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Detection rate of fetal CNS anomalies by first and second trimester ultrasound screening

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Abstract

Objectives The aim of this study was to detect CNS abnormalities in first and second trimester by ultrasound.

Methods This cross-sectional study was performed on pregnant women who referred to the radiology department of Imam Reza and Valiasr hospitals in Tehran-Iran during 2019-2020. After obtaining informed consent, pregnant women were screened in the first trimester at week 13-13 and then in the second trimester at week 18-20 by a 5-8 MHz Ultrasound Transducer. Each ultrasound included examination of the fetal brain and vertebrae at the axial coronal and sagittal planes in the most important anatomical areas, including the trans-thalamic (TT) or the trans-ventricular (TV) plane, transverse cerebellar, and vertebral canal plan. Ultrasound of the first and second trimesters of all mothers was performed. Information of all pregnant mothers was collected and recorded. Data analysis was performed using SPSS software version 25.

Results In this study, 2234 pregnant women were included in the study. The total rate of detected anomalies was found to be 1.3%. The rate of abnormalities detected in the first trimester was far less than in the second trimester. The prevalence of CNS anomalies in the population under 30 years of age was also found 0.9%, while it was 1.6% in the population over 30 years of age.

Conclusion Second trimester ultrasound is the method of choice in diagnosing central nervous system abnormalities. However, first trimester ultrasound is the diagnostic method for structural abnormalities of the skull.

Keywords CNS anomaly, ultrasound, first trimester, second trimester

Introduction

The Central Nervous System (CNS) is the first system to develop in the embryonic period[1] and neural tube defects (NTDs) are the most common central nervous system defect. These defects are caused by neural tube closure problems between the third and fourth weeks of embryonic development[2,3] and are among the causes of stillbirth, neonatal mortality, and severe lifelong disability.[4,5] Neural tube defects are the most common congenital anomaly after cardiac defects and its incidence is 1.4-2 per 1000 live births.[6] Although the exact cause of neural tube defects is not known, but factors such as radiation, medication, malnutrition, chemical and genetic factors are involved in the development of the central nervous system and neural tube defects at the time of fertilization.[7]

CNS abnormalities are the most common reason for referral for prenatal diagnosis and concern of many patients. Almost all CNS abnormalities occur as a result of abnormalities in the period of embryogenesis and its development. Although many CNS abnormalities can be assessed in the first and second trimesters, others develop or become visible later in pregnancy.[8] CNS anomalies are also the most important factor in morbidity and mortality during infancy and in children, some of which become symptomatic only in early childhood.[9] Ultrasound is the selective modality and effective diagnostic method for the diagnosis of congenital CNS anomalies. However, ultrasound is currently performed worldwide to detect CNS abnormalities because brain structures continue to develop until the second trimester, at 22 to 19 weeks of gestation.[10] Early detection of anomalies, especially in the first and early second trimesters, helps to plan for intervention and management during pregnancy.

Early detection of CNS abnormalities during pregnancy reduces emotional stress and economic cost.[9] Attempts have been made to reduce the age of screening for CNS anomalies. Screening is recommended at approximately 13-13 weeks of gestation at the same time as routine ultrasound is performed for fetal morphogenetic evaluation.[11] Therefore, the aim of this study was to detect the first and second trimester detection of CNS abnormalities in fetuses of pregnant mothers with ultrasonography.

Materials and Methods

This cross-sectional study was performed on pregnant women who referred to the radiology department of Imam Reza and Valiasr hospitals in Tehran, Iran during 2019-2020. In the present study, a checklist was used to collect information. The checklist includes measurement of nuchal translucency (NT), nasal bone, lateral ventricles, ossification of fetal skull and spine in first trimester anomaly scan, and measurement of biparietal diameter, fetal head circumference, cavum septum pellucidum (CSP) corpus callosum, cerebellum view, transverse cerebellar diameter, cerebellar vermis, cisternagna, nuchal fold, falx cerebri e, fetal spine. Then, women who met the inclusion and exclusion criteria were included in the study.

Inclusion criteria included: pregnant women, gestational age of 11-13 weeks and 18-20 weeks, and having informed consent.

Procedure

After obtaining informed consent, pregnant women were screened in the first trimester at week 13-13 and in the second

trimester at week 18-20 by a 5-8 mhz ultrasound transducer. Each ultrasound included examination of the fetal brain and vertebrae at the axial, coronal, and sagittal planes in the most important anatomical areas, including the trans-thalamic (TT) or the trans-ventricular (TV) plane, transverse cerebellar, and vertebral canal plan. Ultrasound of the first and second trimesters of all mothers was performed. Information of all pregnant mothers was collected and recorded.

Data Analysis

Central and dispersion indices were used to describe the data. Frequency was used for quantitative variables and percentage for qualitative variables. Chi-square tests were used to investigate the relationship between the variables. Kappa statistics were calculated to confirm the prevalence of CNS anomalies in the first and second trimesters. Data analysis was performed using SPSS software version 25. A p value of 0.05 was considered to be statistically significant.

Ethical Considerations

A written letter of introduction was obtained from the university and the selected researcher centers. The purpose of the study was described for all research units and written consent was obtained from after describing the purpose of the study. The information of all patients remained confidential. Ethics declarations of Helsinki and ethics research committees of the University of Medical Sciences were also considered. The code of ethics was taken from the relevant authorities to conduct the research (IR.BUMS.REC.1399.070).

