*fetal*HQ
Publication Abstracts

Fetal Heart Size: A Comparison Between the Point-to-Point Trace and Automated Ellipse Methods Between 20 and 40 Weeks' Gestation

OBJECTIVES

To evaluate whether the global area and circumference of the heart varies between two measurement techniques: the point-to-point trace and the electronic ellipse methods.

METHODS

The epicardial border of the 4-chamber view was measured in 200 fetuses between 20 and 40 weeks' gestation, from which the area and circumference using the point-to-point trace and electronic ellipse were measured. Analysis of variance, correlation, and regression analysis using fractional polynomials and 7 independent variables (head circumference, biparietal diameter, abdominal circumference, femur length, estimated fetal weight, mean ultrasound gestational age, and last menstrual period gestational age) were performed.

RESULTS

The correlation between the mean ultrasound gestational age and last menstrual period gestational age was 0.9880 (5% confidence limit, 0.9716; 95% confidence limit, 0.9880), with an R^2 of 0.9762. The R^2 value for the 7 independent variables regressed against the area and circumference using the point-to-point trace and electronic ellipse methods ranged between 0.885 and 0.965. Comparison of Z scores between this study and previous publications demonstrated that there were differences and similarities, depending on whether the area or circumference was measured.

CONCLUSIONS

This study shows high R^2 values when comparing measurements of the area and circumference against 7 independent variables, irrespective of whether the point-to-point trace or the electronic ellipse method was used to obtain the measurements. A calculator to evaluate the area and circumference is provided, using 7 independent variables from which Z scores and percentiles for individual measurements can be compute

Two-Dimensional Speckle Tracking of the Fetal Heart: A Practical Step-by-Step Approach for the Fetal Sonologist

Various approaches to 2-dimensional speckle tracking have been used to evaluate left ventricular function and deformation in the fetus, child, and adult. In 2015, because of differences in imaging devices and analytical programs, the cardiology community published a consensus document proposing standards for pediatric/adult deformation imaging using 2-dimensional speckle tracking. The understanding and application of deformation imaging in the fetus have been limited by a lack of uniform software, terminology, techniques, and display. This article provides a practical, step-by-step approach for deformation analysis of the fetal heart using offline software that is independent of specific ultrasound vendors.

Area of the fetal heart's four-chamber view: a practical screening tool to improve detection of cardiac abnormalities in a low-risk population

OBJECTIVE

The objective of this article is to evaluate whether the area of the four-chamber view of the fetal heart computed from two orthogonal diameters could be used to screen for cardiac malformations.

METHODS

Two hundred control fetuses were examined between 20 and 40 weeks of gestation. The end-diastolic area was computed from the orthogonal basal-apical and transverse diameters obtained from the four-chamber view. Regression analysis of the computed area versus six independent variables was performed between 20 and 40 weeks. Fetuses with major heart defects were identified from a low-risk population of 4352 fetuses undergoing second-trimester or third-trimester screening ultrasound. The end-diastolic area was derived and the Z-score and centile computed. An area greater than the 95th centile was considered to be abnormal.

RESULTS

From the screening population, the incidence of major heart defects was 2.8/1000. Of the 12 fetuses with major heart defects, 50% (6/12) demonstrated an area greater than the 95th centile. Of the fetuses with an enlarged heart, 66% (4/6) had outflow tract abnormalities.

CONCLUSIONS

Measurements of the orthogonal basal-apical and transverse diameters can be used to compute the area of the four-chamber view. Fetuses with major heart defects who have an enlarged heart can be identified using this technique.

Computing the Z Score and Centiles for Cross-sectional Analysis: A Practical Approach

Although Z scores have been reported in the literature, one of the problems for the nonstatistician is understanding the systematic approach used to compute the predicted mean and standard deviation, components of the Z score equation, which may vary as the independent variable changes over time (eg, gestational age). This review focuses on a step-by-step analysis using linear, quadratic, and fractional polynomials to compute the mean and standard deviation as a function of a continuous independent variable. Once the mean and standard deviation are computed, the Z score and centile can be derived and Z score calculators created that enable investigators to implement the results in the laboratory and/or clinical setting.

