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CLINICAL RESEARCH

Comparison of two- and three-dimensional transthoracic echocardiography for measurement of aortic annulus diameter in children

Comparaison de l'échocardiographie 2D et 3D dans la mesure de l'anneau aortique chez l'enfant

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KEYWORDS
Aortic valve;
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Children;
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Summary
Background. — Accurate evaluation of aortic root geometry is necessary in congenital aortic valve lesions in children, to guide surgical or angiographical intervention.
Aim. — To compare aortic annulus diameters measured by two- and three-dimensional transthoracic echocardiography (2D- and 3D-TTE), to determine the feasibility and reproducibility of 3D imaging and assess the dynamic changes during the cardiac cycle.
Methods. — Thirty children without heart disease were prospectively included. Two orthogonal aortic annulus diameters were measured offline using multiplanar reconstruction in diastole and in systole and were compared with the measurement of the aortic annulus diameter by 2D-TTE.
Results. — Mean age was 11 ± 3.6 years. Feasibility of 3D imaging was 100%. The coefficients of intra- and interobserver variability were 3.5% and 6%, respectively. The 2D mean diameter was significantly smaller than the 3D maximum diameter in systole (1.94 vs. 2.01 mm; $p = 0.005$).

Abbreviations: 2D, two-dimensional; 2D-TTE, two-dimensional transthoracic echocardiography; 3D, three-dimensional; 3D-TTE, three-dimensional transthoracic echocardiography; CI, confidence interval; Dmax, maximum diameter; Dmin, minimum diameter; SD, standard deviation.

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2D and 3D measurements were well correlated ($p < 0.0001$). The maximum and minimum diameters in 3D were significantly different both in systole and in diastole ($p < 0.001$) underlining an aortic annulus eccentricity. The mean aortic annulus diameters were not significantly different between systole and diastole, with important individual variability during the cardiac cycle.
Conclusion. — This study demonstrated the feasibility and reproducibility of 3D-TTE for the assessment of the aortic annulus diameter in a normal paediatric population. Because of an underestimation of the maximum diameter by 2D-TTE and the asymmetry of the aortic annulus, 3D measurements could be important before percutaneous aortic valvuloplasty or surgical replacement.

MOTS CLÉS
Valve aortique ;
Échocardiographie 2D ;
Échocardiographie 3D ;
Anneau aortique ;
Pédiatrie

Résumé
Contexte. — L'évaluation de la géométrie de la racine aortique est indispensable avant toute chirurgie ou cathétérisme interventionnel de la valve aortique.
Objectif. — Le but de l'étude a été de comparer le diamètre aortique par échocardiographie transthoracique, de déterminer la faisabilité and la reproductibilité de l'imagerie 3D et d'analyser la variation au cours du cycle cardiaque.
Méthodes. — Trente enfants sans cardiopathie ont été étudiés prospectivement. L'anneau aortique a été mesuré dans deux plans orthogonaux en systole et diastole en utilisant un logiciel multiplan 3D et comparé au diamètre 2D.
Résultats. — L'âge médian était de $11 \pm 3{,}6$ ans. La faisabilité de l'écho 3D était de 100%. Le coefficient de variabilité intra- et interobservateur était de 3,5% et 6%. Le diamètre moyen 2D était inférieur au diamètre 3D en systole (1,94 vs 2,01 mm; $p = 0{,}005$). Les mesures 2D et 3D étaient bien corrélées ($p < 0{,}0001$). Les diamètres maximal et minimal 3D de l'anneau aortique étaient différents de façon significative en systole et en diastole soulignant l'excentricité de l'anneau aortique ($p < 0{,}001$). Le diamètre moyen de l'anneau aortique n'était pas différent entre la systole et la diastole avec une importante variabilité individuelle au cours du cycle cardiaque.
Conclusion. — Cette étude montre la faisabilité et la reproductibilité de l'écho 3D dans la mesure de l'anneau aortique chez l'enfant. Dans la mesure où l'écho 2D sous-estime le diamètre de l'anneau aortique à cause de son asymétrie, l'écho 3D peut être un examen important avant un geste percutanée ou chirurgicale de la valve aortique.

Background

Aortic valvular stenosis is a relatively common congenital heart disease, involving about 6—7% of infants born with congenital heart disease [1]. Invasive treatment, by either surgical or percutaneous procedures, requires an accurate assessment of the aortic root geometry, especially of the aortic annulus diameter, to minimize the risk of complications, such as aortic regurgitation. Previous studies performed in adults with severe aortic stenosis suggested an underestimation of the aortic annulus diameter with two-dimensional (2D) echocardiography compared with tomography [2]. Only a few studies have addressed this subject in a paediatric population [3]. Real-time three-dimensional echocardiography (3D-TTE) is an emergent non-invasive technique, useful in the evaluation of cardiac chamber volumes and mass, and left ventricular wall motion and in the analysis of morphology and function of heart valves [4]. The aim of our study, therefore, was to investigate the value of 3D echocardiography by comparing 2D-TTE and 3D-TTE measurements of the aortic annulus diameter in children without any cardiac condition.

Methods

Population

Echocardiography data were collected prospectively. Only children with normal cardiac anatomy and function assessed by physical examination, electrocardiography and standard 2D echocardiography were included in the study; real-time 3D-TTE images were then acquired. Children with bicuspid aortic valve or any aortic root disease were not selected. Informed verbal consent was obtained from each patient and legal representatives after a full explanation of the procedure had been given. A written consent form was not required according to French law, given that the echocardiography evaluation was part of the regular management of the children and was required by their medical condition. The study protocol was approved by the National Commission for Data Processing and Freedoms (No. 1673449). No additional examination was performed for the sole purpose of the study. Thirty patients were included between December 2011 and April 2012 in the echocardiography laboratory of the