Pulsatility Index of the Middle Cerebral Artery in Normal Fetuses

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Objective : *To establish the reference ranges of the middle cerebral artery pulsatility index (MCA PI) in normal fetuses between 20 and 37 weeks gestation.*
Study design : *A descriptive study.*
Setting : *Antenatal Care Clinic, Outpatient department, Faculty of Medicine, Srinagarind Hospital, Khon Kaen University.*
Subjects : *At least sixteen women of each gestational age with an uncomplicated singleton pregnancy between 20 and 37 weeks gestation.*
Method : *All recruited pregnant women were enrolled for abdominal Doppler ultrasonography to determine fetal MCA PI for each week of gestational age.*
Main outcome measures : *The MCA PI reference range for normal fetuses between 20 and 37 completed weeks of gestation.*
Results : *The MCA PI decreased as gestational age advanced from 1.97 (SD 0.48) at 20 weeks to 1.15 (SD 0.18) at 37 weeks.*
Conclusion : *We established the reference ranges of the fetal MCA PI for reference use in our Antenatal Care Clinic.*

Keywords : *Pulsatility index, Middle cerebral artery, Doppler ultrasound*

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The antenatal assessment of intrauterine growth restriction (IUGR) should be an important goal for every obstetrician because significant fetal or neonatal complications may be associated with diminished fetal growth. We found that the rate of perinatal mortality and morbidity is between 3 to 10 folds greater than normal fetuses[1]. This condition can also increase fetal distress, meconium aspiration, hypoglycemia, hypothermia and polycytemia, which all lead to abnormal physical and mental development. There are two ways to detect IUGR by ultrasonography, first, estimated fetal weight measured by ultrasonic parameters such as head circumference (HC), abdominal circumference (AC) and femur length (FL). This is one of the most common and logical methods of identifying IUGR[2]. The second and best way is by using Doppler evaluation of other fetal vessels. Of the two, the second way has the earliest detection rate. We believed that early prenatal diagnosis and appropriate treatment of IUGR decreases perinatal mortality and morbidity.

In normal pregnancy, middle cerebral artery (MCA) resistance decreases as gestational advances but in IUGR we found that MCA resistance abnormally decreases as brain sparing effect progresses[2]. For this reason, abnormally decreasing fetal circulatory resistance can be detected before IUGR detection.

There was no middle cerebral artery pulsatility index (MCA PI) reference range in a Thai population. The aim of this study was to establish the reference ranges of the MCA PI in normal fetuses with gestational age between 20 and 37 weeks. This study was approved by Khon Kaen University Ethics committee.

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Subjects and Method

During February 1,2003 and July 31, 2003, a total of at least 16 pregnant women for each gestational age calculated by the formula

$$N = Z^2_{\alpha}(SD)^2 = \frac{(1.96)^2}{D^2} \times \frac{(0.26)^2}{(0.13)^2}$$

with the total of 312 uncomplicated singleton pregnancies were recruited from the Antenatal Care Clinic at Srinagarind hospital, Khon Kaen University. All were given the information sheet and gave fully informed consent. Gestational age which between 20 and 37 weeks was calculated from the first day of the last normal menstrual period without hormonal contraception. In case of taking hormonal contraception, gestational age was confirmed by ultrasonographic measurement in the first twelve weeks of gestation. Fetal anomalies, abnormal fetal karyotype and maternal conditions which may affect fetal growth were excluded from this study. All the subjects had given birth of normal baby with no IUGR.

A 5 MHz transducer (Aloka SSD 2000) was used to obtain the pulse range-gated Doppler signal from the fetal MCA by only one ultrasonographer.

While the pregnant women lay semirecombent, using trans-abdominal ultrasonography. A transverse view of the fetal brain was obtained at the level of the biparietal diameter. The transducer was then directed towards the base of the skull at the level of the lesser wing of the sphenoid bone. The middle cerebral artery could be seen as a major branch of the circle of Willis. The Doppler sample was then placed at the middle one third, so the angle was not more than 20 degrees. When flow velocity waveforms of satisfactory quality has been obtained, at least three waveforms were measured by the investigator and averaged.

Means and 2SD of the fetal MCA PI was calculated for gestational week 20 to 37, respectively. Then we constructed a curve of normal value for each gestational age using mean + 2SD.

