

The Value of Ultrasonography in Detecting the Deflection Angle and Deviation Distance of Conotruncal Septum in Early Diagnosis of Fetal Conotruncal Heart Defects in Xinjiang, China

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Objective: To evaluate the diagnostic value of conal septum deflection angle and deviation distance in the early ultrasonographic detection of fetal conotruncal heart defects (CTDs) in Xinjiang, China.

Methods: Between January 2021 and December 2024, a total of 80 fetuses with CTDs and 80 gestational age-matched healthy controls were enrolled from three tertiary centers. Three-dimensional fetal echocardiography was performed to measure the conal septum deflection angle and maximum deviation distance in the anterior-posterior (AP), left-right (LR), and up-down (UD) orientations. Group comparisons were conducted among tetralogy of Fallot (TOF), double outlet right ventricle (DORV), transposition of the great arteries (D-TGA), and controls using Welch's ANOVA, Kruskal-Wallis tests, and post hoc pairwise analyses.

Results: Both TOF and DORV groups exhibited significantly larger AP and LR deflection angles than controls ($P < 0.001$), whereas D-TGA showed increased AP angle but no significant LR difference ($P \approx 0.30$). UD angles were significantly smaller in all CTD subtypes compared with controls (all $P < 0.001$). Deviation distances followed similar trends, with DORV presenting the largest AP and LR displacement (32.50 ± 3.07 mm and 31.73 ± 3.83 mm, respectively), significantly greater than TOF and D-TGA (all $P < 0.001$). Hedges' g indicated very large effect sizes for AP displacement in DORV ($g = 15.29$) and TOF ($g = 7.90$).

Conclusion: Quantitative assessment of conal septum deflection angle and deviation distance reveals distinct geometric signatures among CTD subtypes, with DORV showing the most pronounced abnormalities. Three-dimensional echocardiographic measurement of these parameters provides a reproducible and sensitive approach for early CTD detection, facilitating accurate prenatal diagnosis and perinatal management planning.

Keywords: fetal echocardiography, conotruncal heart defects, conal septum deflection, prenatal diagnosis, three-dimensional ultrasound

Introduction

Conotruncal Heart Defects (CTDs) represent a group of complex congenital heart anomalies that arise from abnormal development of the embryonic ventricular outflow tract during cardiogenesis. Among the most significant genetic contributors to CTDs is the 22q11.2 deletion syndrome (22q11.2DS), also known as DiGeorge syndrome, a microdeletion syndrome associated with both cardiac and extracardiac manifestations. Epidemiological studies indicate

that approximately 40–50% of patients with 22q11.2DS exhibit CTDs, particularly involving the cardiac outflow tract and aortic arch, which highlights the critical relationship between this genetic syndrome and structural heart defects.¹

The spectrum of CTDs in 22q11.2DS includes several well-characterized phenotypes such as Tetralogy of Fallot (TOF), pulmonary atresia with ventricular septal defect (PA/VSD), persistent truncus arteriosus (PTA), aortic arch anomalies, transposition of the great arteries (D-TGA), and double outlet right ventricle (DORV).² The specificity of these malformations not only facilitates the identification of underlying syndromes like 22q11.2DS, but also aids in recognizing associated extracardiac anomalies, including palatal defects, immunodeficiency, and neurodevelopmental disorders.³

Clinically, CTDs are significant due to their association with adverse outcomes such as pulmonary hypertension, cardiac enlargement, heart failure, arrhythmias, and increased risk of sudden cardiac death.⁴ These sequelae underscore the necessity for early diagnosis and intervention, as timely management can improve long-term survival and quality of life for affected individuals.⁵

In this study, we focused on TOF, D-TGA, and DORV because they are the most prevalent CTD subtypes in our cohort and exhibit distinct, measurable patterns of conal septum malalignment suitable for quantitative analysis. Other CTDs such as PA/VSD and PTA often lack well-defined conal structures, making accurate measurement of deflection angle and offset distance unreliable and reducing comparability across subtypes.

Considering the complex pathogenesis and significant clinical impact of CTDs, this study aims to evaluate the diagnostic utility of the conal septum deflection angle and deviation distance as measurable parameters in the early ultrasonographic detection of CTDs.

