SRYAHWA PUBLICATIONS

Archives of Radiology
ISSN: 2638-521X | Volume 5, Issue 1, 2024
https://doi.org/10.22259/2638-521X.0501002

RESEARCH ARTICLE

Doppler Waveform Indices of Foetal Middle Cerebral Artery in Normal Pregnancies: Correlation with Gestational Age of 20 to 40 Weeks"

Panna Lal Saha[1], Misbah Uddin Ahmed[2], Syed Badrul Ahsan Apu[3], Afroza Bilkis Jahan[4], Mousumi Anuradha Sangma[5], Muhammad Mohsin[6], Biplab Kumar Podder[7]

[1]M Phil (Radiology & Imaging), thesis part, Dept. of Radiology & Imaging, Mymensingh Medical College, Myemensingh, Bangladesh
[2]Associate Professor and Head, Department of Radiology & Imaging, Mymensingh Medical College, Myemensingh, Bangladesh
[3]Medical Officer, Dept. of Radiology & Imaging, Mymensingh Medical College Hospital, Myemensingh, Bangladesh
[4]Radiologist, Dept. of Radiology & Imaging, Mymensingh Medical College Hospital, Myemensingh, Bangladesh
[5]Thesis part student of MD, Radiology & Imaging, Mymensingh Medical College, Myemensingh, Bangladesh
[6]Thesis Part Student of MD, Medicine, Mymensingh Medical College, Myemensingh, Bangladesh
[7]Radiologist, Department of Radiology and Imaging, 250 Beded General, Hospital, Tangail, Bangladesh

Received: 01 May 2024 Accepted: 15 May 2024 Published: 03 June 2024
Corresponding Author: Panna Lal Saha, M Phil (Radiology & Imaging), thesis part, Dept. of Radiology & Imaging, MMCH, Myemensingh, Bangladesh.

Abstract

Currently, evaluation of fetal vessels by Doppler ultrasound has become standard for antenatal care of high risk pregnancies. Foetal Middle Cerebral Artery Doppler flow velocity waveform indices measurement is a well known modality for detecting foetal compromise in all over the world. The purpose of the study was to determine gestational age-dependent Doppler waveform indices of the foetal Middle Cerebral Artery (MCA) including Resistive Index (RI), Pulsatility Index (PI), Systolic to Diastolic (S/D) ratio and Peak Systolic Velocity (PSV) in normal Bangladeshi obstetric population of 20 to 40 weeks gestation and correlation of these indices with the increment of gestational age. In this cross sectional study, 56 pregnant women with normal healthy pregnancy and gestational age of 20 to 40 weeks were investigated for foetal MCA Doppler examination. In this study it was observed that RI, PI and S/D ratio were decreased with the increment of gestational age and PSV was increased with the increment of gestational age. It was also observed from correlation analysis between dependent Doppler indices with independent gestational age that only PSV had positive relationship ($r = 0.652$) and other had negative relationship. All the correlations were statistically significant ($p< 0.0001$).

Keywords: Doppler waveform indices, Foetal Middle Cerebral Artery, Gestational age of 20 to 40 weeks.

1. Introduction

Now-a-days, Doppler Ultrasonography (DU) velocimetry of uteroplacental, umbilical and fetal vessels has become the established method for antenatal monitoring[1,2].Circulatory changes, reflected in certain fetal Doppler waveforms, predict adverse perinatal outcome[3]. There is an enormous growth in both technical aspects of Doppler ultrasound and its application as one of the popular imaging modalities in the department of Radiology and Imaging as well as to the physician to assay the condition of blood vessels and flow pattern in various diseases. In addition Doppler ultrasound has an important contribution to make to the surveillance of fetus compromised by intrauterine growth retardation (IUGR)[4,5,6]. The advent of color and pulsed Doppler

