

RANGE AND VARIATION OF FETAL LEFT VENTRICULAR OUTFLOW TRACT ANGLE IN NORMAL PREGNANCY

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ABSTRACT

The purpose of studying the fetal Left Ventricular Outflow Tract angle in normal pregnancy is to establish a baseline measurement for prenatal evaluations. Identifying deviations from the normal Left Ventricular Outflow Tract range can help detect congenital heart defects, particularly conotruncal anomalies, aiding in early diagnosis and improved clinical management. This research aims to enhance the accuracy of fetal heart assessment using ultrasonography. The Left Ventricular Outflow Tract angle is measured as the angle between the longitudinal axis of the left ventricle and the outflow tract (the aorta as it exits the heart). Its measurement requires precise imaging and proper alignment of the ultrasound probe. The study included 394 pregnant females, with mean age of 27.3 years and mean gestational age was 26.8 weeks. The Left Ventricular Outflow Tract angle ranged from 129 to 163 degrees (mean = 145.5 degrees, SD = 6.24). The cardiac axis ranged from 31 to 53 degrees (mean = 43.3 degrees, SD = 3.50). One-way ANOVA showed no significant difference in mean LVOT angle across gestational age groups ($F = 0.713$, $p = 0.639$). One-way ANOVA demonstrated no significant difference in mean LVOT angle across cardiac axis categories ($p = 0.435$). Left Ventricular Outflow Tract angle did not significantly correlate with gestational age and cardiac axis indicating that these factors do not significantly affect the Left Ventricular Outflow Tract angle in normal pregnancies.

KEYWORDS

Congenital heart defects, fetal ultrasonography, left ventricular outflow tract, normal pregnancy,

Received on: October 8, 2025

Accepted for publication: February 15, 2026

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DOI: <https://doi.org/10.3126/nmcj.v28i1.92048>

Cite this paper as: Acharya R, Shrestha A, Poudel S, Adhikari P, Banskota S. Range and variation of fetal left ventricular outflow tract angle in normal pregnancy. *Nepal Med Coll J* 2026; 28: 42-7.

INTRODUCTION

The embryonic development of the heart is a meticulously coordinated process that starts early in human growth. Cardiac formation begins during gastrulation. During this stage, precardiac mesodermal cells are generated and migrate, leading to the formation of two endocardial tubes.¹ At the start of the fourth week of embryonic development, cardiac looping occurs with the formation of the primary atrial septum.^{2,3} This folding process is crucial in shaping the heart into its more complex form, including the development of the Left Ventricular Outflow Tract (LVOT).² The LVOT forms in close association with the processes of heart looping and septation, where the heart undergoes significant morphological changes.³ A key component in this process is the LVOT, which is essential for directing blood from the left ventricle to the aorta. Proper development and alignment of the LVOT are vital for effective cardiac function, and deviations in this process can result in congenital heart defects, a leading cause of morbidity and mortality in neonates.²⁻⁴

The outflow tract (OFT) is a myocardial tube extending from the developing ventricles to the aortic sac, which is situated within the pharyngeal arches.⁵ Septation of the OFT begins at the distal end during the sixth week of development and progresses in a proximal direction, completing after one week.⁶ The OFT cushions are arranged in a spiral pattern, reflecting the pathways of the aortic and pulmonary streams in adulthood.⁷ The septum ensures that the aortic blood stream enters the left fourth pharyngeal arch artery and the pulmonary stream enters the left and right sixth pharyngeal arch arteries.^{8,9} Failure of complete OFT cushion fusion causes persistent truncus arteriosus, while a defect limited to the proximal cushions results in a subarterial (outlet) VSD. Parallel rather than spiral development of the OFT cushions leads to transposition of the great arteries.^{10,11,13} Anatomically, the left ventricular outflow tract is considered the region of the left ventricle between the anterior cusp of the mitral valve and the ventricular septum, which is continuous with the ascending aorta.¹² Ultrasonographically, the left ventricular outflow tract angle is defined as the angle between the interventricular septum and the ascending aorta.¹³ The LVOT angle is a crucial parameter for understanding both normal and abnormal heart development. Variations in the LVOT angle can indicate congenital heart defects, which are among the most common congenital anomalies. Despite its importance, the mechanisms and factors influencing LVOT

angle development remain an area of active research.