Materials and Methods

General Information

From January 2021 to December 2024, a total of 80 fetuses diagnosed prenatally with CTDs by fetal echocardiography were recruited from The First Affiliated Hospital of Shihezi University, The Second Division of Xinjiang Production and Construction Corps Hospital, and The Third Division Hospital of Xinjiang Production and Construction Corps.⁶ A control group of 80 healthy fetuses in the same period was selected, matched by gestational age (± 1 week), maternal age (± 2 years), parity, and region.

For all participants, the study purpose and potential risks of CTDs to fetal cardiac development were explained to the family members, and written informed consent was obtained. Fetuses with uncertain diagnoses underwent repeat echocardiography in the perinatal clinic, and the diagnosis was confirmed by two associate chief physicians independently. All examinations followed standardized protocols across centers.

A multidisciplinary team (MDT) consisting of pediatric cardiologists, neonatologists, obstetricians, geneticists, and ultrasound specialists reviewed each CTDs case to assess fetal growth and development, cardiac structure, circulatory changes, and potential surgical risks. The study protocol was approved by the ethics committees of Scientific and Ethical Committee of the First Affiliated Hospital, Shihezi University.

Inclusion and Exclusion Criteria

Inclusion Criteria

- (1) Completed prenatal echocardiography between 20–28 weeks of gestation.
- (2) Signed informed consent from the family.

Exclusion Criteria

- (1) Associated major extracardiac malformations or arrhythmias (including atrial fibrillation).
- (2) Maternal systemic infectious diseases.
- (3) Incomplete clinical or imaging data.

Methods

Three-dimensional echocardiography was performed in three orientations (inward, leftward, downward) to quantitatively measure the conal septum deflection angle and deviation distance. These values were compared between the CTDs group and controls under each orientation, and imaging characteristics were summarized.

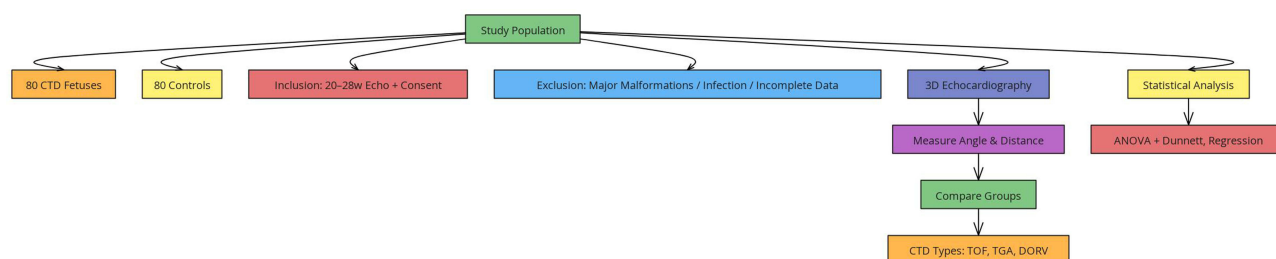


Figure 1 CTD Study Workflow.

Diagnosis followed The Ultrasonographic Diagnostic Medicine of Fetal Congenital Heart Disease guidelines.⁷ Routine screening included fetal growth and development assessment, abdominal transverse section to determine situs and atrial orientation, four-chamber view, left ventricular outflow tract, right ventricular outflow tract, short-axis view of the cardiac base, and three-vessel trachea view.

CTDs diagnosis was based on abnormal conal septum deflection angle and maximum deviation distance. Measurements were taken using GE Voluson E10/E8 (or equivalent) with 3.0–5.0 MHz transducers, with output power ≤ 100 mW/cm².

Evaluation Criteria

Deflection angle and deviation distance were compared among four groups: TOF, D-TGA, DORV and normal controls (Figure 1).

Statistical Analysis

All statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean \pm standard deviation (SD) or median with interquartile range (IQR), depending on normality assessed by the Shapiro–Wilk test. For comparisons among the four study groups (TOF, DORV, D-TGA, and controls), one-way analysis of variance (ANOVA) or Welch’s ANOVA (for heteroscedastic data) was applied, followed by post hoc multiple comparisons using Dunnett’s, Games–Howell, or Tukey’s test, as appropriate. Non-normally distributed variables were analyzed using the Kruskal–Wallis test with Holm-adjusted pairwise comparisons. Effect sizes were calculated using Hedges’ *g* with 95% confidence intervals (CIs). A two-tailed *p*-value < 0.05 was considered statistically significant.

