

## Original Article

## Quantitative analysis of normal fetal medulla oblongata volume and flow by three-dimensional power Doppler ultrasound



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## ABSTRACT

**Objective:** Assessment of the fetal medulla oblongata volume (MOV) and blood flow might be important in the evaluation of fetal brain growth. We used three-dimensional power Doppler ultrasound (3DPDUS) to assess the fetal MOV and blood flow index in normal gestation. The relationships between these parameters were further analyzed.

**Methods:** We assessed the total volume and blood flow index of the fetal MO in normal pregnancies using a 3DPDUS (Voluson 730 Expert). The true sagittal plane over the fetal occipital area was measured by a 3D transabdominal probe to scan the fetal MO under the power Doppler mode. Then, we quantitatively assessed the total volume of the fetal MOV, mean gray area (MG), vascularization index (VI), and flow index (FI).

**Results:** A total of 106 fetuses, ranging from 19 weeks to 39 weeks of gestation, were involved in our study. The volume of the fetal MO was highly positively correlated with gestational age [correlation coefficient ( $r$ ) = 0.686,  $p < 0.0001$ ]. The MG was negatively correlated with gestational age [ $r = -0.544$ ,  $p < 0.0001$ ]. VI and FI showed no significant correlation with gestational age ( $p = 0.123$  and  $p = 0.219$ , respectively).

**Conclusion:** 3DPDUS can be used to assess the fetal MOV and blood flow development quantitatively. Our study indicated that fetal MOV and blood flow correlated significantly with the advancement of gestational age. This information may serve as reference data for further studies of the fetal brain and blood flow under abnormal conditions.

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## Introduction

The fetal brain volume and perfusion is crucial both in the evaluation of fetal growth and central nervous system (CNS) development. Deficient perfusion of the fetal brain may be related to a poor prognosis of CNS development and even to fetal well-being. A previous study thought unexplained stillbirth might be related to neuronal pathology in the arcuate nucleus of the medulla oblongata [1]. Cerebral malformations are encountered in about 1% of all births [2]. With the advent of high-resolution three-dimensional power Doppler

ultrasound (3DPDUS), it is easier to assess all possible planes, views, and vascularization whenever the targeted-scanned 3D volume is obtained, including any part of fetal brain [3–6]. Recent evolution in ultrasound equipment has enabled more refined diagnosis of most congenital malformations of the brain. Through a structured analysis of the fetal CNS anatomy, even rare conditions are now being detected more often [7]. In this study, we focus on analyzing the fetal medulla oblongata (MO), which has not been studied previously.

The MO connects the higher levels of the brain to the spinal cord, and it is responsible for several functions of the autonomous nervous system, including respiration, cardiac center, vasomotor center, and reflex centers. After 28 gestational weeks, the fetal heartbeats become more variable. The maturation of the CNS, including the cerebral cortex and MO, plays an important role in controlling the fetal heart rhythm. The variability of the fetal heartbeat directly

