Methods to Improve the Efficiency of Prenatal Ultrasound Diagnosis of Fetal Cleft Lip and Palate: Postprint

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Abstract

Objective To analyze the contributory role of clinical history combined with conventional three-section views of the lip and palate, transverse view of the superior alveolar process, other special views, and three-dimensional ultrasound in conjunction with different fetal positions in improving the efficacy of prenatal ultrasound diagnosis of fetal cleft lip and palate. Methods From September 2014 to December 2016, 7000 second-trimester fetuses (gestational age 20–24+6 weeks) in our hospital underwent facial ultrasound screening. Clinical history was routinely inquired before ultrasound examination. Standardized conventional three-section views and transverse view of the superior alveolar process served as screening planes. When abnormalities were detected, two-dimensional images of the fetal mouth in both open and closed states were simultaneously acquired, followed by three-dimensional imaging. The results were compared with post-abortion or post-delivery facial findings to evaluate the efficacy of various methods in improving the efficiency and accuracy of prenatal ultrasound diagnosis of cleft lip and palate deformities. Results Among 7000 fetal ultrasound examinations, 27 cases of cleft lip and palate were detected, with 29 cases confirmed by abortion or delivery. The conventional three-section view group identified 20 cases of fetal cleft lip and palate deformities, with 9 cases missed by prenatal ultrasound, yielding a diagnostic concordance rate of 69%. The group employing conventional three-section views, transverse view of the superior alveolar process, other special views, and three-dimensional ultrasound detected 27 cases of fetal cleft lip and palate deformities prenatally, with 2 cases missed, achieving a prenatal ultrasound diagnostic concordance rate of 93%. A statistically significant difference was observed between the two methods in cases of cleft lip with palate involvement ($P<0.05$). Conclusion Routine collection of clinical history by sonographers before examination, accurate identification of normal anatomic structures and sonographic characteristics of the fetal lip, nose, and palate, mastery of techniques for conventional three-section

views, transverse view of the superior alveolar process, and other special views, careful observation of fetal lip and nasal structures and mouth opening/closing movements, combined with application of three-dimensional ultrasound surface rendering mode, will enhance the ultrasound detection rate of cleft lip and palate deformities and provide reliable information for clinicians and pregnant women.

Full Text

Strategies for Improving the Effectiveness of Prenatal Ultrasound in Diagnosing Fetal Cleft Lip and Palate

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Abstract

Objective: To evaluate the contribution of clinical history combined with routine three-plane scanning of the lips and palate, transverse alveolar process plane, other special sections, and three-dimensional ultrasound in different fetal positions to improving the diagnostic efficiency of prenatal ultrasound for fetal cleft lip and palate.

Methods: Facial ultrasound screening was performed on 7,000 fetuses in the second trimester (gestational age 20–24 weeks) in our hospital from September 2014 to December 2016. Medical history was routinely obtained before ultrasound examination. Standardized conventional three-plane scanning and transverse alveolar process plane were used as screening sections. When abnormalities were detected, two-dimensional images were captured with the fetal mouth both open and closed, followed by three-dimensional image acquisition. Results were compared with postnatal or postpartum facial findings to evaluate the diagnostic efficiency and accuracy of various methods for prenatal ultrasound detection of cleft lip and palate malformations.

Results: Among 7,000 fetal ultrasound examinations, 27 cases of cleft lip and palate were detected, which was confirmed in 29 cases after induced labor or delivery. The conventional three-plane group detected 20 cases of cleft lip and palate, with 9 cases missed prenatally, yielding a diagnostic accuracy of 69%. The combined approach group (conventional three-plane, transverse alveolar process plane, other special sections plus three-dimensional ultrasound) detected 27 cases, missing only 2 cases prenatally, achieving a diagnostic accuracy of 93%. The difference between the two methods was statistically significant for cleft lip with palate cases ($P<0.05$).

Conclusion: Routine collection of clinical history before examination, accurate identification of normal structures and sonographic features of the fetal lip, nose, and palate, mastery of conventional three-plane and transverse alveolar process plane techniques, careful observation of fetal lip-nose structures and mouth opening/closing movements, and simultaneous application of three-dimensional ultrasound surface imaging mode can improve the diagnostic rate of cleft lip and palate malformations and provide reliable information for clinicians and pregnant women.