Results

Three hundred and twelve healthy pregnant women were enrolled for this study. The MCA PI was successfully measured in all subjects between 20 and 37 weeks of gestation. The mean MCA PI diminished as gestational age advanced from 1.97(SD 0.48) at 20 weeks to 1.15(SD0.18). Reference ranges (mean+2SD) of fetal MCA PI with gestation were established. The greatest decrease in MCA PI was between 32 and 37 weeks as shown in Fig.1

Table 1. shows patient characteristics.

Table 2. demostrates the number of the subjects for each gestation.

Table 3. shows mean, standard deviation, ranges and mean+2SD of the MCA PI

Discussion

The MCA is the vessel of choice to assess fetal cerebral circulation, as this vessel is straight, fixed and easy to identify allowing minimization of the Doppler angle. In fetal circulation, diastolic blood flow becomes present earlier compared to the fetal aorta and umbilical artery representing the redistribution of

Table 1. Patient characteristics

	No	%
Age (years)		
20-35	302	96.79
> 35	10	3.21
Mean age	26.38	
Gravidity		
1	146	46.80
2	122	39.10
3	34	10.90
4	10	3.20
Term parity		
0	169	54.17
1	120	38.46
2	20	6.41
3	3	0.96
Preterm parity		
0	306	98.08
1	6	1.92
2	0	0
Abortion		
0	272	87.18
1	33	10.58
2	7	2.24
Living child		
0	172	55.13
1	117	37.50
2	23	7.37
Types of contraception		
None	193	61.86
Oral pill	71	22.76
Intrauterine device	12	3.85
Injection	21	6.73
Condom	15	4.80
Duration of hormonal contraceptive termination before pregnancy		
< 3 months*	48	52.17
≥ 3 months	44	47.83

* Ultrasonographic measurement in the first twelve weeks of gestation

Table 2. Numbers of subject

Gestational ages (weeks)	No	%
20	16	5.13
21	16	5.13
22	16	5.13
23	16	5.13
24	18	5.77
25	22	7.05
26	16	5.13
27	17	5.45
28	18	5.77
29	16	5.13
30	17	5.45
31	19	6.09
32	20	6.41
33	18	5.77
34	17	5.45
35	17	5.45
36	17	5.45
37	16	5.13
312	100	

Table 3. Mean, standard deviation, ranges and mean±2SD of the MCA PI

Gestational age (weeks)	Pulsatility index			
	Mean (X)	Standard deviation (SD)	Ranges	X ± 2SD
20	1.97	0.48	1.21-3.10	1.97±0.96
21	2.06	0.41	1.03-2.57	2.06±0.82
22	2.00	0.37	1.22-2.54	2.00±0.74
23	2.06	0.38	1.46-2.68	2.06±0.76
24	2.11	0.28	1.61-2.96	2.11±0.56
25	2.01	0.53	1.33-3.07	2.01±1.06
26	2.10	0.34	1.66-2.70	2.10±0.68
27	2.08	0.39	1.36-2.64	2.08±0.78
28	1.95	0.42	1.30-2.93	1.95±0.84
29	1.97	0.34	1.33-2.75	1.97±0.68
30	1.94	0.55	1.28-3.14	1.94±1.10
31	1.69	0.39	0.81-2.54	1.69±0.78
32	1.76	0.36	1.20-2.48	1.76±0.72
33	1.80	0.41	0.76-2.43	1.80±0.82
34	1.55	0.40	0.74-2.45	1.55±0.80
35	1.47	0.23	1.09-1.89	1.47±0.46
36	1.36	0.37	0.77-2.46	1.36±0.74
37	1.15	0.18	0.75-1.33	1.15±0.36

the flow in the most vital fetal organ[3]. Reference values for indices derived from the flow velocity waveforms of the fetal umbilical artery in uncomplicated pregnancies have previously been recorded[4,5]. But we felt the need to establish reference values of

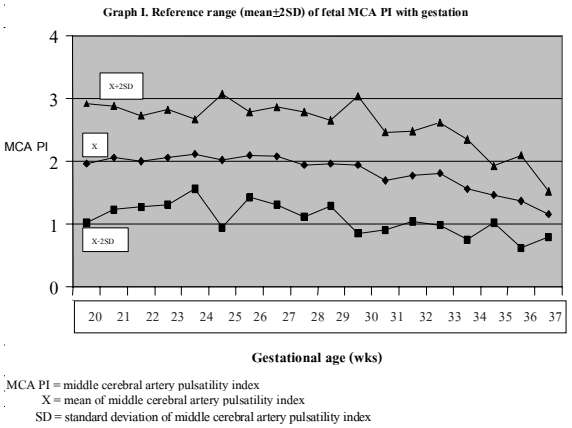

Fig. 1 Reference range (mean±2SD) of fetal MCA PI with gestation

the fetal MCA PI for our own antenatal population. However, several aspects of Doppler studies are limiting. These include lack of complete Doppler flow information, prone to aliasing and quite sensitive to wrong manipulation[6], so that well trained and experienced sonographers are required. The cerebral blood flow may also be influenced with different conditions rather than hypoxemia alone. These are high fetal heart rate, post transfusion syndrome, amniocentesis which will lower MCA impedance while uterine contractions, low heart rate, fetal head compression and indomethacin therapy are associated with higher impedance[3].