MATERIALS AND METHODS

All normal pregnancies between 18 and 42 weeks of gestation referred to the ultrasonography unit of the Department of Radiology, Nepal Medical College, from October 2024 to September 2025 were enrolled in the study after obtaining approval from the Nepal Medical College Institutional Review Committee (Ref.: 19-082/083).

All scans were performed on a Fujifilm Arietta 50 ultrasonography system using a curvilinear transducer (3.5–5 MHz). After confirmation of a normal pregnancy, gestational age was stratified to account for developmental changes in fetal cardiac orientation and to establish gestation-specific normative ranges of the left ventricular outflow tract (LVOT) angle. Pregnancies were categorized into seven predefined gestational age groups (15–18 weeks, 19–22 weeks, 23–26 weeks, 27–30 weeks, 31–34 weeks, 35–38 weeks, and 39–42 weeks), following which LVOT angle measurements were obtained.

Inclusion criteria: All normal pregnancies confirmed on routine ultrasound with appropriate gestational growth parameters.

Exclusion criteria: Fetuses with any congenital anomalies (cardiac or non-cardiac), multiple gestations, and pregnancies with maternal complications such as diabetes, hypertension, or intrauterine growth restriction.

The angle is defined as the angle between the longitudinal axis of the left ventricle and the ascending aorta as it exits the heart. The measurements were taken in the standard LVOT view obtained in the apical or subcostal four-chamber approach. To minimize bias, all measurements were taken by a single radiologist thereby eliminating interobserver variation. For each case, three consecutive measurements of the LVOT angle were taken, and the mean value was recorded to improve accuracy. All statistical analyses were performed using SPSS 17.

RESULTS

A total of 394 pregnant women were enrolled in the study. The age ranged from 18 to 49 years, with a mean age of 27.31 years (SD = 4.80 & variance = 23.06). The mean gestational age at the time of ultrasonography was 26.79 weeks (SD = 7.1 & variance = 51.15).