Results

Baseline Maternal Characteristics

Normality testing indicated that maternal age in the CTDs group was normally distributed ($P > 0.05$), whereas that in the control group was not ($P < 0.05$). Gestational age and BMI were normally distributed in both groups ($P > 0.05$). As shown in Table 1, maternal age [28.0 (26.0, 31.0) vs 27.0 (25.0, 30.0)] showed no significant difference between the CTDs and control groups ($Z = 3567.0$, $P = 0.209$). Mean gestational age (34.77 ± 1.63 vs 34.79 ± 1.81 weeks) and BMI (21.62 ± 2.09 vs 21.16 ± 2.15 kg/m²) were also similar ($t = -0.046$, $P = 0.963$; $t = 1.377$, $P = 0.170$, respectively) (Table 1).

Table 1 Comparison of General Maternal Characteristics Between the CTDs and Control Groups

Item	Maternal Age (Years) M(Q1, Q3)	Gestational Age (Weeks) ($\bar{x} \pm s$)	BMI (kg/m ²) ($\bar{x} \pm s$)
CTD group	28.0 (26.0, 31.0)	34.77 ± 1.63	21.62 ± 2.09
Control group	27.0 (25.0, 30.0)	34.79 ± 1.81	21.16 ± 2.15
<i>t</i> / <i>Z</i>	3567.0	-0.046	1.377
<i>P</i> -value	0.209	0.963	0.170

Comparison of Cone Partition Deflection Angles in Different Sections Between the CTDs and Control Groups

Orientation-Specific Conal Septal Deflection Across CTDs Subtypes

Group means (Mean±SD, °) for conal septal deflection were: TOF 34.43±4.65 (anterior–posterior, AP), 37.17±4.51 (left–right, LR), 90.37±8.78 (up–down, UD); DORV 41.68±5.48, 41.16±4.28, 97.24±9.26; D-TGA 26.44±3.00, 27.30±2.80, 94.56±9.99; and controls 22.70±2.09, 26.58±1.90, 125.39±5.24. Assumption checks indicated variance heterogeneity; therefore, Welch's ANOVA was used for AP and UD, and the Kruskal–Wallis's test for LR, revealing significant overall group effects for all orientations (all $P < 0.001$). Compared with controls, TOF and DORV showed greater AP and LR angles and smaller UD angles (Holm-adjusted $P < 0.001$), while D-TGA showed a greater AP angle and a smaller UD angle (both $P < 0.001$) with no difference in LR ($P \approx 0.30$). Within case subtypes, DORV had the largest AP and LR angles versus both TOF and D-TGA (Games–Howell, all $P < 0.01$), and TOF exceeded D-TGA for AP and LR (all $P < 0.01$); for UD, only DORV exceeded TOF (Tukey $P = 0.015$), and other pairwise comparisons among cases were not significant (Tables 2 and 3).

Three-Panel Distribution Plot Summary (AP, LR, UD)

The distribution of conal septal deflection angles across four groups (TOF, DORV, D-TGA, and Control) revealed distinct patterns in all three dimensions (AP, LR, and UD). Both TOF and DORV groups demonstrated elevated AP and LR angles compared to controls, while D-TGA showed smaller angular deviations closer to control levels. In contrast, the control group exhibited significantly higher UD angles, suggesting less conal deviation in the vertical plane. Group-wise annotations of sample size, mean (μ), and median (M) reinforced these trends, with particularly high UD values in controls ($\mu \approx 125^\circ$, $M \approx 125^\circ$) and relatively lower AP values ($\mu \approx 22^\circ$, $M \approx 23^\circ$) (Figure 2).

