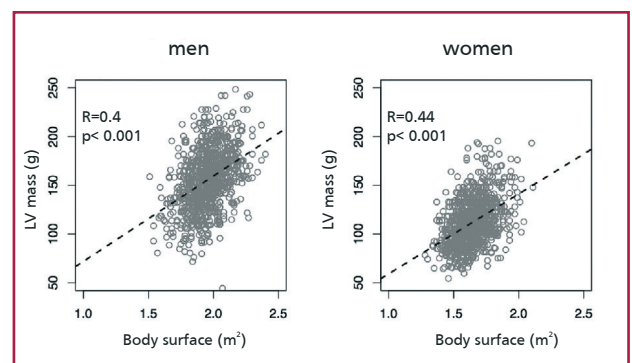


Fig. 2. Correlation between left ventricular (LV) mass and body surface

Table 2. Reference values: left ventricular mass, left ventricular mass indexes and relative wall thickness

Variable	Variable	Men	Women	p
LV mass, g	Mean ± SD	150 ± 30	112 ± 24	< 0.001
	R	44-248	54-195	
	P95	206	153	
LV mass /BS, g/m ²	Mean ± SD	79 ± 14	68 ± 13	< 0.001
	R	21-121	37-117	
	P95	103	91	
LV mass/weight, g/kg	Mean ± SD	1.99 ± 0.36	1.87 ± 0.36	< 0.001
	R	0.54-3.27	0.99-3.28	
	P95	2.6	2,5	
LV mass/height, g/m	Mean ± SD	88.4 ± 16.6	68.8 ± 14.25	< 0.001
	R	23-138	36-120	
	P95	115	93,5	
LVmass/age, g/year	Mean ± SD	4 ± 1.5	3 ± 1.1	< 0.001
	R	1.3-13	0.85-8.5	
	P95	7.4	5.3	
RWT, %	Mean ± SD	0.37 ± 0.05	0.35 ± 0.05	< 0.001
	R	0.22-0.52	0.22-0.63	
	P95	0.45	0.45	

LV: Left ventricular. SD: Standard deviation. R: Range. P95: 95th percentile. BS: Body surface. RWT: Relative wall thickness.

to the latter, endocardial borders are excluded from the thickness measurement and are included in the LVIDd determination, resulting in larger chamber size and smaller wall thickness. Unlike previous works that used the original Devereux formula, (5, 9) the cubic function was applied for LVM estimation, with the correction to avoid the 20% systematic overestimation against necropsy values. (12) These aspects may explain, at least in part, the differences between the values found in our study, which were lower compared to those reported in the works using originally established echocardiographic methods. (2, 3, 19, 20)

The LVM values obtained in this work are comparable to those of more recent studies which have used a similar methodology. In the Strong Heart Study (21) LVM was 154 ± 31 g for men with an upper range of 219 g and 108 ± 25 g for women with an upper range of 164 g. The LVM/BS values found in our study were similar to LVH cutoff points used in the PRESERVE study and LIFE substudy (116 g/m² for men, 104 g/m² for women). (6, 7) Moreover, in the ASE guidelines for chamber quantification, the LVM upper reference limit was set at 224 g for men and 162 g for women. (16) The prognostic validity of the new cutoff points for LVH and cardiovascular events was established in the work of Barbieri et al, (22) who used the same echocardiographic methodology to determine LVM. Similar to extensively reported results, significant differences between men and women were observed for LVM values and their indexes. (5-7, 19, 21, 23)

In relation to the different LVM indexes, a moderate correlation was found with BS and weight, and

a lower correlation with height, similar to that described in the Strong Heart Phase 2 Study, (23) which reported a correlation of 0.49 for LVM/BS, 0.47 for LVM/weight and 0.30 for LVM/height. In our study, the correlation of LVM with age was weak (worse in the case of men), similar to that reported by other authors. (21, 23-25)

The RWT values of our population were similar or slightly higher than those reported in the studies using the same echocardiographic measurement methodology. (16, 21, 26) The ASE guidelines set an upper limit of 0.42 for both genders, whereas in our population the cutoff point was 0.45 for both men and women. The correlation between RWT and BS, weight and height was not significant, whereas with age there was a weak though statistically significant correlation. Consistent with this finding, it has been described that age is associated with increased wall thickness and reduced LVIDd. (26)

