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## CLINICAL ARTICLE

## Fetal middle cerebral artery Doppler indices and clinical application at Korle Bu Teaching Hospital, Accra, Ghana

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## ABSTRACT

**Objective:** To determine normal ranges for various Doppler flow velocity indices of the fetal middle cerebral artery (MCA) and their trends in normal pregnancies at Korle Bu Teaching Hospital, Accra, Ghana. **Methods:** A prospective cross-sectional study was conducted at Korle Bu Teaching Hospital in 2015. Included women had a singleton pregnancy of 20–40 weeks' duration, dated using an early ultrasonography scan, and normal fetal growth. Interviews were conducted to collect data on sociodemographic characteristics, followed by Doppler ultrasonography of the MCA. The resistive index, pulsatility index, systolic-to-diastolic ratio, and peak systolic velocity of the MCA were determined for all participants. **Results:** Overall, 458 pregnant women were recruited. The peak systolic velocity increased with advancing gestational age and a positive correlation of  $r = 0.725$  ( $P < 0.001$ ) was demonstrated between the peak systolic velocity and the gestational age. The resistive index, pulsatility index, and systolic-to-diastolic ratio of the MCA decreased with advancing gestational age in a parabolic pattern. **Conclusion:** The reference curve for the peak systolic velocity increases with gestational age, whereas the other indices decrease in a parabolic pattern.

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## 1. Introduction

Fetal surveillance in contemporary practice involves the use of Doppler ultrasonography of fetal vessels. Commonly used vessels include the umbilical vessels, the middle cerebral artery (MCA), the ductus venosus, and the uterine artery. These tests provide important information for the diagnosis and monitoring of fetal conditions that is not readily obtained from more routine tests of fetal well-being [1].

The umbilical artery is the most common vessel assessed by Doppler ultrasonography for the monitoring of the compromised fetus and to determine the timing of delivery. The role of the MCA is well established in the diagnosis of fetal anemia [2]. Some clinicians strongly support the use of MCA flow velocimetry to obtain information in conditions such as fetomaternal hemorrhage [3], fetal hypoxia, and adverse perinatal outcome [4]. With improved ultrasonography resolution and color Doppler imaging, Doppler assessment of the MCA has become the gold standard in the assessment of intracranial fetal vessels [5].

Normally, the fetal cerebral circulation is a continuous, forward, low flow with high impedance. In the presence of fetal hypoxemia secondary to placental insufficiency, the blood flow is redistributed to the brain, heart, and adrenal glands, with decreased resistance allowing

for increased blood flow and oxygen delivery to the brain [6]. Using Doppler studies, this decreased MCA impedance can manifest as the “brain-sparing reflex,” which has been proposed as an early indicator of autoregulation in cases of intrauterine growth restriction (IUGR) [7,8].

Despite the fact that ultrasonography was introduced relatively early in Africa (at the University of Cape Town, South Africa, in 1970) [9], Africa is the continent where the lowest number of obstetric and Doppler ultrasonography scans are performed. Although the commercialization of medical care has led to the excessive use of obstetric scans in some urban areas of Africa, pulsed-wave Doppler waveform analysis is not commonly done. This may be as a result of the high combined cost of equipment with pulsed-wave Doppler technology and of the training of healthcare workers in operating the units and interpreting results. For most low-income countries, such technology is restricted to a few centers [10].

During the past 10 years, no fewer than 50 works on fetal Doppler ultrasonography from hospital groups and services from across Africa have been published in various national and specialist African journals [11]. Most of the studies have been related to assessment of the fetal MCA in patients with pre-eclampsia [12–14].

The MCA is the most studied fetal brain artery because it is simple to access. Numerous studies have been conducted to establish a normal reference range for common application [8–12]. However, studies from different parts of the world have indicated the possibility of loco-regional differences in the normal range, implying the need to construct local reference ranges and to follow the local range if it differs from published values.