Abnormal Fetal Findings Associated With a Global Sphericity Index of the 4-Chamber View Below the 5th Centile

OBJECTIVES

The purpose of this study was to evaluate the global sphericity index (GSI) of the 4-chamber view and correlate the results with abnormal ultrasound findings.

METHODS

The epicardial end-diastolic basal-apical length (BAL) and transverse length (TL) of the 4-chamber view were measured to compute the GSI (BAL/TL) in 200 control fetuses between 20 and 40 weeks' gestation. Three hundred study fetuses were prospectively examined between 17 and 39 weeks' gestation. The GSI, Z score, and centile were computed for each of the fetuses.

RESULTS

The GSI (1.233; SD, 0.0953) in the control fetuses was independent of gestational age. Eighteen percent of the study fetuses (55 of 300) had a GSI below the 5th centile (<1.08), of whom 96% (53 of 55) had additional abnormal ultrasound findings. Fetuses with an estimated fetal weight below the 10th centile had a significantly ($P < .05$) higher rate of an umbilical artery Doppler pulsatility index above the 95th centile (27% versus 17.7%), a middle cerebral artery Doppler pulsatility index below the 5th centile (27% versus 0%), an abnormal cerebroplacental ratio (27% versus 4.5%), and an amniotic fluid index of less than 5 cm (36% versus 9%). The TL was significantly increased compared with the BAL in fetuses with cardiac dysfunction, irrespective of the estimated fetal weight.

CONCLUSIONS

An abnormal GSI below the 5th centile is associated with abnormal fetal ultrasound findings.

Evaluation of the right and left ventricles: An integrated approach measuring the area, length, and width of the chambers in normal fetuses

INTRODUCTION

The purpose of this study was to simultaneously measure with speckle tracking software the end-diastolic ventricular area (A), basal transverse width (BW), mid-chamber transverse width (MW), and basal-apical length (BAL) in normal fetuses and those with pathology.

METHODS

The 4-chamber view of the fetal heart was obtained in 200 control fetuses between 20 and 40 weeks of gestation and in 9 third-trimester fetuses with heart malformations. The mean and standard deviation for the A, BW, MW, and BAL were computed from the control fetuses and Z scores computed from the 9 fetuses with cardiac malformations.

RESULTS

The A, BAL, BW, and MW were correlated with 7 somatic and age-independent variables (R^2 = .63-.85). The highest R^2 values occurred for the head circumference, estimated fetal weight, and ultrasound mean gestational age (.82-.85). Z-score values and centiles from the 9 fetuses with cardiac malformations suggested that the A, BW, MW, and BAL were below or above the 5th and 95th centiles as expected for the corresponding ventricular pathology.

CONCLUSIONS

This study reports an integrated approach to evaluate the end-diastolic size of the right and left ventricular chambers and demonstrated clinical utility in fetuses with cardiac malformations.

24-segment sphericity index: a new technique to evaluate fetal cardiac diastolic shape

OBJECTIVE

Because of parallel circulation in the fetus and the differential effect that various disease states may have on the shape of the right and left ventricles, this study was conducted to evaluate the sphericity index (SI) of 24 transverse segments distributed from the base to the apex of each of the ventricular chambers.

METHODS

Two hundred control fetuses were examined between 20 and 40 weeks of gestation. The displacement of the ventricular endocardium during the cardiac cycle was computed using offline speckle-tracking software. From the ASCII output of the analysis, we analyzed 24 end-diastolic transverse segments, distributed from the base to the apex of each ventricle, as well as the end-diastolic mid-basal-apical length. The SI was computed for each of the 24 segments by dividing the mid-basal-apical length by the transverse length for each segment. Regression analysis was performed against biometric measurements and gestational age according to last menstrual period and ultrasound. Eight fetuses, in which the four-chamber view appeared subjectively to demonstrate chamber disproportion, were evaluated as examples to demonstrate the utility of this technology.

RESULTS

The SI for each segment was independent of gestational age and fetal biometric measurements. The SI of the right ventricle was significantly (P < 0.001) lower than that of the left ventricle for segments 1-18, suggesting that the right ventricle was more globular in shape than was the left ventricle at the base, mid and a portion of the apical segments of the chamber. Fetuses with various cardiac structural abnormalities and abnormal fetal growth had abnormal SI values that reflected either a more globular or a more flattened ventricular chamber.