There are different ways to express the reference values for a variable: mean ± standard deviation, ranges, percentiles or cutoffs points depending on the evolution of subjects over time or based on expert opinion. (16, 27) The mean ± 2 standard deviations is one of the most commonly used; however, its proper application requires normal data distribution (Gaussian). Conversely, the use of percentiles does not require a specific type of distribution. Because in our population LVM and its different indexes showed heterogeneity regarding the type of data distribution, the use of P95 is the best way to express reference values. For the same reason, in the Gutenberg Heart Study

(27) P95 was estimated for LVM and LVM/BS, and its values were similar to those of our population (LVM in men: 235 g, and in women 162 g; LV/BS in men 115 g/m², and in women 92 g/m²).

Among the strengths of this work, we can mention the number of subjects included in the study, as so far, sample size in published reports has been considerably smaller. Another aspect to highlight is the strict exclusion criteria to avoid confounding variables that could affect LVM values. The use of percentiles allows applying the same statistical criterion to express the reference values of the different variables, regardless of data distribution. Finally, we point out the adequate female representation in the population sample.

The limitations of the study are the small number of individuals over 60 years and the lack of representation of subjects less than 16 years old. No differentiation was made between races, but we can state that this is a representative sample of residents of the city of Buenos Aires. Regarding echocardiographic measurements, interobserver variability was not analyzed, although all studies were performed by a small number of operators. Neither was a follow-up of the individuals carried out as it was not an objective of the study design, but could be the purpose of future studies.

CONCLUSIONS

Using the methodology recommended by the ASE/EAE standards, LVM reference values were estimated for our healthy population, which were comparable to those reported in studies using the same methodology. The LVM showed a moderate correlation with BS and weight. We postulate the use of P95 as a criterion to establish the upper reference values for LVM and its indexes.

RESUMEN

Masa del ventrículo izquierdo en habitantes sanos de la ciudad de Buenos Aires y su correlación con medidas antropométricas

La hipertrofia ventricular izquierda es un predictor de riesgo de eventos cardiovasculares. Los objetivos del presente trabajo fueron establecer los valores de referencia para la masa ventricular izquierda en una población aparentemente sana de la Ciudad Autónoma de Buenos Aires, analizar su correlación con la edad y variables antropométricas y definir la mejor manera de expresar esos datos. Para el cálculo de la masa ventricular izquierda se utilizó metodología ecocardiográfica avalada internacionalmente (American Society of Echocardiography/European Association of Echocardiography) y la fórmula de Devereux ajustada. Luego de aplicar criterios de exclusión estrictos, se incluyeron 1.898 individuos, 48,89% hombres y 51,1% mujeres (edad 38 ± 11 años). El valor de masa ventricular izquierda fue para hombres de 155 ± 30 g (percentil 95 206 g), con distribución normal, y para mujeres de 112 ± 24 g (percentil 95 153 g), con distribución no normal ($p < 0,001$ entre géneros). Los valores son compara-