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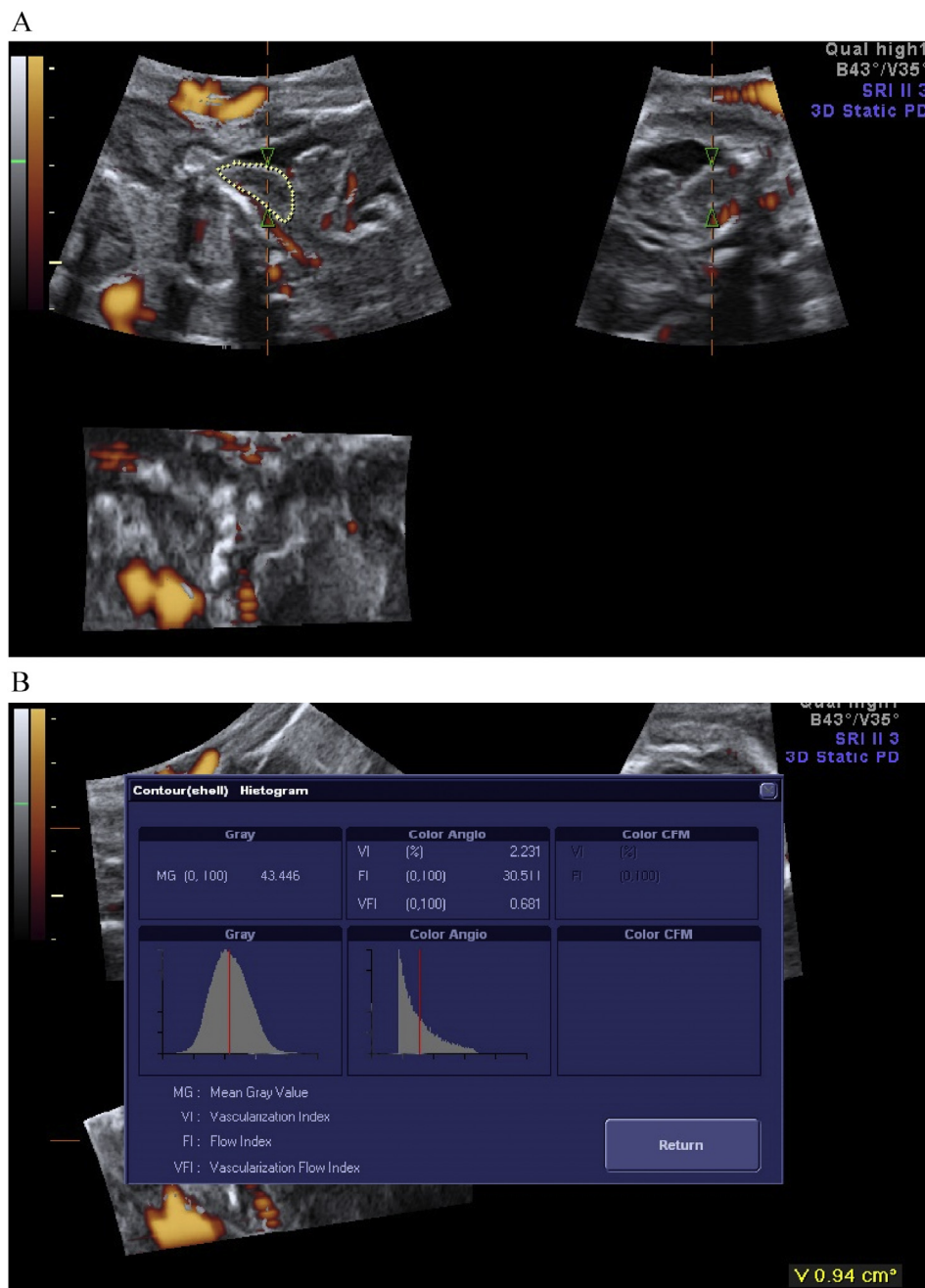
indicates the well-being of the fetus. The volume and vascularization of MO might be an index for evaluating fetal brain maturation.

We measured the fetal medulla oblongata volume (MOV) using 3DPDUS. We tested whether the fetal MOV vascularization and the blood flow change significantly with the increment of gestational age (GA). We conducted a prospective study to assess the fetal MOV, mean gray areas, and vascular indices [i.e., vascularization index (VI) and flow index (FI)] in normal pregnancy using 3DPDUS and quantitative 3D histogram analysis. In an Asian population, our study may be the first series to present an assessment of the fetal MOV and vascularization using 3DPDUS and quantitative 3D histogram analysis.

## Methods

### Patients

In this cross-sectional study, a total of 111 women with normal singleton pregnancy between 19 weeks and 39 weeks gestation were examined. Fetal age was estimated from the last menstrual period and confirmed by ultrasonographic measurement of the crown–rump length. Women with gestational diabetes, preterm labor, antepartum hemorrhage, congenital abnormalities, and maternal systemic disease; women on a regimen of tocolytic and antihypertensive agents; and women absent during patient follow



**Figure 1.** (A) Fetal medulla oblongata (defined by dotted line) volume at 22 weeks of gestation was calculated using the VOCAL technique in six planes. (The red arrow indicates fetal cerebellum.) (B) MG, VI, and FI of the medulla oblongata were analyzed (22 weeks of gestation). FI = flow index; MG = mean gray value; VI = vascularization index; VOCAL = Virtual Organ Computer-Aided Analysis.

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