CONCLUSION

Determination of SI for each of 24 segments of the fetal right and left ventricles provides a comprehensive method to examine the shape of the ventricular chambers.

Longitudinal Annular Systolic Displacement Compared to Global Strain in Normal Fetal Hearts and Those With Cardiac Abnormalities

OBJECTIVES

The purpose of this study was to compare a new technique that measures the midventricular basal-apical longitudinal diastolic and systolic lengths, computes the longitudinal displacement fractional shortening, and compares it to global strain.

METHODS

Two hundred control fetuses were examined between 20 and 40 weeks' gestation, in whom the longitudinal displacement fractional shortening was computed from end-diastolic and end-systolic lengths measured from the apex to the mid portion of the distance between the level of the basal lateral and septal walls using 2-dimnsional speckle tracking. In addition, global strain was computed using speckle tracking. A correlation analysis was used to compare the longitudinal displacement fractional shortening to global strain. The longitudinal displacement fractional shortening of the right ventricle (RV) and left ventricle (LV) was measured in 10 fetuses with heart abnormalities.

RESULTS

The longitudinal displacement fractional shortening for the RV (mean ± SD, 22.94% ± 4.73%) and LV (21.05% ± 4.21%) was independent of gestational age and other biometric growth parameters, as was global strain (RV, -22.7% ± 4.07%); LV, -22.93% ± 3.52%). The RV longitudinal displacement fractional shortening was greater than that of the LV (P < .024). The correlations between the longitudinal displacement fractional shortening and global strain were 0.95 for the RV and 0.97 for the LV. Comparing the longitudinal displacement fractional shortening and global strain in fetuses with abnormal cardiac findings showed concordant findings in 9 of 10 fetuses.

CONCLUSIONS

The RV and LV longitudinal displacement fractional shortening can be computed from 2-dimensional images of the 4-chamber view and correlated with global strain. The longitudinal displacement fractional shortening was significantly greater for the RV than the LV and was abnormal in fetuses with RV and LV cardiac abnormalities.

Twenty-four Segment Transverse Ventricular Fractional Shortening: A New Technique to Evaluate Fetal Cardiac Function

OBJECTIVES

Because of various fetal and maternal disease states, this study was conducted to evaluate the fractional shortening of 24 transverse segments distributed from the base to the apex of the ventricular chambers.

METHODS

Two hundred control fetuses were examined between 20 and 40 weeks' gestation. The transverse displacement of the ventricular endocardium during the cardiac cycle was computed by using offline software. From the output of the analysis, 24 end-diastolic and end-systolic segments were measured from the base (segment 1) to the apex (segment 24) of the right and left ventricles, and the fractional shortening was computed: [(end-diastolic length - end-systolic length)/end-diastolic length] × 100. Examples of fetal cardiovascular abnormalities were selected to demonstrate the utility of this technique.

RESULTS

The fractional shortening for each segment was independent of gestational age and fetal biometric measurements. There was no significant difference in fractional shortening for segments 1 to 5 between the right and left ventricles. However, the fractional shortening of the left ventricle was significantly greater ($P < .0001$) than that of the right ventricle for segments 6 to 24, suggesting that the mid and apical segments of the left ventricle have increased displacement toward the center of the chamber compared to the right ventricle. Fetuses with various cardiac structural abnormalities had abnormal fractional shortening values.

CONCLUSIONS

The fractional shortening of 24 segments of the right and left ventricles provides a comprehensive method to examine the contractility of the ventricular chambers.

Right and left ventricular 24-segment sphericity index is abnormal in small-for-gestational-age fetuses

OBJECTIVE

Fetuses with growth restriction have been reported to have an abnormal sphericity index (SI), which is indicative of the shape of the ventricular chambers of the heart. Our aim was to evaluate the SI for 24 transverse segments distributed from base to apex of the right (RV) and left (LV) ventricles to determine whether, in small-for-gestational-age (SGA) fetuses, the SI is abnormal at locations other than the basal segment.