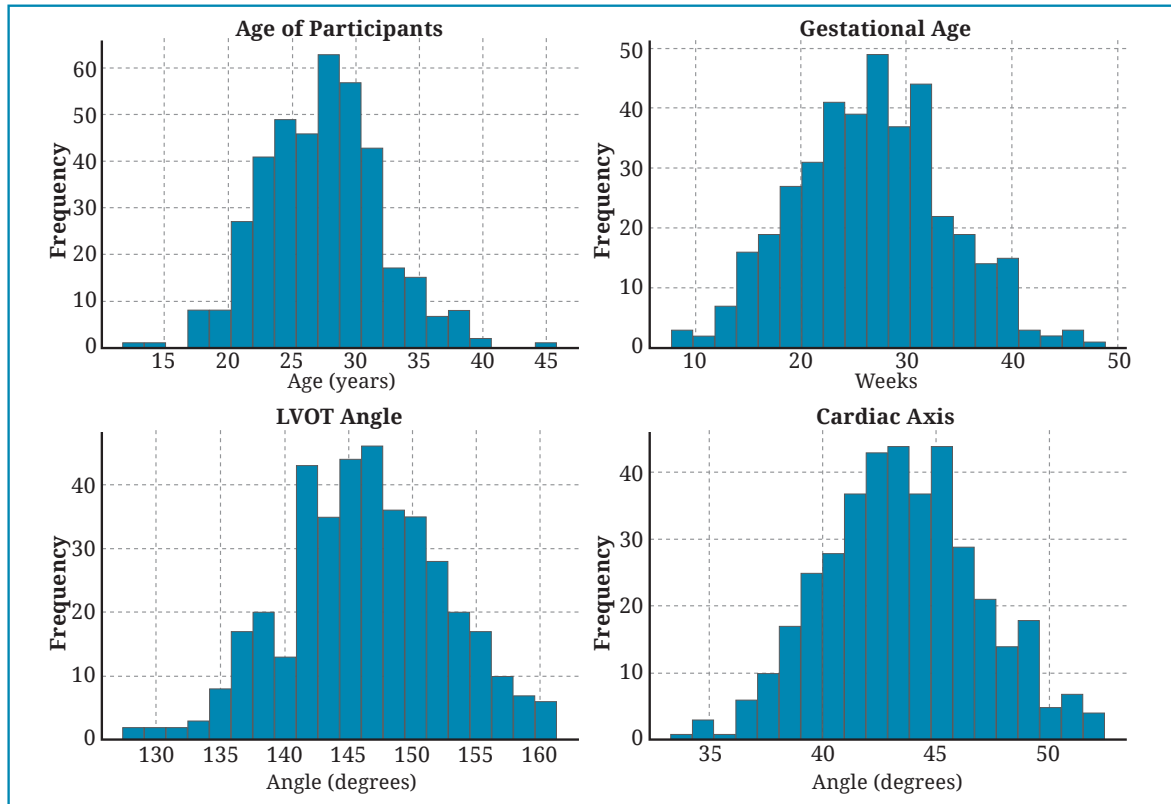


Fig. 1: Histograms demonstrating the distribution of maternal age, gestational age at examination, fetal left ventricular outflow tract (LVOT) angle, and fetal cardiac axis in the study population. All parameters show approximately normal distributions.

The Left Ventricular Outflow Tract (LVOT) angle demonstrated a range from 129° to 163° (range: 34°), with a mean of 145.50° (SE = 0.314, SD = 6.24, variance = 38.95). The cardiac axis ranged from 31° to 53°, with a mean of 43.34° (SE = 0.18, SD = 3.50, variance = 12.23). Both LVOT angle and cardiac axis showed values clustered closely around their respective means, indicating relatively low variability within the study population.

Correlation between LVOT angle and Gestational age: Gestational age was categorized into seven

predefined groups ranging from 15 to 42 weeks of gestation. One-way ANOVA were performed to assess the distribution of LVOT angle with each gestational group which showed no significant difference, $F = 0.713$, $p = 0.639$.

One-way ANOVA was performed to assess differences in LVOT angle across seven different gestational age groups (15–18 to 39–42 weeks). The mean LVOT angle varied modestly across gestational age groups, ranging from 145.01° to 147.06° (Fig. 2).

Table 1: Gestational age-wise distribution of fetal LVOT angle

Gestational Age Groups	Sample size (n)	Mean LVOT (Degrees)	SD	Min (Degrees)	Max (Degrees)	F value	P value
15–18 weeks	48	147.1	7.2	132	159	0.713	0.639
19–22 weeks	109	145.0	6.0	130	160		
23–26 weeks	27	145.0	6.7	135	160		
27–30 weeks	65	145.6	6.4	129	163		
31–34 weeks	78	145.5	6.1	131	162		
35–38 weeks	59	145.1	5.6	133	158		
39–42 weeks	8	146.4	7.8	131	158		

Values are expressed as mean ± standard deviation (SD) in degrees. N denotes the number in each gestational age group. The overall mean LVOT angle for the study population was 145.6 ± 6.4° (n = 394).

The analysis yielded an F-statistic of 0.713 and a p-value of 0.639, indicating no statistically significant difference in LVOT angle between groups. The low F-value suggests minimal between-group variability relative to within-group variability. Thus, the null hypothesis is retained, confirming that gestational age does not significantly influence LVOT angle (Fig. 3).

Correlation between LVOT angle and Cardiac axis: The cardiac axis of sample was categorized into five groups with cardiac axis range as follows:

Table 2: Distribution of cardiac axis range and frequency among different categories (n=394)

Cardiac Axis Categories	Cardiac axis Range (Degrees)	n	%
1	31-35	5	1.3
2	36-40	78	19.8
3	41-45	198	50.3
4	46-50	111	28.2
5	51-55	2	0.5