Hedges' g Forest Plot Summary (AP, UD, LR)

Hedges' g effect size analysis confirmed substantial deviations in conal septal orientation among CTDs groups relative to controls. For the AP dimension, TOF and DORV yielded large positive effect sizes ($g > 3.5$), indicating marked forward

Table 2 Conal Septal Deflection Angles by Group (Mean ± SD, °)

Group	n	AP	LR	UD
TOF	34	34.43±4.65 ^{b*}	37.17±4.51 ^{b*}	90.37±8.78 ^{b*}
DORV	26	41.68±5.48 ^{a*}	41.16±4.28 ^{a*}	97.24±9.26 ^{a*}
D-TGA	20	26.44±3.00 ^{c*}	27.30±2.80 ^c	94.56±9.99 ^{b*}
Control	80	22.70±2.09	26.58±1.90	125.39±5.24

Notes: Superscripts a, b, c: within-case pairwise differences among TOF/DORV/D-TGA (AP/LR by Games–Howell; UD by Tukey); groups sharing a letter do not differ ($P \geq 0.05$). Superscript *: Holm-adjusted $P < 0.05$ vs Control. Global tests: AP (Welch ANOVA) $P < 0.001$; LR (Kruskal–Wallis) $P < 0.001$; UD (Welch ANOVA) $P < 0.001$.

Table 3 Global Tests and Post Hoc Comparisons (Summary)

Outcome	Global Test	Statistic	P
AP	Welch ANOVA	F (Welch)	<0.001
LR	Kruskal–Wallis	H	<0.001
UD	Welch ANOVA	F (Welch)	<0.001

Notes: Post hoc vs Control (Holm-adjusted P): AP—TOF <0.001; DORV <0.001; D-TGA <0.001. LR—TOF <0.001; DORV <0.001; D-TGA 0.30 (ns). UD—TOF <0.001; DORV <0.001; D-TGA <0.001. Within-case (AP/LR: Games–Howell; UD: Tukey): AP—DORV>TOF, DORV>D-TGA, TOF>D-TGA (all $P < 0.01$). LR—DORV>TOF, DORV>D-TGA, TOF>D-TGA (all $P < 0.01$). UD—DORV>TOF ($P = 0.015$); other ns.

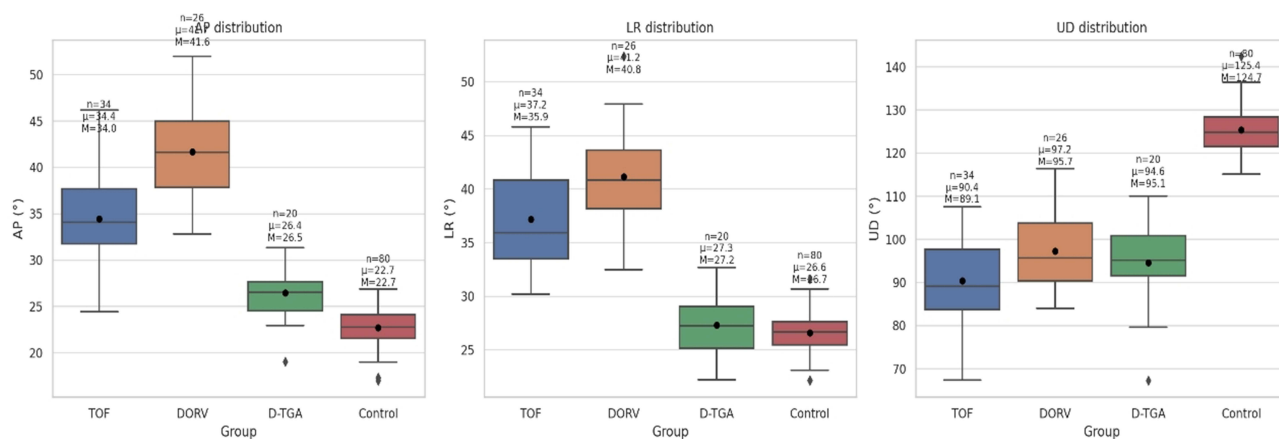


Figure 2 Conal Septal Deflection: Distribution by Group.

displacement, while D-TGA showed moderate separation ($g \approx 1.6$). In the UD axis, all three CTDs groups showed large negative g values (TOF: $g \approx -5.6$), reflecting significantly reduced upward conal deflection compared to controls. LR deviations also revealed large effect sizes, particularly in TOF and DORV groups ($g > 3.5$), supporting the notion of lateralized conal malalignment in these pathologies. All reported effect sizes included 95% confidence intervals (Figure 3).