Citation: Panna Lal Saha, Misbah Uddin Ahmed, Syed Badrul Ahsan Apu, *et al.* Doppler Waveform Indices of Foetal Middle Cerebral Artery in Normal Pregnancies: Correlation with Gestational Age of 20 to 40 Weeks". Archives of Radiology. 2024;5(1): 11-17.

technique has permitted the use of Doppler ultrasound to assess foetal structural abnormalities and complex disease processes involving foetal anemia[7], twin–twin transfusion syndrome and nonimmune hydrops[8]. For obstetric and foetal purpose arcuate placental vessel of maternal part and uterine artery, aorta, middle cerebral artery, carotid, renal, ductous venosus of fetal part are examined. In experienced hands, waveforms from a number of foetal vessels predict the occurrences and timing of adverse events. Although umbilical arteries are the common vessels assessed by DU, recent studies have shown the efficacy of the Middle Cerebral Artery (MCA) Doppler assessment is important. Today, the MCA has emerged as the vessel of choice in the Doppler assessment of fetal intracranial as well as other organs perfusion[9]. Some studies showed that MCA blood flow abnormalities were associated with hypoxia, adverse perinatal outcome and suboptimal neurodevelopment. Thus, its evaluation by Doppler ultrasonogram has become standard for antenatal care of high risk pregnancies such as those suspected to affect by growth restriction, multiple pregnancies, pregnancy induced hypertension, fetal anaemia, Rh immunization, hydrops foetalis and foetal malformations. Applicability of Doppler indices in the diagnosis of abnormalities is possible only when there are reference normal values for each index. Although various investigators have described and established gestational age-related reference curves, the objective of this study was to determine new DU gestational age-dependent reference curves for the MCA indices including RI, PI, S/D ratio and PSV in a normal Bangladeshi obstetric population of 20 to 40 weeks' gestation and correlation of the indices with gestational age will be helpful to the obstetrician for assessment of early foetal outcome.

2. Materials and Methods

This descriptive cross-sectional study was carried out on 56 normal, healthy singleton pregnancies in the department of Radiology and Imaging, MMCH from July 2013 to June 2014. Accurate gestational age was based on last normal menstruation date adapted with ultrasound parameters.

The objectives of the study were discussed in details before their decision to enroll themselves into the study. Demographic information was prospectively recorded. Information included the subject's age, clinical history of disease and ultrasonography of pregnant women to measure foetal MCA Doppler indices.

The ultrasonography was performed first by the investigator himself and subsequently confirmed by a consultant radiologist of the department. The examination was done by Medison, Sonoace X8 with a convex and a curvilinear probe of 3.5 MHz. Doppler examinations were performed on the women placed in a recumbent or semi recumbent position. Prior to Doppler assessment, all of the women underwent gray scale ultrasonography for pregnancy profile [Head Circumference (HC), Abdominal Circumference (AC), Femur Length (FL), and Biparietal Diameter (BPD)]. Estimated fetal weight was calculated according to Hadlock formulas that were built in the machine. Normal fetal growth was confirmed by comparing with the growth chart (between 10^{th} and 90^{th} percentiles). To measure the MCA, an ultrasound scan of the foetal head was performed to obtain a transverse view at the level used usually to measure BPD and the MCA was easily demonstrated as a major branch of circle of Willis. After localization of the MCA by color Doppler flow, velocity was measured from proximal portion of MCA. When the best quality was obtained for flow velocity waveforms, foetal MCA color flow measure was applied and then flow velocity was measured. First PSV and EDV were measured and then PI, RI and S/D were calculated.

After collecting all the data, mean PSV, mean RI, mean PI and mean S/D of foetal MCA were calculated and recorded in the data collection sheet. The mean value was measured using scientific calculator using standard statistical formula. The results were presented in tables and figures. Significance of difference of the Doppler indices values and gestational age was calculated using independent "t" test. Correlation between Doppler indices values and gestational age was observed. Simple regression was carried out to explore the relationship between dependent Doppler values and independent gestational age by computer software "Statistical Package for the Social Sciences" (SPSS). Level of significance i.e. 'p' value was considered <0.05 ($p<0.05$).

