Original article

Determination of Normalized Values of the Tricuspid Annular Plane Systolic Excursion (TAPSE) in 405 Spanish Children and Adolescents

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A B S T R A C T

Introduction and objectives: Tricuspid annular plane systolic excursion (TAPSE) is an echocardiographic measure that allows us to assess right ventricular systolic function. TAPSE measurement is common in adults but reference values for children are scarce. Our objective was to establish reference values for TAPSE in Spanish children and to determine the relationship of these values with age and body surface.
Methods: This prospective study included 405 patients (from newborn to age 18 years, 53% male) referred for assessment of cardiac murmurs. Patients with confirmed cardiac or any other disease were excluded. We collected TAPSE measurements by M-mode echocardiography and recorded anthropometric variables. We analyzed the intra- and interobserver reproducibility of these measurements.
Results: Mean TAPSE values were 17.09 ± 5.09 cm with nonsignificant differences between sexes. A curvilinear regression model proved appropriate, with values increasing in proportion to age group, height, weight, body mass index, and body surface. Body surface showed a strong positive correlation with TAPSE values (r = 0.81), whereas frequency had a negative correlation (r = −0.74). Multivariate analysis confirmed these correlations and the interactions between variables (age, height, weight, body surface). Graphs of estimated normal population-based TAPSE values adjusted by age and body surface are provided.
Conclusions: We present reference values for TAPSE in Spanish children and adolescents. The TAPSE measurement was reproducible and associated directly with age and body surface. These reference values could guide decision making in daily clinical practice.
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Determinación de valores normalizados del desplazamiento sistólico del plano del anillo tricuspídeo (TAPSE) en 405 niños y adolescentes españoles

R E S U M E N

Introducción y objetivos: El desplazamiento sistólico del plano del anillo tricuspídeo (siglas en inglés, TAPSE) es una medida ecocardiográfica que permite evaluar adecuadamente la función sistólica del ventrículo derecho y se emplea habitualmente en adultos. No obstante, hay poca información sobre los valores de referencia de TAPSE en niños. Nuestro objetivo fue determinar valores de referencia de TAPSE en niños españoles y evaluar su relación con la edad y la superficie corporal.
Métodos: Incluimos prospectivamente a 405 sujetos (neonatos hasta 18 años, el 53% varones) remitidos para evaluación de soplo cardiaco. Excluimos a los sujetos con cardiopatía o cualquier otra enfermedad. Recogimos la medida por modo M de TAPSE y variables antropométricas. Analizamos la reproducibilidad intraobservador e interobservadores de las mediciones.
Resultados: El TAPSE medio fue $17,09 \pm 5,09$ cm, sin diferencias significativas entre sexos. Se demostró adecuado un modelo de regresión curvilínea, con valores incrementales proporcionales a los estratos de edad, talla, peso, índice de masa corporal y superficie corporal. La superficie corporal presentó una importante correlación positiva con los valores de TAPSE (r = 0,81), mientras que la frecuencia mantuvo una correlación negativa (r = −0,74). El análisis multivariable confirmó estas correlaciones, así como las interacciones entre variables (edad, talla, peso, superficie corporal). Aportamos gráficas con las estimaciones poblacionales normales para TAPSE ajustadas por edad y superficie corporal.
Conclusiones: Presentamos valores de referencia de TAPSE para población pediátrica española. La medida del TAPSE fue reproducible y se relacionó directamente con la edad y la superficie corporal. Estos valores de referencia podrían guiar la toma clínica de decisiones.
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INTRODUCTION

The complex geometry of the right ventricle (RV) makes systolic function evaluation difficult. The thick trabeculae in the endocardial surface and muscular elongated outflow tract—located in a different plane to that of the inflow tract—prevent us from adopting the theoretical volumetric models that can be applied in the left ventricle.[1–5] Moreover, RV geometry is even more complex in congenital heart disease, where it may lead to RV interventions.[6] The RV functional situation can condition therapeutic management and clinical course in certain congenital abnormalities.[7] Hence, in daily clinical practice, we need a means to reliably, reproducibly measure RV systolic function.[8,9]

In M-mode echocardiography, tricuspid annular plane systolic excursion (TAPSE) measures the variation during the cardiac cycle in the situation of the lateral portion of the annulus of the tricuspid valve, from the apical 4-chamber view. TAPSE is an echocardiographic parameter that estimates RV systolic function adequately and correlates well with reference techniques like cardiac magnetic resonance imaging.[10] Recommendations for echocardiographic evaluation of RV and TAPSE values in the adult population can be found in the literature.[11,12] Isolated, pioneering studies that establish reference values in children and adolescents have also been published.[13] In Spain, however, adequate TAPSE reference values are not available.