Comparison of Cone Partition Deflection Distances in Different Sections Between the CTDs and Control Groups

Intergroup Comparisons of Maximum Conal Septal Deviation Distances

Homogeneity testing indicated unequal variances across groups; therefore, Welch's ANOVA was applied for all three orientations. Global effects were significant for AP, LR, and UD (all $P < 0.001$). As shown in Table 1, compared with controls, TOF and DORV fetuses had larger maximum conal septal deviation distances in all three orientations (Holm-adjusted $P < 0.001$), whereas D-TGA showed larger AP and LR distances (both $P < 0.001$) but no difference in UD ($P = 0.975$). Within case subtypes, DORV exhibited the greatest distances in AP and LR compared with TOF and D-TGA (Games–Howell, all $P < 0.001$), and TOF exceeded D-TGA for these two orientations (all $P < 0.001$). For UD, DORV remained greater than TOF ($P = 0.003$) and D-TGA ($P < 0.001$), and TOF was greater than D-TGA ($P = 0.005$) (Tables 4 and 5).

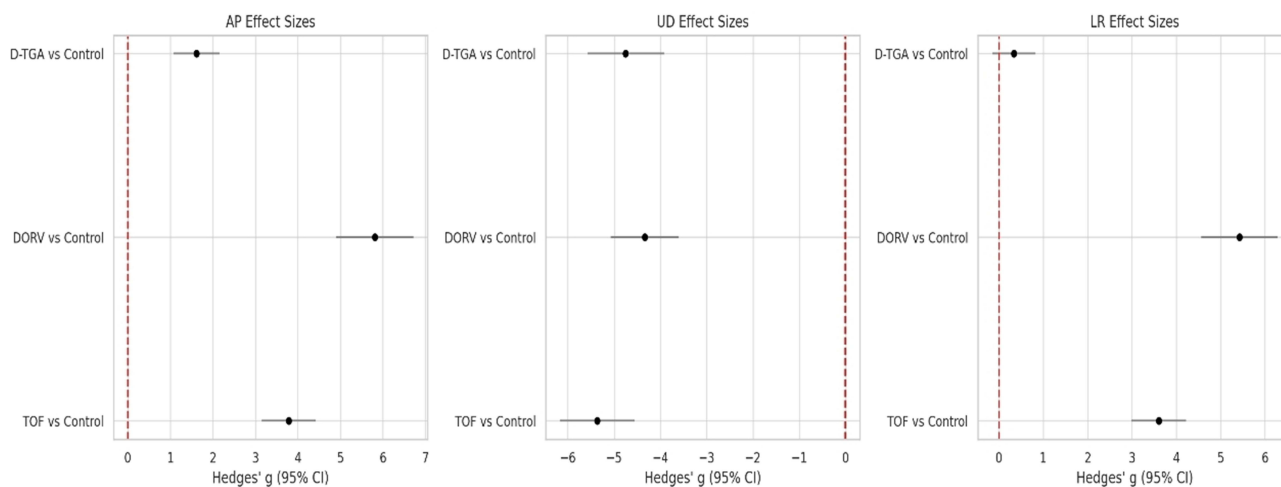


Figure 3 Maximum Cone Partition Deflection Angles of Hedges' g : Effect Sizes (CTDs vs Control).

Table 4 Maximum Conal Septal Deviation Distance by Group (Mean \pm SD, Mm)

Group	n	AP	LR	UD
TOF	44	19.21 \pm 2.06 ^{b*}	19.56 \pm 1.82 ^{b*}	31.49 \pm 4.77 ^{b*}
DORV	18	32.50 \pm 3.07 ^{a*}	31.73 \pm 3.83 ^{a*}	36.45 \pm 5.23 ^{a*}
D-TGA	18	15.05 \pm 1.84 ^{c*}	16.11 \pm 2.18 ^{c*}	26.96 \pm 5.46 ^{c*}
Control	80	7.08 \pm 1.13	8.44 \pm 1.28	27.00 \pm 3.29

Notes: Units: millimeters. Superscripts a, b, c: within-case pairwise comparisons among TOF/DORV/D-TGA (AP/LR by Games–Howell; UD by Tukey); groups sharing a letter do not differ ($P \geq 0.05$). Superscript *: Holm-adjusted $P < 0.05$ vs Control. Global tests for each orientation are summarized in Table 5.

Abbreviations: AP, anterior–posterior; LR, left–right; UD, up–down.