3. Results

Sample size was 56 healthy pregnant women, among them 10 had gestational period less than 25 weeks, whereas 46 pregnant women had gestational period of over 25 weeks. Age distribution of total 56 study subjects showed that mean age of the study subjects was 23.57(SD±7.41) years and their age ranged from 18 to 40 years. The majority (42.9%) of the study subjects were from 20-24 years age group.

Table I. *Values of Doppler Indices in different weeks of gestation*

Pregnancy in weeks	EFW	PSV	S/D ratio	RI	PI
	Mean±SD (Max-Min)	Mean±SD (Max-Min)	Mean±SD (Max-Min)	Mean±SD (Max-Min)	Mean±SD (Max-Min)
20	311.00±0.00	17.45±4.14	4.49±0.44	0.78±0.02	1.59±0.06
	311-311	20.37-14.52	4.80-4.18	0.79-0.76	1.63-1.55
21	394.00±0.00	22.81±3.06	5.99±6.73	0.93±0.03	2.09±0.44
	394-394	24.97-20.64	10.75-1.23	0.95-0.91	2.40-1.78
22	-	20.64±0.00	10.75±0.00	0.91±0.00	1.78±0.00
	-	20.64-20.64	10.75-10.75	0.91-0.91	1.78-1.78
23	586.00±0.00	25.67±1.73	8.53±3.29	0.87±0.06	2.07±0.37
	586-586	27.30-23.86	11.50-5.00	0.91-0.80	2.42-1.69
24	568.50±24.75	32.30±9.10	19.06±10.69	0.94±0.04	2.40±0.44
	586-551	38.73-25.86	26.62-11.50	0.96-0.91	2.71-2.09
25	697.50±58.69	38.13±9.19	42.60±52.90	0.90±0.13	2.35±0.62
	739-656	44.62-31.63	80.00-5.19	0.99-0.81	2.78-1.91
26	826.00±0.00	26.11±0.00	6.07±0.00	0.84±0.00	1.98±0.00
	826-826	26.11-26.11	6.07-6.07	0.84-0.84	1.98-1.98
27	910.00±0.00	54.40±0.00	28.67±0.00	0.97±0.00	2.81±0.00
	910-910	54.40-54.40	28.67-28.67	0.97-0.97	2.81-2.81
28	1079.25±80.25	45.17±9.62	12.42±11.83	0.88±0.07	2.19±0.28
	1152-981	56.93-35.59	30.00-5.42	0.97-0.82	2.57-1.90
29	1296.67±29.91	41.93±7.23	13.43±3.77	0.92±0.02	2.72±0.17
	1329-1270	46.53-33.60	17.78-11.20	0.95-0.91	2.85-2.53
30	1515.33±36.35	45.62±4.41	13.88±8.07	0.91±0.06	2.48±0.23
	1556-1486	50.60-42.22	22.43-6.40	0.96-0.84	2.73-2.27
31	1538.40±70.18	48.91±7.07	13.51±9.33	0.90±0.06	2.32±0.26
	1645-1481	58.59-39.12	29.67-5.52	0.97-0.81	2.62-1.93
32	1745.00±79.05	50.10±7.24	7.62±2.44	0.82±0.06	2.01±0.44
	1833-1680	56.00-42.02	9.77-4.97	0.88-0.77	2.52-1.76
33	1790.00±0.00	49.38±0.00	3.29±0.00	0.70±0.00	1.29±0.00
	1790-1790	49.38-49.38	3.29-3.29	0.70-0.70	1.29-1.29