METHODS

We evaluated 30 SGA fetuses between 25 and 37 weeks of gestation. SI was computed for both ventricles by dividing the end-diastolic mid-basal-apical length by each of 24 end-diastolic transverse segmental widths, from base (Segment 1) to apex (Segment 24). For each ventricle, the Z-score and centile for the SI from each of the 24 segments were computed using the mean and SD from published equations. The 24-segment method, defining abnormal SI as values < 10th centile or > 90th centile, was compared with that of using only the basal segment by chi-square analysis to determine the number of fetuses identified with an abnormal SI.

RESULTS

In 23 of the 30 (77%) SGA fetuses, at least one of the 24 transverse segments in one or both ventricles had an abnormal SI; in 17% of cases, both ventricles were affected, in 23% of cases only the RV was involved and in 37% of cases only the LV was involved. Compared with the 24-segment model, significantly fewer fetuses with an abnormal SI were identified using only basal Segment 1, from the RV base (58%, 7/12; P < 0.01) or only Segment 12, in the mid portion of the RV (50%, 6/12; P < 0.005). Combining measurements of Segment 1 and Segment 12 from the RV identified 83% of fetuses with at least one abnormal SI and was not significantly different from using the 24-segment model. Similarly, significantly fewer fetuses with an abnormal SI were identified using only LV basal Segment 1 (63%, 10/16; P < 0.006) or only Segment 12, in the mid portion of the LV (75%, 12/16; P < 0.03), when compared with the 24-segment model. Combining measurements of both LV Segment 1 and Segment 12 identified 81% (13/16) of fetuses with an abnormal SI and was not significantly different from using the 24-segment model.

CONCLUSION

The 24-segment SI of RV and LV provides a comprehensive method with which to examine the shape of the ventricular chambers and identifies more SGA fetuses with an abnormal SI than are identified using only the basal segment SI.

Quantitative Evaluation of the Fetal Right and Left Ventricular Fractional Area Change Using Speckle Tracking Technology

OBJECTIVES

The purpose of this study was to measure the fractional area change (FAC) of the right and left ventricles in normal fetal hearts between 20 and 40 weeks of gestation using speckle-tracking software.

METHODS

The 4-chamber view of the fetal heart was obtained in 200 control fetuses between 20 and 40 weeks of gestation. The FAC was computed from the ventricular areas [((end-diastolic area) - (end-systolic area)/(end-diastolic area)) x 100] for the right and left ventricles and regressed against 7 independent biometric and age variables. The FAC was correlated with longitudinal fractional shortening (LFS) [((end-diastolic longitudinal length) - (end-systolic longitudinal length) /(end-diastolic longitudinal length)) x 100] obtained from the mid ventricular basal-apical lengths of the right and left ventricular chambers and the transverse fractional shortening (TFS) [((end-diastolic transverse length) - (end-systolic transverse length)/(end-diastolic transverse length)) x 100] from three transverse positions (base, mid, apical) located within each ventricular chamber. To evaluate potential clinical utility, the FAC, LFS, and TFS results were examined in 9 fetuses with congenital heart defects (CHD).

RESULTS

Regression analysis demonstrated significant associations between the FAC and the biometric and age independent variables (R^2 = 0.13 - 0.15). The FAC was significantly correlated with the LFS (R^2 =0.18 to 0.28) and TFS (R^2 = 0.13 to 0.33). The 9 fetuses with CHD illustrated the interrelationship between the FAC, LFS, and TFS when identifying abnormal ventricular function.

CONCLUSIONS

This study reports results from measuring the FAC of the right and left ventricles, and demonstrates a correlation with longitudinal fractional shortening (LFS) and transverse fractional shortening (TFS).

Speckle Tracking of the Basal Lateral and Septal Wall Annular Plane Systolic Excursion of the Right and Left Ventricles of the Fetal Heart

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OBJECTIVE

Annular plane systolic excursion (APSE) has been evaluated for the right (RV) and left (LV) ventricles using M-mode echocardiography. This study examined APSE using 2-dimensional speckle tracking (2DST) of the lateral and septal annuli of the RV and LV in normal fetuses.