Table 5 Global Tests and Post-Hoc Comparisons (Summary)

Outcome	Global Test (Reason)	Statistics (Welch df)	P value
AP	Welch ANOVA (heteroscedastic)	F=809.32 (3, 39.82)	<0.001
LR	Welch ANOVA (heteroscedastic)	F=612.59 (3, 40.01)	<0.001
UD	Welch ANOVA (heteroscedastic)	F=24.76 (3, 41.43)	<0.001

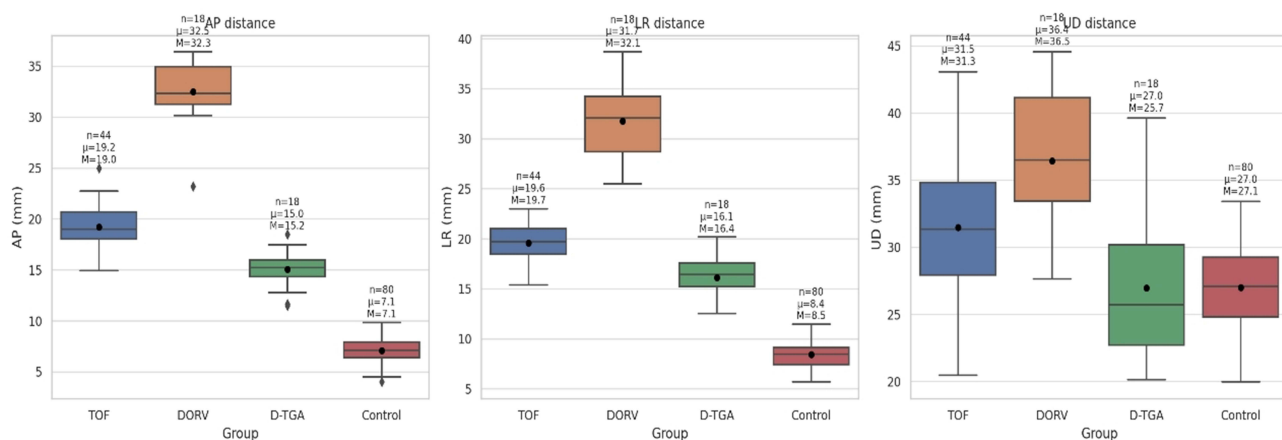
Notes: Post-hoc vs Control (Holm-adjusted P): AP—TOF <0.001; DORV <0.001; D-TGA <0.001. LR—TOF <0.001; DORV <0.001; D-TGA <0.001. UD—TOF <0.001; DORV <0.001; D-TGA = 0.975 (ns). Within-case (AP/LR: Games–Howell; UD: Tukey): AP—DORV>TOF, DORV>D-TGA, TOF>D-TGA (all $P < 0.001$). LR—DORV>TOF, DORV>D-TGA, TOF>D-TGA (all $P < 0.001$). UD—DORV>TOF ($P = 0.003$), DORV>D-TGA ($P < 0.001$), TOF>D-TGA ($P = 0.005$).

Distributions of Conal Septal Displacement Distances

The distributions of conal septal displacement distances in the AP, LR, and UD directions were assessed across CTDs subtypes (TOF, DORV, D-TGA) and controls. All CTDs groups demonstrated markedly increased AP displacement compared to controls, with DORV showing the greatest deviation. Similar patterns were observed in the UD direction, where CTDs groups exhibited greater downward displacement. In contrast, LR displacement showed relatively smaller between-group differences. Each panel includes annotations of sample size (n), mean (μ), and median (M), clearly demonstrating the directional trends in septal deviation associated with CTDs (Figure 4).

Effect Sizes of Displacement Distances: CTDs vs Control (Figure 4)

Hedges' g was used to quantify standardized differences in conal septal displacement distances between CTDs groups and controls. For AP displacement, large effect sizes were observed in DORV ($g = 15.29$, 95% CI: 13.09–17.49) and TOF