The principle objective of the present study was to establish baseline TAPSE values in a sample of Spanish children and adolescents and determine the influence of anthropometric variables on those values.

METHODS

Population

From 1 January 2008 to 30 June 2010, we prospectively enrolled 405 children and adolescents (from newborn to age 18 years) of both sexes who had been referred to the pediatric cardiology service of our tertiary hospital for cardiac murmur studies. We did not include patients with other symptoms (dyspnea or its equivalent in infancy, chest pain, palpitations, etc.), patients diagnosed with any syndrome (eg, trisomy 21, monosomy 45), or patients with any other noncardiovascular diagnosis. We also excluded patients with a final diagnosis of structural heart disease or cardiac arrhythmia during the clinical consultation. At the time of patient assessment, we discounted the presence of noncardiovascular disease on the basis of the medical record.

Echocardiography

We performed a complete transthoracic echocardiography study (Philips iE-33; Philips Medical Systems, The Netherlands) with 5-1 and 8-3 Mhz probes. We followed a standard protocol —without angle correction or recording respiratory cycles— that included segment analysis of extra- and intracardiac relationships, excluded intracardiac defects and defects of the great arteries, and evaluated left ventricular function. We did not consider that patent foramen ovale of <2 mm constituted a structural heart disease. We recorded heart rate (HR), weight, and height at the time of the echocardiographic study. A trained operator (>5 years experience) reviewed and reported on the echocardiograms and included in the study those patients considered normal according to the protocol. We measured TAPSE in 2-dimensional M-mode echocardiograms from the 4-chamber view, positioning the cursor on the lateral tricuspid annulus near the free RV wall and aligning it as close as possible to the apex of the heart (Fig. 1).

Statistical Analysis

Statistical analysis was with SPSS 15.0 (SPSS; Illinois, United States) and R 2.11.0 (R Development Core Team)[14] for raw data analysis. We considered TAPSE values had a normal distribution (demonstrated with a Q-Q plot graph, not shown). Values are expressed as mean ± standard deviation (SD).. We present tables with percentiles and sample deviations. We include Z-score values. The Z-score of a variable is the position, expressed in terms of ± SD, of the case observed with respect to the population mean. We analyzed differences between groups using Student t test or ANOVA—according to the number of variables studied—for quantitative variables, or chi-squared for qualitative variables. To compare the relationship between continuous variables and anthropometric characteristics of the sample, we used different regression models (curvilinear estimates including linear, logarithmic, inverse, squared, cubed, s, compound, potential and exponential). Finally, we used the closest univariate model to obtain correlation coefficients. We defined the curves describing sample trajectories by polynomial local regression (loess). To do so, we used the loess function[15] of the basic R statistics installation.

We estimated mean TAPSE trajectories as a function of population age and body surface (BS) from sample data, using linear models including covariables defined from splines. We determined covariable matrices that defined splines by means of 3 squared functions obtained from B-spline-type base functions. We calculated spline curve significance using likelihood-ratio test and compared the complete model with reduced embedded models that included a simple linear regression. We calculated the design matrices used in the regression models that incorporated the covariables for age and BS transformed by B-splines[16] with the splineDesign function of the R splines package.
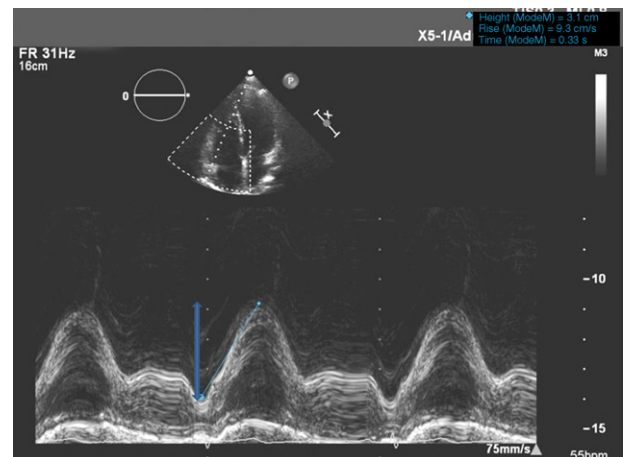

Figure 1. Standard technique for measuring tricuspid annular plane systolic excursion using one-dimensional mode echocardiography.