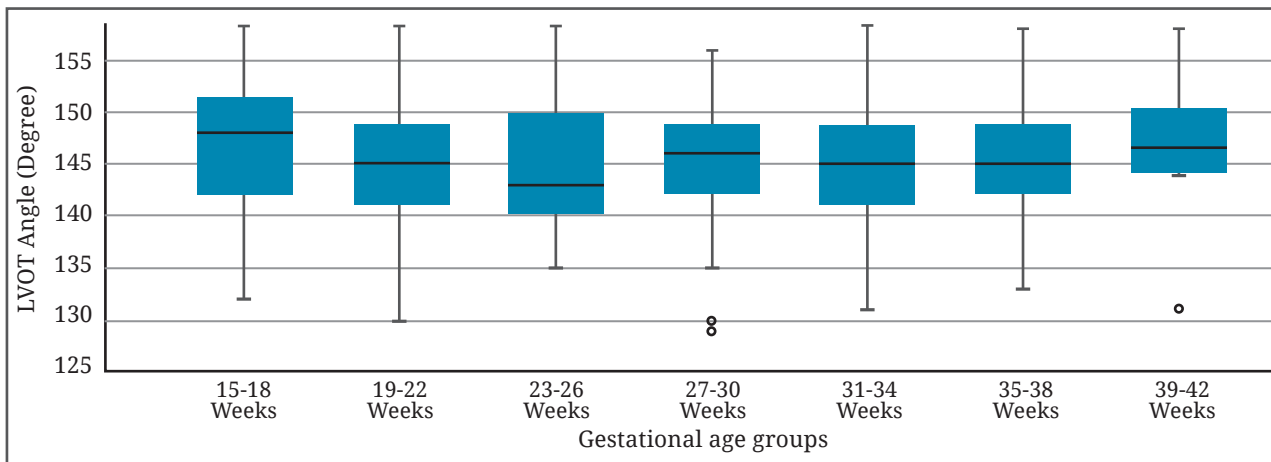


Fig. 2: Distribution of LVOT angle across gestational age groups

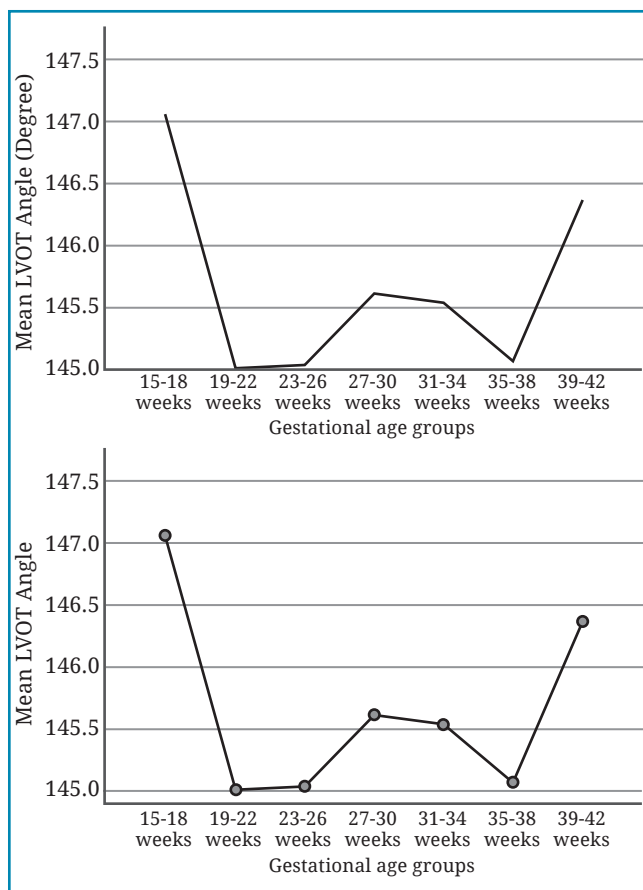


Fig. 3: Variation in mean fetal LVOT angle across gestational age groups – one way ANOVA

Table 3: Analysis result of one-way ANOVA Test of LVOT angle across cardiac axis groups (p value 0.435)

Cardiac axis groups (Degree)	Sample size (n)	LVOT (Degrees)		Mean cardiac axis (Degrees)
		Mean	SD	
1 (31-35)	5	147.4	8.4	33.2
2 (36-40)	78	145.4	5.6	38.9
3 (41-45)	198	145.5	6.1	42.9
4 (46-50)	111	145.4	6.8	47.5
5 (51-55)	2	153.5	3.5	52.0

Mean LVOT angle across five cardiac-axis groups was analyzed using conventional one-way ANOVA test. This analysis showed no significant group difference in LVOT angle with p value of 0.435. Since the p-value exceeds the standard threshold of 0.05, this study fails to reject the null hypothesis, indicating that there is no statistically significant difference in LVOT angle with the cardiac axis.