34	1989.50±208.14	51.86±18.52	6.97±1.27	0.85±0.03	2.16±0.20
	2216-1722	69.38-26.11	8.33-5.71	0.88-0.82	2.42-1.98
35	2446.50±12.77	42.24±3.30	3.93±0.57	0.77±0.04	1.68±0.28
	2465-2438	46.88-39.32	4.54-3.38	0.81-0.72	1.90-1.30
36	2513.25±272.50	67.17±14.83	7.35±5.19	0.75±0.09	1.49±0.32
	2772-2132	86.35-50.36	14.15-2.97	0.88-0.66	1.92-1.16
37	2837.33±137.15	62.96±9.19	4.36±1.49	0.75±0.09	1.48±0.30
	2913-2559	74.21-52.49	6.89-2.48	0.85-0.60	1.86-1.00
38	2732.00±0.00	87.11±0.00	4.72±0.00	0.79±0.00	1.59±0.00
	2732.- 2732	87.11-87.11	4.72-4.72	0.79-0.79	1.59-1.59
39	3078.00±371.94	83.39±11.91	3.78±0.25	0.74±0.02	1.41±0.11
	3341-2815	91.81-74.97	3.95-3.60	0.75-0.72	1.48-1.33
40	2975.00±408.71	62.82±3.54	2.75±0.38	0.64±0.05	1.10±0.11
	3264-2686	65.32-60.32	3.02-2.48	0.67-0.60	1.18-1.02

**EFW= Estimated foetal weight, PSV= Peak systolic volume, S/D= Systolic to diastolic ratio, RI= Resistance Index, PI= Pulsatility Index.

Table 2. *Table showing Doppler Indices of foetal MCA before and after 25 weeks with statistical test results*

	Before 25 weeks				After 25 weeks				P value	Level of significance
Doppler Indices	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**		
PSV	24.28	6.33	14.52	38.73	53.19	15.09	26.11	91.81	0.0001	**
S/D ratio	9.54	7.02	1.23	26.62	10.05	12.62	2.48	80.00	0.904	NS
RI	0.88	0.07	0.76	0.96	0.82	0.10	0.60	0.99	0.080	NS
PI	2.01	0.39	1.55	2.71	1.95	0.53	1.00	2.85	0.705	NS

** Highly significant, * = Significant, NS= Not significant. P<0.05 was considered as significant. Unit of PSV was cm/sec. Rest of the indices did not any unit. PSV= Peak systolic volume, RI= Resistance Index, PI= Pulsatility Index, S/D= Systolic to diastolic ratio.

Table 3. *Correlation analysis between dependent Doppler indices with independent gestational age before & after 25 weeks*

Doppler Indices	Before 25 weeks		After 25 weeks	
	r value	**Level of significance**	**r value**	**Level of significance**
PSV	0.766	0.010**	0.807	0.0001**
S/D ratio	0.648	0.043*	-0.297	0.026*
RI	0.523	0.121NS	-0.593	0.0001**
PI	0.603	0.065NS	-0.486	0.0001**

** Highly significant, * = Significant, NS= Not significant. P<0.05 was considered as significant. Unit of PSV was cm/sec. Rest of the indices did not any unit. PSV= Peak systolic volume, RI= Resistance Index, PI= Pulsatility Index, S/D= Systolic to diastolic ratio.

Table 4. *Correlation analysis between dependent Doppler indices with independent gestational age from 20 to 40 weeks*

Doppler Indices	r value	Level of significance
PSV	0.652	0.0001**
S/D ratio	-0.510	0.0001**
RI	-0.711	0.0001**
PI	-0.749	0.0001**

** Highly significant, * = Significant, NS= Not significant. P<0.05 was considered as significant. Unit of PSV was cm/sec. Rest of the indices did not any unit. PSV= Peak systolic volume, RI= Resistance Index, PI= Pulsatility Index, S/D= Systolic to diastolic ratio.