Keywords: prenatal; ultrasonography; fetal cleft lip and palate; effectiveness

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Introduction

Cleft lip and palate is a common structural malformation with an incidence of approximately 1–2‰ [1]. In China, its prevalence shows a geographic pattern of higher rates in the northwest and lower rates in the southeast [2]. Cleft lip and palate adversely affects multiple aspects of child development, including speech, psychology, masticatory function, maxillofacial growth, and social adaptation. It is often complicated by upper respiratory tract infections, otitis media, malnutrition, and may lead to psychological disorders in some children. The exact etiology remains unclear, but it is widely considered to result from the interaction of genetic and environmental factors. Although surgical and other treatment methods are available, outcomes are often suboptimal compared with normal individuals, affecting the physical and mental health of both the child and family members as well as overall family wellbeing [3–5].

Prenatal ultrasound diagnosis of vermilion border cleft and palate is challenging, with missed diagnoses occurring frequently. To improve the diagnostic accuracy and reduce missed and misdiagnoses of cleft lip and palate, this study summarizes data from our hospital over the past three years to explore more efficient application of two-dimensional and three-dimensional ultrasound for diagnosing cleft lip and palate.

Methods

1.1 General Data We selected 7,000 pregnant women who underwent fetal facial ultrasound screening in the second trimester (gestational age 20–24 weeks) in our hospital from September 2014 to December 2016. Maternal age ranged from 16 to 42 years, with a mean age of 26.3 ± 5.1 years. All were singleton pregnancies. Postpartum or post-induction diagnosis confirmed cleft lip and palate in 29 cases. Among these 29 cases, 2 had a family history, 4 mothers had hepatitis B, 1 had thalassemia, 2 had gestational diabetes, 2 had genital mycoplasma infection, and 6 had taken medication or engaged in hazardous occupations during early pregnancy.

1.2 Equipment Philips iU Elite and GE Voluson E8 color Doppler ultrasound diagnostic instruments were used, with probe frequencies of 2.0–8.0 MHz.

1.3 Examination Protocol Before ultrasound examination, medical history was routinely obtained, including information on adverse pregnancy history, family history of genetic diseases, and smoking or alcohol consumption. Pregnant women were placed in supine or lateral position, and routine prenatal ultrasound diagnosis was performed according to standard sections in sequence. After determining fetal position and orientation, the probe was rotated from the biparietal diameter plane to obtain the conventional three-plane scan of the nose and lips (coronal plane of nose and lips, median sagittal plane of face, and horizontal transverse plane of lips) [6] to observe nasal and lip structures. Simultaneously, the transverse alveolar process plane was performed to assess alveolar process and palatal continuity. Finally, a three-dimensional volume probe was used in surface imaging mode to observe the fetal face. Four-dimensional localization and image acquisition were performed on the facial sagittal plane, with appropriate adjustment of X, Y, and Z axes [7] to obtain three-dimensional facial images displaying the overall appearance and stereoscopic view, facilitating better understanding of the malformation by sonographers, obstetricians, orthodontists, and pregnant women [8].

When echo discontinuity, linear hypoechoic areas, or indentations were detected in the lips, alveolar process, or palate, images were captured with the fetal mouth both open and closed, and fetal tongue protrusion and mouth opening movements were observed whenever possible [9], focusing on the abnormal echo location. Multiple plane scanning was performed for mutual verification to avoid misdiagnosis [10]. Additionally, color flow imaging was applied to observe blood flow direction and continuity in the lips and palate [11]. If the fetal face was poorly visualized due to suboptimal fetal position, thick maternal abdominal wall, oligohydramnios, or multiple pregnancy, the patient was asked to ambulate for 15–20 minutes before re-examination, with follow-up the next day if necessary [12]. Cases were followed up until induced labor or delivery, and ultrasound diagnoses of cleft lip and palate were compared and recorded to analyze the diagnostic rates of conventional three-plane scanning alone versus combined application of conventional three-plane scanning, transverse alveolar process plane, other special sections, and three-dimensional ultrasound.