METHODS

Two hundred normal fetuses were prospectively examined between 20 and 40 weeks' gestation, in which the end-diastolic and end-systolic lengths were measured from the apex to the insertion of the annuli into the lateral and septal walls of the RV and LV using 2DST. Subtracting the end-systolic from the end-diastolic length resulted in the APSE measurement. The APSE values from the ventricular and septal locations were regressed against biometric and gestational age independent variables, and the mean and standard deviation computed using fractional polynomial analysis. Within-subject repeated measures of variance were used to compare results within and between the right ventricular and left ventricular basal APSE values.

RESULTS

When regressed against the independent variables the R^2 for the APSE of the right ventricular lateral wall ranged from 0.39 to 0.40, the left ventricular lateral wall 0.29 to 0.31, the right ventricular septal wall 0.22 to 0.40, and the left ventricular septal wall 0.05 to 0.07. There was a significant difference ($P < .001$) for APSE between the right ventricular and left ventricular lateral wall and their respective septal annuli, the left ventricular and right ventricular lateral wall annuli, and the left ventricular and right ventricular septal annuli.

CONCLUSIONS

The right ventricular and left ventricular lateral and septal wall APSE can be computed using 2DST and are associated with changing fetal biometric and age measurements.

Evaluation of Fetal Left Ventricular Size and Function Using Speckle-Tracking and the Simpson Rule

OBJECTIVES

This study was conducted to evaluate left ventricular (LV) size and function in healthy fetuses and to test a cohort of fetuses at risk for abnormal function using speckle-tracking software.

METHODS

Two hundred control fetuses were examined between 20 and 40 weeks' gestation. With the use of offline speckle-tracking software, the end-diastolic and end-systolic volumes were measured and the following computed: stroke volume (SV), SV per kilogram, cardiac output (CO), CO per kilogram, and ejection fraction. These were regressed against 7 independent variables related to the size, weight, and age of the fetuses. Five fetuses with risk factors for LV dysfunction were examined to sample the validity of the data from the control group.

RESULTS

The R^2 values for measurements of the end-diastolic volume, SV, and CO correlated with the 7 independent variables of fetal size and age (0.7-0.78), whereas the SV/kg, CO/kg, and ejection fraction had lower R^2 values (0.02-0.1). The measurements were normally distributed (Shapiro-Wilke > 0.5). The 5 fetuses at risk for abnormal LV function had measurements of LV size and function that were consistent with the expected pathologic condition.

CONCLUSIONS

Speckle tracking can provide a comprehensive evaluation of the size and function of the fetal LV.

Comprehensive Evaluation of Fetal Cardiac Ventricular Widths and Ratios Using a 24-Segment Speckle Tracking Technique

Greggory R. DeVore MD , Bettina Cuneo MD , Berthold Klas BS , Gary Satou MD , Mark Sklansky MD, Comprehensive Evaluation of Fetal Cardiac Ventricular Widths and Ratios Using a 24-Segment Speckle Tracking Technique, First published: 02 October 2018, https://doi.org/10.1002/jum.14792

Introduction

This study was conducted to evaluate the 24-segment transverse widths of the right and left ventricles distributed from the base to the apex of the ventricular chambers and compute the right ventricular (RV)/left ventricular (LV) ratios for each segment.

Methods

Two hundred control fetuses were examined between 20 and 40 weeks' gestation. Using offline speckle-tracking software, the 24 end-diastolic transverse widths were computed and the RV/LV ratios were regressed against 7 independent variables related to the size, weight, and age of the fetuses. Five fetuses with coarctation of the aorta and 5 fetuses with pulmonary stenosis were examined to exemplify the utility of these measurements.

Findings

The 24-segment transverse widths were associated with changes in fetal size, weight, and age. Regression equations were developed to describe these changes with R^2 values between .5 and .82. The measurements were normally distributed (Shapiro-Wilk > 0.5). The RV/LV ratio for the 24 segments did not strongly correlate (R^2 = .001 to −.2) with fetal size, weight, or gestational age. Fetuses with coarctation of the aorta and pulmonary stenosis demonstrated characteristic changes in the 24-segment transverse widths and the RV/LV ratios in the basal (segments 1–8), mid (segments 9–16) and apical (segments 17–24) sections of the ventricles.

Conclusions

The 24-segment transverse widths of the right and left ventricles and the RV/LV ratios provide a comprehensive method to examine the width of the ventricular chambers.