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**Table 1**  
Demographic information and Doppler indices of the middle cerebral artery by gestational age (n = 458).<sup>a</sup>

Gestational age, wk	No.	Age, y	Pulsatility index	Resistive index	Peak systolic velocity, cm/s	S/D ratio
20	20	30.90 ± 6.40	1.48 ± 0.30	0.75 ± 0.06	23.30 ± 6.50	4.99 ± 1.64
21	20	28.30 ± 3.80	1.60 ± 0.35	0.75 ± 0.09	27.40 ± 7.40	5.36 ± 1.89
22	20	29.00 ± 6.30	1.81 ± 0.35	0.79 ± 0.05	30.00 ± 7.30	5.26 ± 2.03
23	20	29.20 ± 4.30	1.65 ± 0.41	0.77 ± 0.04	27.20 ± 7.90	5.25 ± 1.22
24	25	33.40 ± 4.30	1.46 ± 0.23	0.69 ± 0.20	27.10 ± 2.40	4.29 ± 0.75
25	20	28.40 ± 6.40	1.35 ± 0.46	1.03 ± 0.35	27.80 ± 7.40	5.61 ± 1.19
26	21	29.40 ± 6.20	1.59 ± 0.28	0.81 ± 0.06	29.40 ± 6.90	5.20 ± 1.29
27	20	30.40 ± 4.60	1.85 ± 0.40	0.82 ± 0.07	32.10 ± 12.10	9.95 ± 12.41
28	20	30.10 ± 3.50	1.80 ± 0.52	0.82 ± 0.10	34.60 ± 7.70	8.44 ± 1.79
29	20	30.70 ± 5.70	1.70 ± 0.41	0.79 ± 0.08	38.50 ± 11.50	7.21 ± 1.45
30	23	28.30 ± 6.90	1.83 ± 0.29	0.82 ± 0.05	44.60 ± 8.80	6.15 ± 1.45
31	22	30.00 ± 4.60	1.83 ± 0.24	0.82 ± 0.05	44.70 ± 9.80	6.41 ± 1.39
32	22	32.00 ± 6.60	1.69 ± 0.25	0.80 ± 0.08	47.30 ± 8.00	6.73 ± 1.59
33	22	34.60 ± 4.80	1.64 ± 0.40	0.80 ± 0.10	44.00 ± 11.10	5.97 ± 2.07
34	23	32.60 ± 3.90	1.53 ± 0.19	0.80 ± 0.03	48.40 ± 9.90	5.35 ± 1.21
35	25	30.60 ± 4.30	1.46 ± 0.34	0.77 ± 0.06	51.30 ± 8.40	4.48 ± 1.22
36	22	29.20 ± 5.10	1.45 ± 0.24	0.80 ± 0.07	51.70 ± 10.50	5.04 ± 1.40
37	24	30.50 ± 2.90	1.48 ± 0.29	0.78 ± 0.06	51.50 ± 11.10	5.11 ± 1.36
38	24	28.80 ± 6.20	1.29 ± 0.33	0.73 ± 0.08	48.90 ± 8.80	4.20 ± 1.68
39	23	30.10 ± 4.70	1.39 ± 0.38	0.74 ± 0.09	56.10 ± 15.60	4.13 ± 1.43
40	22	31.30 ± 3.60	0.99 ± 0.05	0.67 ± 0.05	53.70 ± 11.60	3.07 ± 0.63

Abbreviation: S/D, systolic to diastolic.

<sup>a</sup> Values are given as mean ± SD unless indicated otherwise.

Therefore, the aim of the present study was to evaluate the range of normal local values at Korle Bu Teaching Hospital, Accra, Ghana.

