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RESEARCH ARTICLE

# Peak systolic velocity Doppler of middle cerebral artery in small for gestational age (SGA) fetus

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**BACKGROUND:** Small for gestational age (SGA) has high frequency which increases the risk of long-term adverse outcomes. Thus the aim of this study was to evaluate peak systolic velocity Doppler of middle cerebral artery (MCA) in SGA fetus in order to find appropriate method to diagnosis SGA sooner.
**MATERIALS and METHODS:** This prospective longitudinal study was conducted on 90 pregnant women with a diagnosis of SGA fetus and 90 pregnant women with normal fetus. Then MCA and umbilical artery assessment were performed for all subjects and compared between two groups.
**RESULTS:** Doppler assessment showed that umbilical artery PI was significantly higher in SGA group as compared to normal group ($1.11 \pm 0.37$ vs $0.98 \pm 0.18$, $P = 0.003$), while MCA PI was significantly lower in SGA group ($1.77 \pm 0.44$ vs $1.92 \pm 0.47$, $P = 0.028$). On the other hand, PSV did not differ between the groups ($P = 0.592$). Moreover, we found that PSV was more in SGA group by grouping maternal age ($< 27$ years) ($P = 0.006$), and gestational age ($> 34$ weeks) ($P < 0.001$).
**CONCLUSION**: The results of this study suggest that MCA PI decreased significantly in SGA fetuses, while UA PI increased in this group. Moreover, PSV increased in this group when evaluated in different subgroups (based on maternal age and gestational age).

**Keywords** small for gestational age, middle cerebral artery, peak systolic velocity

## Introduction

Small for gestational age (SGA) has been defined as the 10th percentile in a growth chart (Ropacka-Lesiak, 2012), which is approximately 40% of non-anomalous singleton stillbirths (Gardosi et al., 2005; PMMRC, 2012). SGA increases the risk of long-term adverse outcomes such as abnormal neuromotor development and cardiovascular disorders. (Lobmaier et al., 2014) However, the prevalence of SGA is high and it makes adverse outcomes in future for infant, but the majority of SGA pregnancies are not identified before birth (Wright et al., 2006; McCowan et al., 2010; Roex et al., 2012). On the other hand, recognizing SGA before delivery, significantly decreased severe morbidity/mortality of SGA (more than 4-fold reduction). (Lindqvist and Molin, 2005) Therefore, finding a new noninvasive method with high sensitivity and specificity in detection SGA before delivery is necessary.

Doppler velocimetry is the most frequently used non-invasive method in clinical practice to identify fetal condition and fetal-placental circulations (Hecher et al., 2001), which may be used in the early detection of defective placentation, and restricted fetal development. (Cruz-Martinez and Figueras, 2009) Although umbilical arteries are the common vessels evaluated by Doppler ultrasonography, recent studies confirm the efficacy of middle cerebral artery (MCA) Doppler assessment of fetal circulation, fetal condition, and fetal organs perfusion (Bahlmann et al., 2002; Kassanos et al., 2003; Hernandez-Andrade et al., 2004), which may predict SGA. As to best of our knowledge, there isn't enough prospective study about this issue, on the other hand, some limited studies performed have antithesis results, and therefore, this study was designed to evaluate the efficacy of peak systolic velocity Doppler of MCA in SGA fetus.

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## Methods and materials

### Study design and target group

This prospective longitudinal study was conducted in Obstetrics and Gynecology of Ahvaz Imam Hospital, southwest of Iran from November 2015 to May 2016. All the fetus with SGA, were enrolled in the study. Inclusion criteria consisted of pregnant woman with singleton fetus referred to Obstetrics and Gynecology clinic of Ahvaz Hospitals with a diagnosis of SGA (based on ultrasound biometry, estimated fetal weight (EFW) and abdominal circumference (AC) $<$ 10th percentile in a growth chart with normal anatomy) and control group consisted of pregnant woman with normal fetus (based on EFW and AC $>$ 10th percentile in a growth chart with normal anatomy). Exclusion criteria consisted of multiple pregnancy, congenital abnormalities, and placental abruption, oligohydramnios, biophysical profile $<$ 6, RH sensitization, present fetal distress.