1.4 Statistical Analysis SPSS 21.0 statistical software was used for data analysis. Count data were expressed as rates (%) and compared using chi-square tests, with $P<0.05$ considered statistically significant.

Results

2.1 Comparison of Prenatal Ultrasound and Postpartum Detection of Cleft Lip and Palate Among 7,000 fetal ultrasound examinations, 27 cases

of cleft lip and palate were detected, with 29 cases confirmed after induced labor or delivery, yielding a malformation rate of 4.1‰. These included 5 cases of isolated cleft lip, 23 cases of cleft lip with palate, and 1 case of isolated cleft palate. Ultrasound missed 1 case of isolated cleft palate and 1 case of degree I vermilion border cleft, with no misdiagnoses.

The conventional three-plane group detected 20 cases of cleft lip and palate, missing 9 cases prenatally (1 case of degree I vermilion border cleft, 7 cases of cleft lip with palate, and 1 case of isolated cleft palate). The combined approach group (conventional three-plane, transverse alveolar process plane, other special sections plus three-dimensional ultrasound) detected 27 cases, missing only 2 cases prenatally (1 case of degree I vermilion border cleft and 1 case of isolated cleft palate). Compared with postnatal findings, the conventional three-plane group had a diagnostic accuracy of 69% and a missed diagnosis rate of 31%. The combined approach group achieved a diagnostic accuracy of 93% and a missed diagnosis rate of 7%, with no misdiagnoses.

Eight cases were complicated by other structural malformations, including exencephaly, semilobar holoprosencephaly, lobar holoprosencephaly, Dandy-Walker malformation, cerebellar vermis agenesis, cerebellar dysplasia, hydrocephalus, double outlet right ventricle, endocardial cushion defect, ventricular septal defect, interrupted aortic arch, aortic arch stenosis, persistent left superior vena cava, duplicated kidney, polycystic kidney, and bilateral clubfoot. Additional minor anomalies included bilateral renal pelvis dilation, increased nuchal fold thickness, single umbilical artery, bilateral choroid plexus cysts, and left ventricular bright spot. Family history revealed that among the 29 cleft lip and palate cases, 2 had a family history, 4 mothers had hepatitis B, 1 had thalassemia, 2 had gestational diabetes, 2 had genital mycoplasma infection, and 6 had taken medication or engaged in hazardous occupations during early pregnancy.

The comparison of prenatal ultrasound and postpartum detection results between the conventional three-plane group (20 cases) and the combined approach group (27 cases) is shown in .

As shown in , comparison of detection rates between the two methods for isolated cleft lip revealed no statistically significant difference (^{2}=0.050, P=0.696). However, for cleft lip with palate, the difference was statistically significant (^{2}=4.041, P=0.044). For isolated cleft palate, comparison was not possible as neither method detected this malformation.

2.2 Ultrasonographic Findings in 29 Confirmed Cases

1. Isolated cleft lip (4 cases): The main manifestation was unilateral or bilateral discontinuity of the upper lip, which could extend to the nostril and cause deformation and flattening of the affected nostril.
2. Cleft lip with palate (23 cases): Ultrasound showed discontinuity of the upper lip extending to the nasal root with nasal deformation, accompanied

by discontinuity of echoes in the alveolar process and palate ([Figure 1: see original paper], [Figure 2: see original paper]).

Discussion

The development of cleft lip and palate results from the interaction of environmental and genetic factors. Environmental factors include maternal smoking and alcohol consumption during pregnancy, folic acid and other vitamin/micronutrient deficiencies, hyperthermia, psychological stress, obesity, occupational exposure, ionizing radiation, and infections [13–15]. Additionally, cleft lip and palate shows familial aggregation; if a first-degree relative has cleft lip and palate, the risk to offspring is 30–40 times higher than in those without a family history. The concordance rate in monozygotic twins is 40–60%, compared with only 3–5% in dizygotic twins, indicating that genetic factors play an important role [16]. Thorough understanding of family history and risk factors for cleft lip and palate formation is crucial for ultrasound examination.