**Figure 4** Conal Septal Deviation Distance: Distribution by Group.

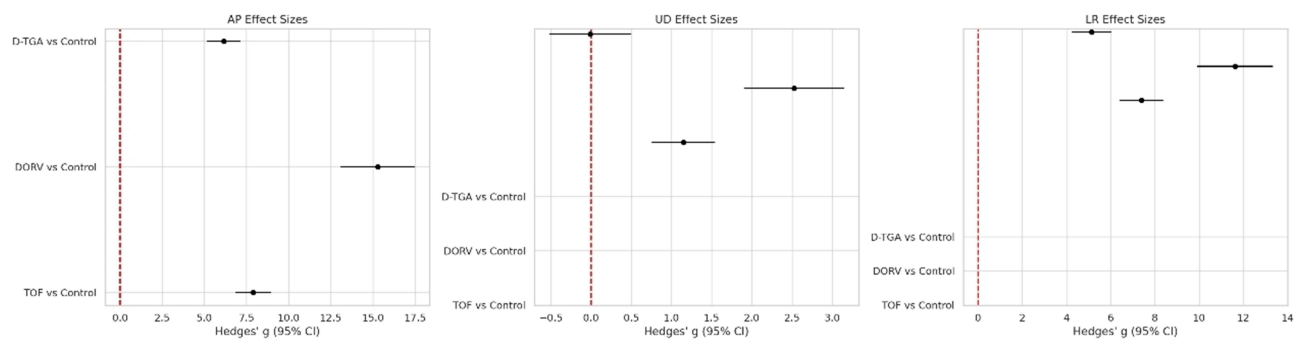


Figure 5 Maximum Conal Septal Deviation Distances of Hedges' g: Effect Sizes (CTDs vs Control).

($g = 7.90$, 95% CI: 6.85–8.95), indicating significant anterior malposition. D-TGA also showed a substantial effect ($g = 6.16$). In the UD direction, DORV ($g = 2.52$, 95% CI: 1.90–3.15) and TOF ($g = 1.15$) displayed moderate to large effects, suggesting inferior conal shift. LR displacement demonstrated smaller or negligible effect sizes, suggesting lateral alignment was relatively preserved in these CTDs (Figure 5).

Discussion

Ultrasound Assessment of Conal Septum Deflection and Deviation

The technical overview of ultrasound detection of conical deflection Angle and offset distance explains the vital role of ultrasound detection in the early diagnosis of fetal heart conic artery trunk malformation.⁸ The principle of this technique is straightforward, and the principle of conduction and reflection of ultrasound is used for image acquisition and analysis. By measuring the deflection angle and deviation distance of the septum conus, we can better determine the malformation of the conus trunk in the fetal heart.⁹

The average heart cone is divided into two large arteries connecting the ventricle; the outflow of the septum is intact, and the cone is flat or slightly deflected.¹⁰ In early embryonic development, when the conical septum is poorly rotated, hypoplastic, or unable to properly connect the muscular septum, resulting in CTDs.¹¹ 22q11 is the most common human chromosomal microdeletion.¹² A low copy of chromosome 22 flanking a segment of about 3 Mb deletion, can lead to DiGeorge syndrome; studies showed that 22q11 microdeletion caused TBX 1 transcription factor loss in the T-BOX gene family because of its specific gene expression in the heart, haploid expression, can cause cardiac CTDs.¹³ A mouse model constructed with DiGeorge syndrome suggests that TBX 1 is a major transcription factor that mainly regulates the phenotype of cardiac development and is associated with the deflection of the conical stem.¹⁴ In CTDs, the conus can undergo significant deflection, and this phenomenon can be assessed at the beginning of the first 18–24 weeks, which helps doctors evaluate the presence of the conic trunk malformation and its severity.^{15,16} In some cases, an abnormal deflection of the septum conus may be the only clinical sign, suggesting the possible presence of such a malformation.¹⁷

Summary of Main Findings

This multicenter study demonstrates that three-dimensional echocardiographic measurement of the conal septum deflection angle and deviation distance provides significant discriminatory power in differentiating CTDs subtypes from normal fetal hearts. Both TOF and DORV displayed pronounced AP and LR angular deviations, while D-TGA exhibited a smaller deviation pattern with preserved LR alignment. DORV consistently showed the largest displacement in both AP and LR planes, underscoring the extent of malalignment in this subtype.

Our quantitative results are consistent with prior literature indicating that CTDs share a common embryological origin in abnormal conotruncal rotation and septation but vary in the degree and direction of conal malalignment. The high effect sizes obtained (eg, AP displacement $g = 15.29$ for DORV) confirm the robustness of these morphometric parameters for diagnostic purposes.