### Participants

The study flowchart is shown in Fig. 1. During one year, 185 pregnant women were included that 5 cases were excluded and finally Doppler ultrasonography was performed for 180 pregnant women (90 pregnant women with a diagnosis of SGA fetus, who had been diagnosed by obstetrics and gynecology specialist and based on inclusion and exclusion criteria and 90 pregnant women with normal fetus). The study received ethics approval from the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (IR.AJUMS.REC.1395.720), and all participants gave written informed consent.

Routine obstetric ultrasonography was performed for each subject and then Doppler assessment was done for both groups. Doppler examinations were performed by perinatal group in Imam Obstetrics & Gynecology Hospital by 3.5 MHz convex transducer. MCA and umbilical artery assessment were performed, when subjects placed in a recumbent or semirecumbent position. To eliminate signals from slowly moving organs, we set high-pass filter at 50–100 Hz. The power was set $<$ 50 mW/cm$^2$ and the sample volume was set 2–3 mm for the MCA. To obtain an insonation angle, the angle between the direction of blood flow and sound radiation was as close as possible to 0°, and always $<$ 20°. We avoid to perform any unnecessary pressure on the fetal head. All mentioned stages were performed for three times. To evaluate the MCA, the transducer was moved toward the base of the skull of fetus at the level of the lesser wing of the sphenoid bone to identify the circle of Willis (as a major branch of the circle of Willis). After localization of the MCA, peak systolic velocity was measured from proximal portion of MCA. After

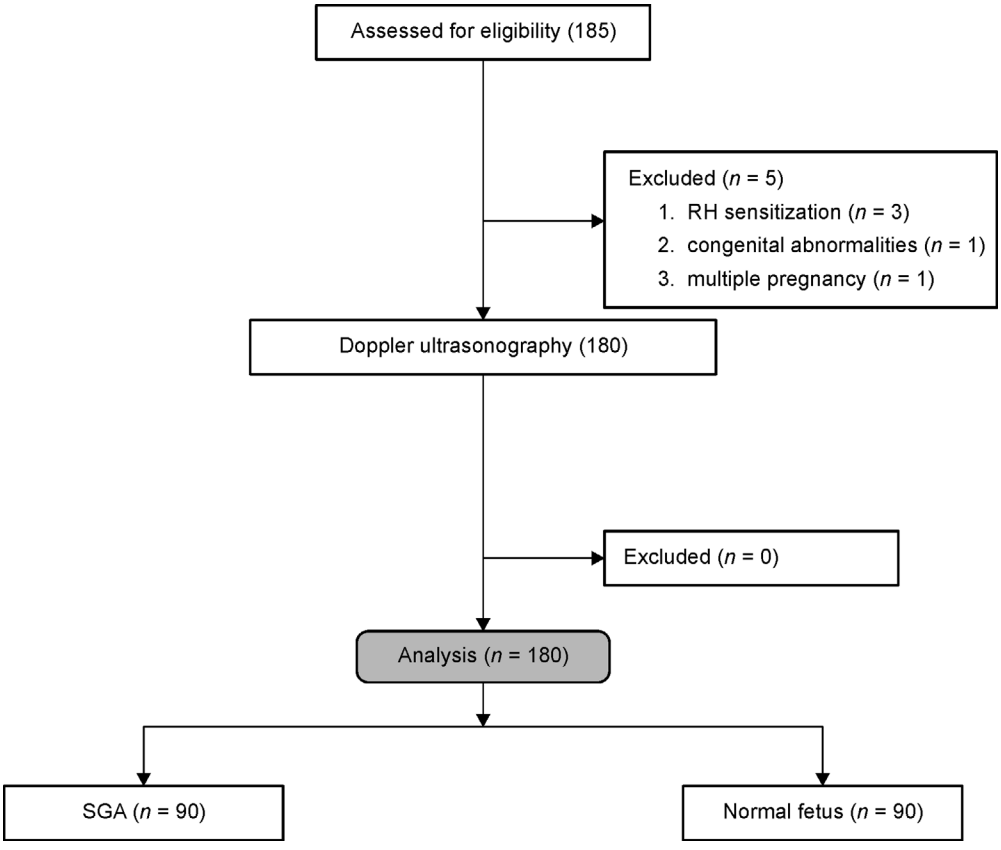


**Figure 1** Study flowchart

delivery, hemoglobin and arterial blood gas (ABG) of fetus were measured by blood sampling far away from the local of umbilical cord was cut.