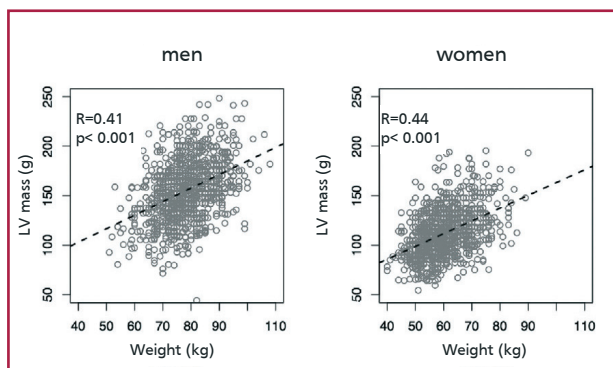


Fig. 3. Correlation between left ventricular (LV) mass and weight

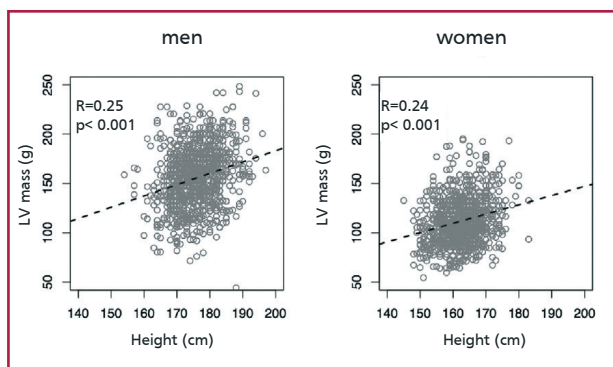


Fig. 4. Correlation between left ventricular (LV) mass and height

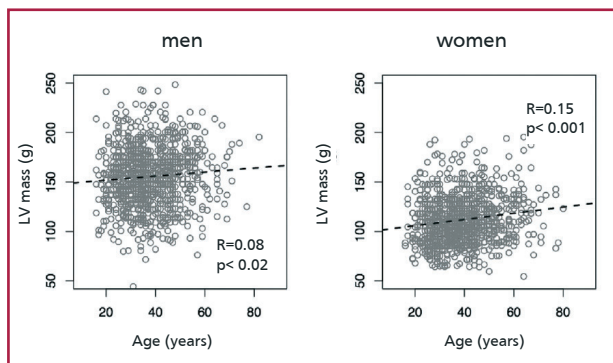


Fig. 5. Correlation between left ventricular (LV) mass and age

bles a los referidos en estudios con similar metodología. Los índices de masa ventricular izquierda calculados mostraron una correlación moderada para superficie corporal y peso, y diferencias significativas entre géneros. Las distintas variables calculadas exhibieron heterogeneidad en el tipo de distribución (normal o no normal) de sus datos, por lo que consideramos que el percentil 95 es la mejor manera de expresar los valores de referencia. En conclusión, se estimaron los valores de referencia para masa ventricular izquierda en una población sana y se observó una correlación moderada con superficie corporal y peso. Proponemos la utilización del percentil 95 para expresar el valor superior de referencia para los datos obtenidos.

Palabras clave > Hipertrofia - Ecocardiografía
Ventriculos cardíacos

Conflicts of interest

None declared.