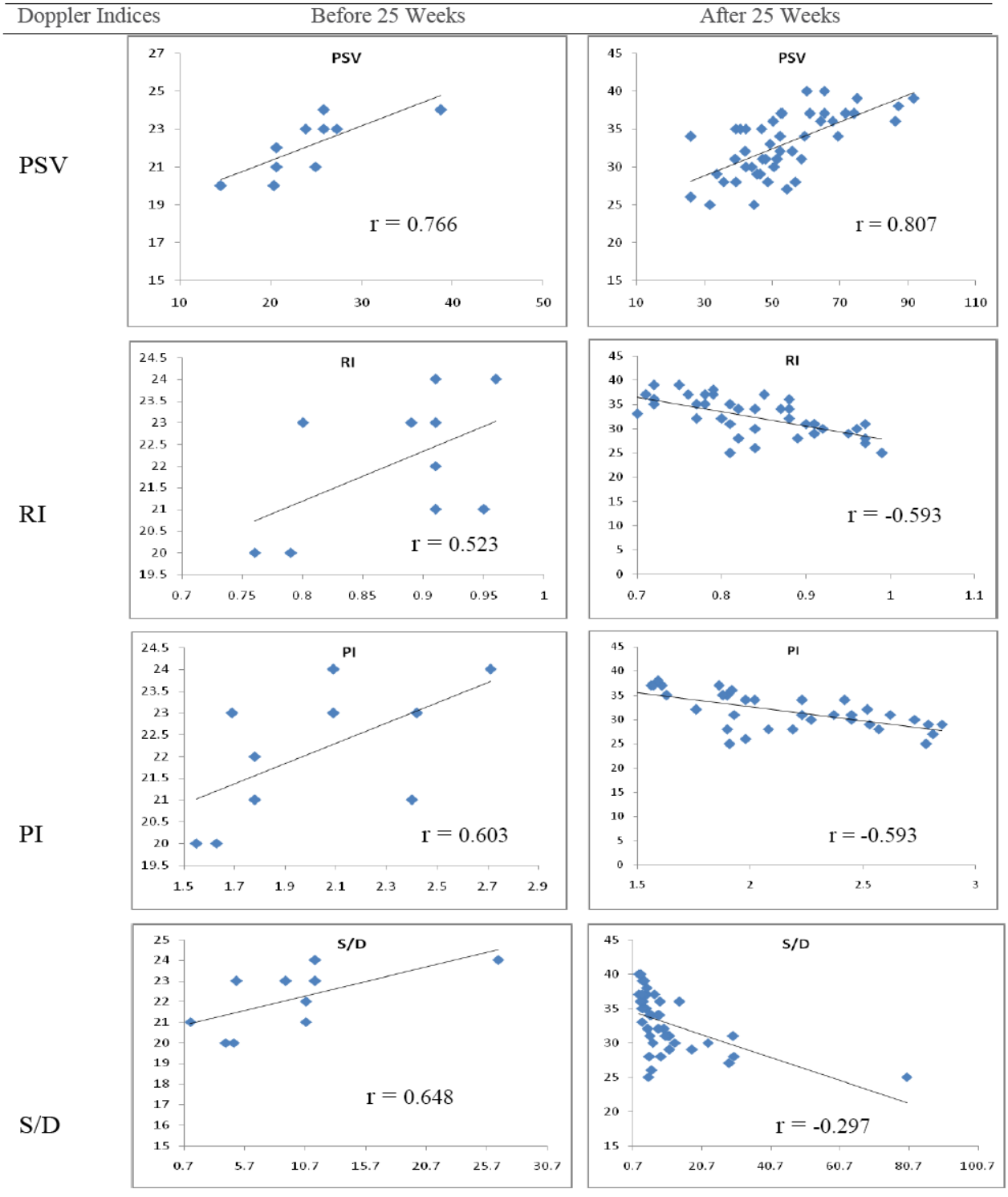

Figure 1. *Regression analysis between dependent Doppler indices with independent gestation age before and after 25 weeks.*