Results

A total of 2234 pregnant women were included in the study. The overall prevalence of central nervous system abnormalities in the first and second trimesters was assessed. In the first and second trimester 2230 (99.8%), and 2208 patients (98.8%) had no central nervous system abnormalities, respectively. The prevalence of CNS anomalies in the first and second trimester scans was 0.2% and 1.3%, respectively.

Table 1 shows the prevalence of various central nervous system abnormalities in the first and second trimesters. The most common type of anomaly was related to choroid plexus cyst.

The prevalence of central nervous system anomalies in the first trimester by age groups is shown in Table 2. The prevalence of CNS anomalies was 0.1% in the population under 30 years of age, while it was reported to be 0.3% in the population over 30 years of age. However, no significant difference was observed between the two groups (P = 0.617).

Table 3 shows the prevalence of central nervous system anomalies in the second trimester by age groups. The prevalence of CNS anomalies in the population under 30 years of age was 0.9%, while it was 1.6% in the population over 30 years of age. However, no statistically significant difference was observed between the two groups (P = 0.122).

The level of agreement for the detection of CNS anomalies in the first and second trimester ultrasounds is summarized in Table 4. The agreement between the detection of CNS anomalies in the first and second trimester sonography was 0.233, indicating a weak agreement between the detection of CNS anomalies in the first and second trimester sonography.

Table 1. **Prevalence of various anomalies of the central nervous system in the first and second trimesters**

Variable	Frequency
lumbosacral Meningocell	1
Chiari type 2 malformation	3
Ventriculomegaly	4
Choroid plexus cyst	12
Hydrocephalus	3
Dandy-Walker malformation	3
anencephalus	2
Occipital encephalitis	1
Skull deformity	1

Discussion

Early detection of anomalies, especially in the first trimester and early second trimester, helps plan for intervention and management during pregnancy, leading to reduction of emotional stress and economic cost.[12] Therefore, the aim of this

Table 2. **Prevalence of central nervous system anomalies in the first trimester by age groups**

Variable			Frequency	P-value
Age	30 (Year)≤	No	1443 (99.9%)	0.617
		Yes	2 (0.1%)	
		Total	1445 (100%)	
	30 (Year)≥	No	787 (99.7%)	
		Yes	2 (0.3%)	
		Total	789 (100%)	

Table 3. **Prevalence of central nervous system anomalies in the second trimester by age groups**

Variable			Frequency	P-value
Age	30 (Year)≤	No	1442 (99.9%)	0.122
		Yes	13 (0.1%)	
		Total	1445 (100%)	
	30 (Year)≥	No	776 (98.4%)	
		Yes	13 (1.6%)	
		Total	789 (100%)	

Table 4. **The level of agreement between of CNS anomalies in first and second trimester ultrasound**

		The second quarter		Statistics of Kappa
		Negative Number (percent)	Positive Number (percent)	
First three months	Negative	2204 (98.7%)	26 (1.2%)	0.233
	Positive	0 (0%)	4 (0.2%)	
	Total	2204 (98.7%)	30 (1.3%)	

study was to detect CNS anomalies in first and second trimester through sonography. In this study, 2234 were included. The total rate of detected anomalies was 1.3%. The rate of abnormalities detected in the first trimester was far less than in the second trimester. The prevalence of CNS anomalies in the population under 30 years of age was 0.9%, while it was found to be 1.6% in the population over 30 years of age. Various studies have been performed in this regard.

One study by Onkara[13] a prevalence of 0.31% for CNS anomalies, which is less than the present study. The reason for this difference may be the gestational age. Another study by Neeta Natu[10] reported that the detection rate of congenital anomalies in low-risk and high-risk pregnancies was 2.6%, which is higher than our study. The reason for this difference could be the study population. In Lorie's study,[14] the number of undiagnosed anomalies in the first trimester among the low-risk and high-risk population was higher than our study, which could be due to the number of pregnant women and the type of population studied.

Carroll[15] reported that 77% of ultrasound results in the diagnosis of brain abnormalities were consistent with fetal autopsy. Dulgheroff[16] found that the prevalence of structural abnormalities in the first, second and third trimesters of pregnancy was 2.95%, which is higher than the present study; the reason for this difference may be related to gestational age. Sefidakht et al.[17] compared the sonographic findings with the diagnosis of ventriculomegaly and its correlation with the MRI findings. The results of the study showed that MRI is superior to ultrasound and clinical examination at birth in the diagnosis of CNS anomalies. In the present study, the diagnosis of anomaly by ultrasound in the second trimester was the method of choice, but the use of MRI for future studies and its comparison with ultrasound are recommended.

In the study by Struksnaes et al.,[18] the correlation between the results of ultrasound at week 11-33 and autopsy was investigated. They concluded that there was a 96.9% agreement between the findings of ultrasound and autopsy, and ultrasound was recommended as a useful and reliable method for diagnosing CNS anomalies. However, in the present study, the second trimester ultrasound was found to be a useful diagnostic method for diagnosing CNS anomalies.

Conclusion

First trimester ultrasound is a useful diagnostic method in diagnosing structural abnormalities of the skull. Second trimester ultrasound is the method of choice for diagnosing central nervous system abnormalities.

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