Interpretation in the Context of Existing Research

Previous studies have reported that abnormal conal septum alignment is a hallmark feature of CTDs such as TOF, DORV, and TGA. Our findings refine this knowledge by providing specific numerical thresholds that could be incorporated into diagnostic algorithms. For example:

1. DORV: The largest AP ($41.68 \pm 5.48^\circ$) and LR ($41.16 \pm 4.28^\circ$) deflections in our study correspond with the “double conus” anatomy described by Yagel et al, in which both great arteries originate from the right ventricle, reflecting severe conotruncal malrotation.
2. TOF: Significant AP and LR deviations are consistent with anterior and cephalad displacement of the infundibular septum, leading to aortic override and pulmonary stenosis.
3. D-TGA: Our data show increased AP deflection but no LR deviation, supporting the concept that TGA arises from failure of conotruncal spiraling with preserved lateral positioning.

Notably, the smaller UD angles in all CTDs subtypes compared with controls indicate reduced vertical conal septum alignment, which may reflect hypoplasia or incomplete resorption of the sub arterial conus, as described in fetal morphometric studies.

Diagnostic Value and Clinical Implications

Improved Detection Sensitivity

Routine prenatal detection of CTDs has historically been suboptimal, with detection rates for outflow tract anomalies remaining as low as 50–60% in some series despite updated imaging protocols. The addition of quantitative conal septum measurements could serve as a second-tier screening parameter, particularly in cases where standard four-chamber or outflow tract views are equivocal.

Subtype Differentiation

Differentiating between TOF and DORV prenatally is challenging, particularly when large ventricular septal defects obscure the relationship between the great arteries and ventricles. Our results suggest that combined AP and LR angle thresholds could serve as a reliable discriminator, enhancing the accuracy of prenatal subtype diagnosis and informing surgical planning.

Integration into Screening Protocols

Given the reproducibility of our measurements, these parameters could be incorporated into second-trimester anomaly scans for high-risk populations. This is especially relevant in Xinjiang, where the geographic distribution of specialized cardiac care facilities makes accurate referral triage essential.

Technical Strengths of the Study

Key strengths include:

1. Standardized three-dimensional acquisition minimizing projection artifacts.
2. Objective measurement protocols that enhance reproducibility.
3. Large effect sizes indicating robust between-group differences.

These features collectively support the feasibility of implementing this method in routine prenatal echocardiography.¹⁸

Study Limitations

Despite its strengths, this study has several limitations:

1. Sample size imbalance among subtypes, particularly DORV and D-TGA, may affect inter-subtype comparisons.

2. Operator dependence remains an inherent challenge in echocardiography, although standardized training and blinding can mitigate bias.
3. Cross-sectional design limits insights into longitudinal changes in conal septum orientation during gestation.
4. Exclusion of extracardiac malformations reduces generalizability, as many CTDs co-occur with other anomalies.

Future Research Directions

1. Establishing gestational age-specific reference ranges for conal septum angles and distances in healthy fetuses.
2. Correlating prenatal measurements with postnatal surgical complexity and long-term outcomes.
3. Integrating morphometric data into machine learning algorithms for automated detection.
4. Evaluating combined utility with fetal MRI for complex or borderline cases.

Conclusion

Quantitative three-dimensional echocardiographic assessment of conal septum deflection angle and deviation distance provides a sensitive, reproducible, and clinically meaningful tool for the early detection and differentiation of CTDs subtypes. Adoption of this technique into prenatal screening protocols could improve diagnostic accuracy, facilitate timely referral, and ultimately enhance outcomes for affected neonates, particularly in geographically dispersed regions such as Xinjiang.

Abbreviations

CTDs, Conotruncal Heart Defects; TOF, Tetralogy of Fallot; DORV, Double Outlet Right Ventricle; TGA, The great arteries; AP, Anterior-Posterior; LR, left-right; UD, up-down.

Data Sharing Statement

The data supporting the findings of this investigation are available upon reasonable request from the corresponding author.

Ethics Approval and Consent to Participate

This study was submitted to and approved by the Science and Technology Ethics Committee of the First Affiliated Hospital of Shihezi University (Approval No. KJ2021-077-01).

Written informed consent for publication was obtained from all participants.

This study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for Publication

Written informed consent for publication was obtained from all participants.

Author Contributions

All authors report no relationships that could be construed as a conflict of interest. All authors take responsibility for all aspects of reliability and freedom from bias of the data presented and their discussed interpretation.

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing interests.

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