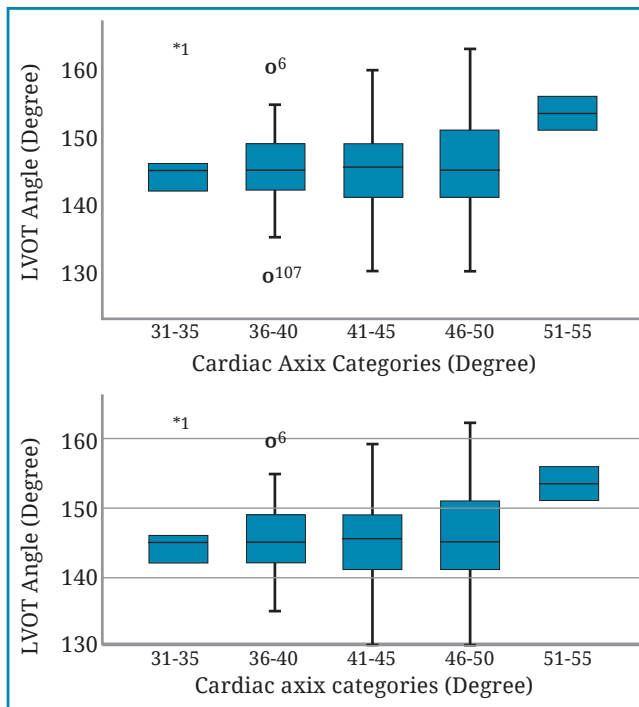


Fig. 4: Box-and-Whisker plot showing the distribution of fetal LVOT angle across cardiac axis categories

DISCUSSION

In recent times, the imaging of the fetal heart has seen significant advancements. Specialized ultrasound technique, typically performed between 18 and 24 weeks of gestation, allows for detailed evaluation of the fetal cardiac structure and function.¹⁴ Improved resolution and the incorporation of doppler imaging have enhanced the ability to assess blood flow and detect congenital heart defects with greater accuracy.¹⁵ Standardized imaging protocols play a crucial role in early diagnosis and perinatal management planning.¹⁶ These developments have markedly improved outcomes by enabling timely intervention and informed parental counseling.

The International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) began recommending the inclusion of outflow tract views—specifically the left and right ventricular outflows—as part of standard fetal heart imaging protocols in 2013.¹⁷ Prior to this, the primary focus had been on the four-chamber view. The addition of the outflow tract assessment was aimed at improving the detection of certain congenital heart anomalies that are not always visible in the four-chamber view alone, such as transposition of the great arteries and outflow obstructions. These recommendations were later reaffirmed and further detailed in ISUOG's 2023 updated guidelines, which emphasize the importance of systematically evaluating both outflow tracts during the second-trimester anomaly scan to enhance diagnostic accuracy.¹⁸

Several studies have attempted to quantify

the outflow tract views by measuring the angles between the inflow and outflow tracts. In a study conducted by Sternfeld *et al*¹³ in 2021, the left ventricular outflow tract (LVOT) angle was reported to range between 127° and 163°. Similarly, Bezzer *et al*¹⁹ documented a comparable range in their study. Our findings are consistent with these results, showing an LVOT angle range of 129° to 163°. Other investigations have reported slightly narrower ranges, such as 126°–144° and 122°–135°, respectively.^{20,21}

Sternfeld *et al*¹⁹ also compared the cardiac outflow angles in fetuses with atrioventricular canal defect (AVC), D-transposition of the great arteries (D-TGA), and valvular aortic stenosis (AS). In fetuses with AVC, the angle ranged from 122.0° to 128.6°, with a mean of 124.8° ± 2.4°. In contrast, fetuses with D-TGA or AS demonstrated significantly wider angles, ranging from 159.9° to 175.2°, with a mean of 164.8° ± 5.0°. These findings highlight the importance not only of visualizing the outflow tracts but also of quantitatively assessing them. The narrower angles observed in AVC and the broader angles in D-TGA/AS suggest a potential diagnostic marker.