REFERENCES

- Weidemann F, Niemann M, Ertl G, Stork S. The different faces of echocardiographic left ventricular hypertrophy: clues to the etiology. *J Am Soc Echocardiogr* 2010;23:793-801. <http://doi.org/d443q>
- Koren MJ, Devereux RB, Casale P, Savage DD, Laragh JH. Relation of left ventricular mass and geometry to morbidity and mortality in uncomplicated essential hypertension. *Ann Intern Med* 1991;114:345-52. <http://doi.org/nkg>
- Levy D, Garrison R, Savage D, Kannel WB, Castelli WP. Prognostic implications of echocardiographically determined left ventricular mass in the Framingham study. *N Engl J Med* 1990;322:1561-6. <http://doi.org/c7rz7k>
- Vakili BA, Okin PM, Devereux RB. Prognostic implications of left ventricular hypertrophy. *Am Heart J* 2001;141:334-41. <http://doi.org/cfbgnk>
- Casale P, Devereux RB, Milner M, Zullo G, Harshfield GA, Pickering TG, et al. Value of echocardiographic measurement of left ventricular mass in predicting cardiovascular morbid events in hypertensive men. *Ann Intern Med* 1986;105:173-8. <http://doi.org/nkh>
- Devereux RB, Wachtell K, Gerds E, Boman K, Nieminen MS, Papademetriou V, et al. Prognostic significance of left ventricular mass change during treatment of hypertension. *JAMA* 2004;292:2350-6. <http://doi.org/ctxzr>
- Devereux RB, Palmieri V, Sharpe N, De Quattro V, Bella JN, De Simone G, et al. Effects of once-daily angiotensin-converting enzyme inhibition and calcium channel blockade-based antihypertensive treatment regimens of left ventricular hypertrophy and diastolic filling in hypertension. The Prospective Randomized Enalapril Study Evaluating Regression of Ventricular Enlargement (PRESERVE) Trial. *Circulation* 2001;104:1248-54. <http://doi.org/dkz48>
- Casale PN, Devereux RB, Alonso DR, Campo E, Kligfield P. Improved sex-specific criteria of left ventricular hypertrophy for clinical and computer interpretation of electrocardiograms: validation with autopsy findings. *Circulation* 1987;75:565-72. <http://doi.org/dbrfdq>
- Devereux RB, Reichek N. Echocardiographic determination of left ventricular mass in man. Anatomic validation of the method. *Circulation* 1977;55:613-8. <http://doi.org/nkj>
- Troy BL, Pombo J, Rackley CE. Measurement of left ventricular wall thickness and mass by echocardiography. *Circulation* 1972;45:602-11. <http://doi.org/nkk>
- Missouris CG, Forbat SM, Singer DRJ, Markandu ND, Underwood R, Mac Gregor GA. Echocardiography overestimates left ventricular mass: a comparative study with magnetic resonance imaging in patients with hypertension. *J Hypertens* 1996;14:1005-10. <http://doi.org/cj6t5n>
- Devereux RB, Alonso DR, Lutas EM, Gottlieb GJ, Campo E, Sachs I, et al. Echocardiographic assessment of left ventricular hypertrophy: comparison to necropsy findings. *Am J Cardiol* 1986;57:450-8. <http://doi.org/cbvbw9>
- Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography: American Society of Echocardiography committee on standards, subcommittee on quantitation of two-dimensional echocardiograms. *J Am Soc Echocardiogr* 1989;2:358-67.
- Wikstrand J. Calculation of left ventricular mass in man— a comment. *J Hypertens* 1997;15:811-3. <http://doi.org/fwnbh9>
- DuBois D, DuBois EF. A formula to estimate the approximate surface area if height and weight be known. *Arch Intern Med* 1916;17:863-71. <http://doi.org/fgm7tq>
- Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. *J Am Soc Echocardiogr* 2005;18:1440-63. <http://doi.org/b92m9w>
- Stephens MA. EDF statistics for goodness of fit and some comparisons. *J Am Statistical Assoc* 1974;347:730-7. <http://doi.org/nkm>
- R Development Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, ISBN 3-900051-07-0, 2010, <http://www.R-project.org/>
- Park S, Seo HS, Shim CY, Choi EY, Ko YG, Choi D, et al. Effect of geometric remodeling on left ventricular longitudinal contractile reserve in patients with hypertension. *J Am Soc Echocardiogr* 2008;21:246-50. <http://doi.org/cdp9hn>
- Kouzu H, Yuda S, Muranaka A, Doi T, Yamamoto H, Shimoshige S, et al. Left ventricular hypertrophy causes different changes in longitudinal, radial and circumferential mechanics in patients with hypertension: a two dimensional speckle tracking study. *J Am Soc Echocardiogr* 2011;24:192-9. <http://doi.org/djwpmn>
- Ilercil I, O'Grady MJ, BA, Roman MJ, Paranicas M, Lee E T, Welty TK, et al. Reference values for echocardiographic measurements in urban and rural populations of differing ethnicity: The Strong Heart Study. *J Am Soc Echocardiogr* 2001;14:601-11. <http://doi.org/fnmsvx>
- Barbieri A, Bursi F, Mantovani F, Valenti C, Quaglia M, Berti E, et al. Prognostic impact of left ventricular mass severity according to the classification proposed by the American Society of Echocardiography/European Association of Echocardiography. *J Am Soc Echocardiogr* 2011;24:1383-91. <http://doi.org/bnrtg8>
- Devereux RB, Roman MJ, Simone G, O'Grady MG, Paranicas M, Yeh J, et al. Relations of left ventricular mass to demographic and hemodynamic variables in American Indians. *Circulation* 1997;96:1416-23. <http://doi.org/nkn>
- Shub C, Klein AL, Zachariah PK, Bailey KR, Tajik AJ. Determination of left ventricular mass by echocardiography in a normal population: effect of age and sex in addition to body size. *Mayo Clin Proc* 1994;69:205-11. <http://doi.org/nkp>
- De Simone G, Devereux RB, Roman MJ, Ganau A, Chien S, Alderman MH, et al. Gender differences in left ventricular anatomy, blood viscosity and volume regulatory hormones in normal adults. *Am J Cardiol* 1991;68:1704-8. <http://doi.org/bdjdkh>
- Ganau A, Saba PS, Roman MJ, de Simone G, Realdi G, Devereux RB. Aging induces left ventricular concentric remodeling in normotensive subjects. *J Hypertens* 1995;13:1818-22. <http://doi.org/fv76gc>
- Wild PS, Sinning CR, Roth A, Wilde S, Schnabel RB, Lubos E, et al. Distribution and categorization of left ventricular measurements in the General Population. Results from the Population-based Gutenberg Heart Study. *Circ Cardiovasc Imaging* 2010;3:604-13. <http://doi.org/d55st9>