4. Discussion

In foetal intracranial circulation, diastolic blood flow appears earlier than the fetal aorta and umbilical artery representing redistribution of the flow to the most vital fetal organ. Also, comparing changes in the fetal cerebral circulation with changes in the systemic circulation or the umbilical arteries have shown that foetal cerebral circulation changes to be more promising as a predictor of the condition of the foetus[10]. So, the MCA has been the vessel of choice to assess fetal cerebral circulation. Measuring foetal MCA Doppler waveform indices (RI, PI, S/D and PSV) & correlation with normal values according to gestational age will be helpful to the obstetrician for assessing foetal condition. Seri et al.[11], showed that the gestational age and birth weight below which infants were too immature to survive, and thus the provision of intensive care was unreasonable, appeared to be at <23 weeks and less than 500 g. respectively. Infants both at ≥ 25 weeks of gestation and with a birth weight of ≥ 600 g. were mature enough to warrant initiation of intensive care, as the majority of these patients survived, and at least 50 % did so without severe long-term disabilities. So in the study the age of viability considered as 25 weeks and the Doppler indices observations were categorized in two groups (less than 25 weeks groups and more than 25 weeks). The foetal MCA PSV has been suggested as a potential test to predict the foetal haematocrit level. The presence of a raised PSV is a strong indicator of foetal anaemia. A low level haematocrit is associated with an increase in MCA PSV. Regarding PSV in this study it was seen that mean (±SD) PSV was 24.28 (±6.33) cm/sec before 25 weeks. After 25 weeks mean PSV was 53.19 cm/sec (SD±15.09). Before 25 weeks minimum and maximum PSV was 14.52 cm/sec and 38.73 cm/sec respectively. After 25 weeks minimum and maximum PSV was 26.11 cm/sec and 91.81 cm/sec respectively. Thus PSV had positive correlation with increment of gestational age (r value 0.807 and level of significance 0.0001). This increase in PSV with the increment of gestational age is consistent with the study conducted by Bahlmann et al[9]. and Ebrashy et al[12] demonstrated a continuous increase of MCA PSV over the period from 18 to 40 and 19 to 41 weeks of gestation respectively. In current study, foetal MCA RI (expressed as Mean ±SD) was 0.88±0.07 before 25 weeks and 0.82±0.10 after 25 weeks. RI was ranged from 0.76 to 0.96 and 0.60 to 0.99 before and after 25 weeks respectively. RI had negative correlation (r value = -0.711) with increase of gestational age. Minimum RI value was 0.618 at 42nd week and maximum RI value was 0.803 at 28 th week in the study carried out by Bahlmann et al[9] and the result was somewhat similar with this study. In my study, foetal MCA PI it was found that it ranged from 1.55 to 2.71 before 25 weeks and mean (±SD) was 2.01±0.39 and after 25 weeks it was ranged from 1.00 to 2.85, mean was 1.95 ±0.53. PI had negative correlation with increase of gestational age (r value = -0.749). Komwilaisak et al[13] observed the MCA PI decrease as gestational age advanced from 20 weeks [1.97 (SD 0.48)] to 37 weeks [1.15 (SD 0.18)]. Statistical analyses was similar between the present study and the study carried out by Komwilaisak et al.[13] The fall in the fetal MCA PI after 25th week of gestation was probably reflect a decreasing vascular resistance with increasing gestational age or correlation with deoxyribonucleic acid production in fetal brain. Mean (±SD) S/D ratio was 9.54 (±7.02) before 25 weeks and 10.05 (±12.62) after 25 weeks. S/D ratio also had negative correlation with increase of gestational age, particularly after 25 weeks of gestation. The principal reason for this was decreasing age especially at the end of pregnancy that accompanying by blood flow volume increasing. Statistical analysis showed no significant difference between mean S/D ratio before and after 25 weeks of gestation. But this statistical analysis was related with the study carried out by Manning et al[14] and Sunsaneevithayakul et al[15]. However, several aspects of Doppler studies are limiting. These include lake of complete Doppler flow information, prone to aliasing and quite sensitive to wrong manipulation, so that well trained and experienced sonographers are required. As the study was done on limited number of population we feel that this study should be conducted on a wider scale and in population who reside in different geographic localities.