In this series, among 29 cases of cleft lip and palate, 2 had a family history, 4 mothers had hepatitis B, 2 had thalassemia, 2 had gestational diabetes, 2 had genital mycoplasma infection, and 6 had taken medication or engaged in hazardous occupations during early pregnancy. When examining these high-risk pregnant women, sonographers mentally prioritize them as "key" examination subjects and adopt measures to improve detection rates and image quality. Our experience suggests that many patients lack relevant knowledge, and clinical ultrasound requisition forms often lack detailed history, failing to provide sufficient information for sonographers. Therefore, sonographers need to enhance their knowledge of various risk factors for fetal malformations and obtain as much pre-examination information as possible by tracing histories. Based on this analysis, timely and focused ultrasound examinations guided by medical history can improve diagnostic efficiency.

Conventional fetal facial ultrasound screening has traditionally used a single coronal plane of the nose and lips, which is useful for detecting cleft lip but has limitations in confirming cleft palate and is even more challenging for evaluating whether cleft lip is associated with cleft palate [17–18]. Our study found that conventional three-plane scanning has a high detection rate for isolated cleft lip but a low rate for cleft palate. Image analysis revealed that ultrasound cannot penetrate the bony alveolar process, creating an acoustic shadow that obscures the soft and hard palate, making it difficult to display direct signs prenatally [19]. However, the transverse alveolar process plane is relatively easy to obtain and has definite value in diagnosing primary and median cleft palate [20]. Using discontinuity or irregular arrangement of the alveolar process as a suspicious indicator for cleft palate, the combination of conventional three-plane scanning, transverse alveolar process plane, other special sections, and three-dimensional

ultrasound can improve the diagnostic rate of cleft lip and palate malformations.

In this series, all 23 cases of cleft lip with palate were detected without missed diagnoses of the palatal component after applying the transverse alveolar process plane following identification of cleft lip. However, one case of isolated cleft palate was missed, likely because decreased amniotic fluid in front of the upper lip and proximity to the uterine wall made transverse alveolar process plane scanning difficult, preventing observation of alveolar process continuity and deciduous tooth arrangement. Color Doppler ultrasound can be used to observe amniotic fluid flow in the fetal oral and nasal cavities; normal flow is unidirectional, while simultaneous visualization of two colored flow streams in the oral and nasal cavities suggests possible cleft palate. Detection of arterial spectrum at the suspected cleft site with spectral Doppler confirms cleft palate. One case of vermilion border cleft was missed; image review showed intact upper lip continuity with a faint vertical linear hypoechoic area visible in some sections. Postnatal examination revealed a small tightly apposed lip fissure.

In summary, prenatal ultrasound examination should routinely include inquiry of relevant maternal history to guide timely and focused scanning. During real-time dynamic scanning using conventional three-plane scanning of the fetal nose and lips, careful observation should be made from anterior to posterior, superior to inferior, and left to right, examining the morphology and continuity of the upper and lower lips, nasal tip position, columella position, nostril size, nasal collapse, and alveolar process and palatal continuity. Each plane should visualize the internal structures, margins, and adjacent areas of the nose, lips, and palate to comprehensively evaluate major facial structures and their relationships while excluding artifacts. The transverse alveolar process plane should be performed routinely, especially when fetal lip abnormalities are detected, with focused observation of alveolar process and palatal continuity. When echo discontinuity, linear hypoechoic areas, or indentations are found in the lips, alveolar process, or palate, images with the fetal mouth open and closed should be obtained, focusing on the abnormal echo location. Color flow imaging should be applied to observe blood flow direction and continuity in the lips and palate. Finally, three-dimensional volume probe with surface imaging mode should be used to display fetal facial structures more intuitively. If the fetal face is poorly visualized due to suboptimal fetal position, thick maternal abdominal wall, oligohydramnios, or multiple pregnancy, the patient should be advised to ambulate for 15–20 minutes before re-examination, with follow-up the next day if necessary. Through routine history collection, accurate identification of normal structures and sonographic features, mastery of conventional three-plane and transverse alveolar process plane techniques, careful observation of fetal lip-nose structures and mouth movements, and simultaneous application of three-dimensional ultrasound surface imaging mode, sonographers can improve the diagnostic rate of cleft lip and palate malformations and provide reliable information for clinicians and pregnant women.

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Note: Figure translations are in progress. See original paper for figures.