Effects of Respiration on Right Ventricular Size and Function: An Echocardiographic Study

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SUMMARY. The effects of quiet respiration and body position on right ventricular (RV) size and function were assessed by two-dimensional (2DE) and M-mode echocardiography in 15 healthy children. All end-diastolic echocardiographic dimensions, areas, and volumes increased slightly but significantly with inspiration. At end-systole similar changes were found. RV ejection fractions were significantly higher during inspiration, as were stroke volume indices. RV dimensions also increased from supine to left lateral decubitus position. Thus, our results indicate a need for standardization of 2DE and M-mode measurements not only for body position, but also for respiratory phase when used to assess RV size and function.

KEY WORDS: Right ventricle — Echocardiography — Respiration — Body position

The clinical importance of right ventricular (RV) function has become increasingly evident through recent years. Thus, there is a need for noninvasive assessment of RV size and function. The complex geometry and pumping activity of the RV and the position near the chest wall has, however, made echocardiographic measurement difficult. RV volume estimation by two-dimensional echocardiography (2DE) is possible, but variations with transducer positions, incomplete visualization of endocardium, and various geometrical assumptions may cause problems [2, 4, 6, 7, 9, 11, 22, 23]. Respiration affects echocardiographic assessment of left ventricular size and function [1]. Changes in RV M-mode dimensions by respiration and body position have been reported [3, 10], but the influence on dimensions, volumes, and function assessed by 2DE have not been extensively measured. The purpose of this study is to assess (1) the echocardiographic effects of respiration on RV dimensions, areas, and derived function, (2) the effects of body position on RV dimensions, and (3) the intraobserver reproducibility of RV size and function when respiratory phases are taken into account.

Materials and Methods

Subjects

Fifteen healthy children (8 boys) aged 6–16 years (11.4 ± 2.3 [mean ± 1SD]) participated. Their body surface areas ranged from 0.8–2.0 m² (1.3 ± 0.3). They were healthy as judged by history, clinical examination, and echocardiography and were taking no medications.

Echocardiography

2DE and M-mode echocardiograms were obtained by a VingMed model CFM 700 or CFM 750 imaging system with a 3.75- or 5.0-MHz transducer. An electrocardiogram (ECG) and a respiratory tracing by a nasal thermal element were recorded simultaneously with the echocardiogram. Standard long- and short-axis parasternal views [8] and a modified apical four-chamber view were used [20]. A position slightly medial to the apical impulse with the transducer directed toward the right shoulder was used to obtain the maximal RV size and to record both atrioventricular valves simultaneously. 2DE and M-mode dimensions from the parasternal long-axis view were obtained with the subjects both in a supine and a left lateral decubitus position. All variables from short-axis and apical four-chamber view were obtained from the left lateral decubitus position only.

Measurements and Calculations

Echocardiographic RV dimensions and areas are illustrated in Fig. 1. 2DE and M-mode dimensions were measured in end-
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Fig. 1. Right ventricular (RV) echocardiographic variables. (A) Apical four-chamber view. L, RV length; W, RV width. (B) D1, Parasternal long-axis dimension. (C) D2, Parasternal short-axis dimension. (D) RESP, Respiratory tracing with positive expiratory deflection. Thin arrows: End of inspiration (left) and end of expiration (right). Thick arrows: M-mode dimensions at end-inspiration (D3), at end-expiration (D4).

diastole only by the trailing to the leading edge method [3, 18]. The RV cavity was outlined by tracing the endocardial surface from apical four-chamber view at end-diastole and end-systole, and minor drop outs were filled in. A straight line was traced through the border of the tricuspid valve. End-diastole was defined as the beginning of the QRS complex, and end-systole as the end of the T wave or smallest area. The heart beats selected for analysis were the last beats during expiration and inspiration before the onset of the next respiratory phase. All the measurements are the average of three cardiac cycles at end-inspiration and three at end-expiration. The echocardiographic data were indexed for body surface area when comparing variables at end-expiration and end-inspiration. The RV ejection fraction (RVEF) was calculated as (EDV - ESV)/EDV x 100%, where EDV is end-diastolic volume and ESV is end-systolic volume. Simpson’s single plane method was employed for volume calculations [9].

Statistical Analysis

All data are expressed as mean ± 1SD. Intraobserver variability was assessed by evaluating randomly selected echocardiograms from 10 healthy children 8 weeks apart. The variability was expressed as coefficient of variation [17]. The difference between variables at end-expiration and end-inspiration was evaluated by a paired Wilcoxon’s test (two-tailed). Differences were regarded as significant at p < 0.05.

Results

Influence of Respiration on RV Variables Obtained by Echocardiography

RV echocardiographic variables from healthy children at end-expiration and end-inspiration are shown in Table 1. All RV dimensions increased slightly but significantly with inspiration, as did RV stroke volume indices and RVEF (Table 1 and Fig. 2). RV end-diastolic area increased with inspiration from 16.1 ± 1.5 to 17.4 ± 1.6 cm²/m² (p < 0.001), while RV end-systolic area increased from 9.7 ± 0.8 to 10.3 ± 1.2 cm²/m² (p < 0.01). RVEDV also increased with inspiration from 39.3 ± 7.0 to 44.7 ± 7.6 ml/m², while RVESV increased from 19.4 ± 3.5 to 21.4 ± 4.9 ml/m² (p < 0.01).

Influence of Body Position

RV M-mode dimensions, which were 1.1 ± 0.3 cm/m² and 1.5 ± 0.3 cm/m² at end-expiration and end-inspiration respectively, in the supine position, increased to 1.4 ± 0.5 cm/m² (p < 0.003), and 1.7 ± 0.5 cm/m² (p < 0.05), respectively, in the left lateral position. Corresponding 2DE dimensions also increased similarly, in the long-axis view (Table 1).

Intraobserver Variability

The coefficients of variation were <6% for all single dimensions and areas at end-expiration and end-inspiration, <7.0% for EDV, ESV, and EF at end-inspiration, while at end-expiration, the coefficients of variation for EDV and EF were 8.4 and 6.5%, respectively. Stroke volumes had coefficients of