There was a fall in the fetal MCA PI with advancing gestational age which is comparable to other studies[7-9]. This decrease was probably reflected a decreasing vascular resistance with increasing gestational age[7] or correlation with deoxyribonucleic acid production in fetal brain[9].

Unequal sample size for each gestational did not discredit our data because the sample size, at least sixteen pregnancy women for each gestation, was adequately calculated.

The strengths of this study were first, an adequate sample size. Second, we were able to measure at all gestational age from 20 to 37 weeks. Third, we used only one ultrasonologist to avoid inter-observer variation. And lastly, we used only one ultrasonography and one trans-abdominal transducer to avoid equipment's variation. The reference values of the MCA PI from this study can be used in the evaluation and management of fetal situations such as intrauterine growth restriction and fetal anemia[10,11].

However, we study in cross sectional rather than longitudinal measurement due to time's limitation.

We think longitudinal study was considered necessary if it is possible.

In conclusion, reference range of MCA PI was established for reference use in our Antenatal Care Clinic.

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ค่า Pulsatility index ของหลอดเลือด middlecerebral artery ในกลุ่มทารกปกติ

รัตนา คำวิลัยศักดิ์, ปิยะมาศ ศักดิ์ศิริวุฒโฒ, ถวัลย์วงค์ รัตนสิริ, พิไลวรรณ กลีบแก้ว

วัตถุประสงค์ *: เพื่อศึกษาค่าpulsatility index ของหลอดเลือด middle cerebral artery ในกลุ่มทารกปกติที่มีอายุครรภ์ตั้งแต่ 20-37 สัปดาห์*

ชนิดของการวิจัย *: การวิจัยเชิงพรรณนา (descriptive study)*

สถานที่ที่ทำวิจัย *: ห้องตรวจครรภ์ แผนกผู้ป่วยนอก คณะแพทยศาสตร์ โรงพยาบาลศรีนครินทร์ มหาวิทยาลัยขอนแก่น*

กลุ่มตัวอย่าง *: สตรีตั้งครรภ์เดี่ยว สุขภาพแข็งแรง มีอายุครรภ์ตั้งแต่ 20-37 สัปดาห์ ที่ตรวจไม่พบความผิดปกติของทารกในครรภ์ อย่างน้อย 16 คนต่อหนึ่งอายุครรภ์*

วิธีการวิจัย *: นำสตรีตั้งครรภ์ที่มีลักษณะตามเกณฑ์เข้ารับการตรวจคลื่นเสียงความถี่สูงชนิดดอปเปลอร์เพื่อหาค่า pulsatility index ของหลอดเลือด middle cerebral artery ของทารกปกติในครรภ์*

ตัววัดที่สำคัญ *: ค่า pulsatility index ของหลอดเลือด middle cerebral artery ในกลุ่มทารกปกติที่มีอายุครรภ์ตั้งแต่ 20-37 สัปดาห์*

ผลการวิจัย *: ค่า pulsatility index ของหลอดเลือด middle cerebral artery ในกลุ่มทารกปกติที่มีอายุครรภ์ตั้งแต่ 20-37 สัปดาห์ มีค่าลดลงตามอายุครรภ์ที่เพิ่มขึ้นจาก 1.97 (SD 0.48) ที่อายุครรภ์ 20 สัปดาห์ถึง 1.15 (SD 0.18) ที่อายุครรภ์ 37 สัปดาห์*

สรุป *: ได้ตารางและกราฟที่แสดงค่า pulsatility index ของหลอดเลือด middle cerebral artery ในกลุ่มทารกปกติที่มีอายุครรภ์ตั้งแต่ 20-37 สัปดาห์สำหรับใช้อ้างอิง ณ ห้องตรวจครรภ์ แผนกผู้ป่วยนอก คณะแพทยศาสตร์ โรงพยาบาลศรีนครินทร์ มหาวิทยาลัยขอนแก่น*