Previous studies have reported the prenatal detection rate of D-TGA to be low and highly variable, ranging from 3% to 27%.²²⁻²⁶ Therefore, incorporating this angle measurement into routine prenatal screening may substantially improve the detection rate of D-TGA. Early prenatal identification of such complex congenital heart defects is crucial, as it allows for appropriate perinatal planning and timely postnatal management. Given that these conditions often require specialized surgical interventions, early diagnosis ensures that delivery and subsequent care can be coordinated at a tertiary care center equipped for complex cardiac surgeries.

Previous studies have demonstrated that the LVOT angle is not influenced by gestational age or cardiac axis.^{13,19,20,21} Our findings are consistent with this observation, indicating that the LVOT angle can be reliably measured at any stage of pregnancy.

In Nepal, there is a growing interest in fetal cardiac imaging, with increased efforts to incorporate outflow tract views into routine prenatal screening. However, these views have not yet been fully adopted in standard practice.^{27,28} Through this study, we aim to highlight the importance of not only visualizing the outflow tracts but also performing quantitative measurements. Incorporating these measurements into routine assessments may enhance the early detection of congenital heart defects and ultimately improve clinical outcomes.

Conflict of interest: None

Source of research fund: None

REFERENCES

1. Buijtenendijk MFJ, Barnett P, van den Hoff MJB. Development of the human heart. *Am J Med Genet C Semin Med Genet* 2020; 184: 7-22. DOI:10.1002/ajmg.c.31778.
2. Bayraktar M and Männer J. Cardiac looping may be driven by compressive loads resulting from unequal growth of the heart and pericardial cavity: observations on a physical simulation model. *Front Physiol* 2014; 5: 112. DOI: 10.3389/fphys.2014.00112.
3. Männer J. The anatomy of cardiac looping: a step towards the understanding of the morphogenesis of several forms of congenital cardiac malformations. *Clin Anat* 2009; 22: 21-35.
4. Hoffman JI and Kaplan S. The incidence of congenital heart disease. *J Am Coll Cardiol* 2002; 39: 1890-900. DOI: 10.1016/S0735-1097(02)01886-7.
5. Rana MS, Sizarov A, Christoffels VM, Moorman AF. Development of the human aortic arch system captured in an interactive three-dimensional reference model. *Am J Med Genet A* 2014; 164: 1372-83.
6. Sizarov A, Lamers WH, Mohun TJ, Brown NA, Anderson RH, Moorman AF. Three-dimensional and molecular analysis of the arterial pole of the developing human heart. *J Anat* 2012; 220: 336-49.
7. Stoller JZ and Epstein JA. Cardiac neural crest. *Semin Cell Dev Biol* 2005; 16: 704-15.
8. Anderson RH, Chaudhry B, Mohun TJ et al. Normal and abnormal development of the intrapericardial arterial trunks in humans and mice. *Cardiovasc Res* 2012; 95: 108-15.
9. Van den Hoff MJ, Moorman AF, Ruijter JM et al. Myocardialization of the cardiac outflow tract. *Dev Biol* 1999; 212: 477-90.
10. Okamoto N, Akimoto N, Hidaka N, Shoji S, Sumida H. Formal genesis of the outflow tracts of the heart revisited: previous works in the light of recent observations. *Congenit Anom (Kyoto)* 2010; 50: 141-58.
11. Costell M, Carmona R, Gustafsson E, González-Iriarte M, Fässler R, Muñoz-Chápuli R. Hyperplastic conotruncal endocardial cushions and transposition of great arteries in perlecan-null mice. *Circ Res* 2002; 91: 158-64.
12. Walmsley R. Anatomy of left ventricular outflow tract. *Brit Heart J* 1979; 41: 263-70.