5. Conclusion

In this study it can be concluded that PI, RI and S/D were decreased and PSV was increased with increment of gestational age. So, from the finding of the present work it was conceivable that, by duplex color Doppler sonography foetal MCA indices can be measured and compairing with the normal reference values according to gestational age early foetal abnormality can be detected, that can help to prevent adverse perinatal outcome.

6. References

1. Dubiel M, Breborowicz GH, Marsal K, Gudmundsson S. Fetal adrenal and middle cerebral artery Doppler velocimetry in high-risk pregnancy. Ultrasound Obstet Gynecol. 2000; 16 : 414 -418
2. Gagnon R, Hof MV. The Use Of Fetal Doppler In Obstetrics. J Obstet Gynaecol.2003; 25(7):601-607
3. Baschat AA, Gembruch U. The cerebroplacental Doppler ratio revisited. Ultrasound Obstet Gynecol. 2003; 21:124 – 127
4. Mari G, Hanif F, Kruger M, Cosmi E, Santola-Forgas J, Teadwell MC. Middle cerebral artery peak systolic velocity: a new Doppler parameter in the assessment of growth-restricted fetuses. Ultrasound Obstet Gynecol. 2007; 29: 310–316
5. Berkley E, Chauhan SP, Abuhamad A. Doppler assessment of the fetus with intrauterine growth restriction. American Journal of Obstetrics and Gynecology. 2012April; 300-307
6. Mari G, Hanif F. Fetal Doppler: Umbilical Artery, Middle Cerebral Artery, and Venous System. Semin Perinatol. 2008; 32: 253-257
7. Kachewar SG, Gandage SG, Pawer HJ. An Indian Study Of A Novel Non-Invasive Method Of Screening For Foetal Anaemia. Journal of Clinical and Diagnostic Research. 2012; 6: 688-691
8. Tarzamni MK, Sobhani NNN, Eshraghi N, Tarzamni M, Talebi Y. Nomograms of Iranian fetal middle cerebral artery Doppler waveforms and uniformity of their pattern with other populations' nomograms. BMC Pregnancy and Childbirth. 2008; 8: 50-62
9. Bahlmann F, Reinhard I, Krummenauer F, Neubert S, MacChiella D, Wellek S. Blood flow velocity waveforms of the fetal middle cerebral artery in a normal population: reference values from 18 weeks to 42 weeks of gestation. J Perinat Med. 2002; 30:490 – 501.
10. Arduini D, Rizzo G. Prediction of fetal outcome in small for gestational age fetuses: comparison of Doppler measurements obtained from different fetal vessels. J Perinat Med. 1992; 20: 29-38.
11. Seri I, Evans J. Limits of viability: definition of gray zone. Journal of Perinatology. 2008; 28: S4-S8.
12. Ebrashy A, Azmy O, Ibrahim M, Waly M, Edris A. Middle Cerebral/ Umbilical Artery Resistance Index Ratio as Sensitive Parameter for Fetal Well-being and Neonatal Outcome in Patients with Preeclampsia: Case-control Study. Croat Med J. 2005; 821-825
13. Komwilaisak R, Saksiriwuttho P, Ratanasiri T, Kleebkaow P, Seejorn K. Pulsatility index of the middle cerebral artery in normal fetuses. J Med Assoc Thai. 2004; 87: S34-S37.
14. Manning FA, Morrision I, Harmen CR, Lange IR, Menticoglo S. Fetal assessment based on fetal biophysical profile scoring: Experience in 19221 referred high-risk pregnancies. Am J Obstet Gynecol. 1987; 157: 880-884.
15. Sunsaneevithayakul P, Siwadune T, Boriboonhirunsarn D, Titapant V, Sutuntavibul A. Reference centile charts for fetal umbilical artery Doppler velocimetry waveform of thai fetuses. Thai J Obstet Gynaecol. 2000; 12: 201-211.