## 2. Materials and methods

The present study was a prospective cross-sectional study conducted between January 5 and May 30, 2015, at the maternity unit of the obstetrics department at Korle Bu Teaching Hospital, which is affiliated with the Medical School of the University of Ghana. The inclusion criteria were: a low-risk singleton pregnancy; a pregnancy duration of 20–40 weeks, with the pregnancy dated using early ultrasonography before 12 weeks of pregnancy; and normal fetal growth (growth curve between the 10th and 90th percentiles). The exclusion criteria were evidence of congenital or fetal structural anomaly on the sonogram; oligohydramnios as confirmed by an amniotic fluid index of less than 5; abnormal fetal biometry with an estimated fetal weight below the 10th percentile or above the 90th percentile (IUGR, small

for gestational age, or large for gestational age); a history of smoking and alcohol consumption during the index pregnancy; and chronic medical conditions (hypertension, diabetes mellitus, autoimmune disorders). The study aims were explained to the women and all participants were asked to provide written informed consent before any ultrasonography was performed. The study was approved by the Ethical and Protocol Review Committee of the College of Health Sciences, University of Ghana.

Before the ultrasonography examination, participants were interviewed and a questionnaire was completed that included details of sociodemographic characteristics and obstetric history.

All ultrasonography examinations were performed by J.D.S. and A.S.-D., who had been trained in obstetric ultrasonography and Doppler imaging. The examinations were performed with the woman placed in a recumbent or semirecumbent position. Initially, greyscale ultrasonography was performed to evaluate for multiple pregnancies and to assess parameters related to the fetal anatomy and biophysical profile, including

**Table 2**  
Percentile values for Doppler indices of the middle cerebral artery according to gestational age (n = 458).

Gestational age, wk	Pulsatility index			Resistive index			Peak systolic velocity			S/D ratio		
	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th
20	1.19	1.41	2.10	0.68	0.77	0.83	13.00	24.00	33.00	3.31	4.44	7.40
21	1.19	1.43	2.11	0.60	0.74	0.89	17.00	24.80	41.00	3.55	4.41	8.90
22	1.21	1.95	2.20	0.68	0.80	0.86	20.00	27.50	41.00	0.89	5.40	9.20
23	1.24	1.54	2.20	0.71	0.78	0.83	18.00	25.60	43.40	3.90	5.14	7.70
24	1.18	1.43	1.96	0.18	0.72	0.84	22.00	27.80	29.70	3.54	4.20	6.10
25	0.69	1.50	1.86	0.77	0.85	1.55	15.00	28.10	42.60	4.20	5.03	7.50
26	1.15	1.56	2.10	0.71	0.80	0.89	18.00	32.30	39.00	3.54	5.10	6.69
27	1.19	1.96	2.30	0.70	0.84	0.90	7.20	35.40	46.50	4.33	6.85	46.00
28	1.03	1.96	2.60	0.65	0.84	0.95	20.00	36.40	42.50	2.80	7.70	8.35
29	0.91	1.92	2.10	0.64	0.81	0.89	25.00	36.00	65.50	2.71	6.33	7.30
30	1.42	1.75	2.12	0.74	0.83	0.88	30.00	43.20	54.20	4.10	5.60	8.20
31	1.51	1.77	2.20	0.73	0.84	0.87	29.00	43.90	61.00	4.55	6.45	8.90
32	1.41	1.54	2.00	0.62	0.84	0.87	35.50	46.50	62.00	4.20	7.20	8.90
33	1.11	1.66	2.04	0.61	0.81	0.88	27.10	44.80	56.00	3.17	5.63	8.30
34	1.29	1.52	1.83	0.75	0.80	0.84	31.00	51.00	63.00	4.20	5.20	7.20
35	1.08	1.32	2.10	0.70	0.73	0.88	38.70	48.40	64.00	3.38	3.80	7.50
36	1.03	1.38	1.86	0.64	0.80	0.86	40.00	51.00	68.00	2.78	4.94	6.89
37	1.01	1.53	1.98	0.70	0.77	0.86	38.00	52.60	69.10	3.33	4.37	6.92
38	0.96	1.14	1.98	0.66	0.68	0.88	34.90	51.60	64.50	2.91	3.15	8.33
39	0.77	1.37	1.98	0.58	0.75	0.88	33.00	55.00	95.20	2.34	3.60	7.00
40	0.92	0.99	1.05	0.62	0.65	0.76	33.00	55.50	67.80	2.65	2.86	4.14

Abbreviation: S/D, systolic to diastolic.

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