13. Sternfeld AR, Betzer T, Tamir A et al. Can fetal echocardiographic measurements of the left ventricular outflow tract angle detect fetuses with conotruncal cardiac anomalies? *Diagnostics (Basel)* 2021; 11: 1185. DOI: 10.3390/diagnostics11071185.
14. Donofrio MT, Moon-Grady AJ, Hornberger LK et al. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. *Circulation* 2014; 129: 2183-242.
15. Rudski LG, Lai WW, Afilalo J et al. Guidelines for the echocardiographic assessment of the right heart in adults: a report from the ASE. *J Am Soc Echocardiogr* 2020; 33: 693-710.
16. Yagel S, Arbel R, Anteby EY, Raveh D, Achiron R. Fetal cardiac scanning: who, how and when? *Ultrasound Obstet Gynecol* 2007; 29: 81-5.
17. International Society of Ultrasound in Obstetrics and Gynecology (ISUOG). Guidelines for the performance of the fetal heart examination: recommendations from the ISUOG. *Ultrasound Obstet Gynecol* 2013; 41: 348-59.
18. Carvalho JS, Araujo Júnior E, Ciardelli V et al. ISUOG Practice Guidelines (updated): sonographic screening examination of the fetal heart. *Ultrasound Obstet Gynecol* 2023; 61: 788-803. DOI: 10.1002/uog.26265.
19. Bezzer T, Raucher Sternfeld A, Tamir A, Mizrahi Y, Gindes L. Measurement of the aortic outlet angle by ultrasound in fetuses with and without congenital heart malformations involving the left ventricular outflow tract. *Ultrasound Obstet Gynecol* 2017; 50: 170. DOI: 10.1002/uog.18049.
20. Barboza LA, Garcia Fde M, Barnoya J, Leon-Wyss JR, Castaneda AR. Subaortic membrane and aorto-septal angle: an echocardiographic assessment and surgical outcome. *World J Pediatr Congenit Heart Surg* 2013; 4: 253-61.
21. Barkhordarian R, Wen-Hong D, Li W, Josen M, Henein M, Ho SY. Geometry of the left ventricular outflow tract in fixed subaortic stenosis and intact ventricular septum: an echocardiographic study in children and adults. *J Thorac Cardiovasc Surg* 2007; 133: 196-203.
22. Blyth M, Howe D, Gnanapragasam J, Wellesley D. The hidden mortality of transposition of the great arteries and survival advantage provided by prenatal diagnosis. *Brit J Obstet Gynecol* 2008; 115: 1096-100. DOI: 10.1111/j.1471-0528.2008.01793.
23. Bull C; British Paediatric Cardiac Association. Current and potential impact of fetal diagnosis on prevalence and spectrum of serious congenital heart disease at term in the UK. *Lancet* 1999; 354: 1242-7. DOI: 10.1016/S0140-6736(99)01167-8.
24. Garne E, Stoll C, Clementi M. Evaluation of prenatal diagnosis of congenital heart diseases by ultrasound: experience from 20 European registries. *Ultrasound Obstet Gynecol* 2001; 17: 386-91. DOI: 10.1046/j.1469-0705.2001.00385.x.
25. Jaeggi ET, Sholler GF, Jones ODH, Cooper SG. Comparative analysis of pattern, management and outcome of pre- versus postnatally diagnosed major congenital heart disease: a population-based study. *Ultrasound Obstet Gynecol* 2001; 17: 380-5. DOI: 10.1046/j.1469-0705.2001.00398.
26. Marek J, Tomek V, Škovránek J, Povýšilová V, Šamánek M. Prenatal ultrasound screening of congenital heart disease in an unselected national population: a 21-year experience. *Heart* 2011; 97: 124-30. DOI: 10.1136/hrt.2010.206623.
27. Shrestha S, Lee JW, Kc A et al. An evaluation of obstetric ultrasound education program in Nepal using the RE-AIM framework. *BMC Med Educ* 2021; 21:19. DOI: 10.1186/s12909-020-02461-y.
28. Bhandari R, Oli N, Sharma S et al. Spectrum of congenital heart disease in Nepal from 2002–2022: a systematic review and meta-analysis. *Congenit Heart Dis* 2023; 18: 31-45.