### Data analysis

Data were analyzed and reported only for patients with completed information. Statistical analysis of data was performed using SPSS version 22 software. Chi-square test was used to compare qualitative variables between groups. Kolmogorov–Smirnov test was used in order to evaluate the normal distribution of all quantitative studied parameters. Student *t*-test and paired *t*-test were used for variables with normal distribution, on the other hand Mann–Whitney and Wilcoxon tests were used for variables without normal distribution. The two tailed p-value less than 0.05 were considered significant.

## Results

Demographic feature in term of maternal age ($P = 0.452$), maternal BMI ($P = 0.533$), gravid ($P = 0.563$), history of infertility ($P = 0.773$), maternal hypertension ($P = 0.6$), preeclampsia ($P = 0.732$), and gestational age ($P = 0.264$) in both groups was similar, however the frequency of maternal diabetes type II was significantly higher in SGA group (7.8% vs 1.1%, $P = 0.03$) (Table 1). Moreover, other features such as gestational age at birth ($P < 0.001$), and infant birthweight ($P < 0.001$) were significantly lower in SGA group.

Furthermore, we found that cesarean section rate was significantly more in SGA group (45.6% vs 16.7%, $P < 0.001$), and as well as admitting to the NICU (28.9% vs 2.2%, $P < 0.001$). However, apgar in first minute ($P = 0.137$), infant hemoglobin ($P = 0.835$), PH ($P = 0.111$), and $Pco_2$ ($P = 0.743$) in both groups did not have significant differences, while Hco3 was significantly lower in SGA group ($21.68 \pm 2.38$ vs $23.12 \pm 2.05$, $P < 0.001$).

Doppler assessment showed that umbilical artery PI was significantly higher in SGA group as compared to normal group ($1.11 \pm 0.37$ vs $0.98 \pm 0.18$, $P = 0.003$), while MCA PI was significantly lower in SGA group ($1.77 \pm 0.44$ vs $1.92 \pm 0.47$, $P = 0.028$). On the other hand, PSV did not differ between the groups ($P = 0.592$).

Furthermore, we found that umbilical artery PI remains significant (higher in SGA group) in pregnant women with age $< 25$ years ($P < 0.001$), BMI $> 27$, ($P < 0.001$), gestational age $< 34$ weeks ($P = 0.003$), vaginal delivery ($P = 0.012$), fetus did not admit to NICU ($P = 0.037$), and fetus with hemoglobin $< 13$ mg/dl ($P < 0.001$), with PH $> 7.2$ ($P = 0.006$), PCO2 $> 40$ mmHg ($P = 0.013$), and Hco3 $> 22$ ($P = 0.023$). Moreover, we found that MCA PI remains significant (lower in SGA group) in pregnant women BMI $> 27$, ($P < 0.001$), gestational age $< 34$ weeks ($P = 0.003$), fetus did not admit to NICU ($P = 0.002$), and fetus with PH $> 7.2$ ($P = 0.026$), and Hco3 $> 22$ ($P = 0.036$). Moreover, we found

**Table 1** Studied variables in both SGA and normal groups

| Group variables | | Normal fetus ($n = 90$) | SGA fetus ($n = 90$) | *P*-value |
|---|---|---|---|---|
| Maternal age (year) | | 31.2±3.56 | 30.66±5.68 | 0.452 |
| Maternal BMI (kg/m$^2$) | | 27.55±3.2 | 27.27±2.89 | 0.533 |
| Gravid | | 2.01±0.8 | 2.08±0.99 | 0.563 |
| History of infertility | | 6 (6.7%) | 7 (7.8%) | 0.773 |
| PMH | Diabetes type II | 7 (7.8%) | 1 (1.1%) | 0.03 |
| | Hypertension | 9 (10%) | 7 (7.8%) | 0.6 |
| Preeclampsia | | 5 (5.6%) | 4 (4.4%) | 0.732 |
| Gestational age (week) | | 33.72±2.18 | 33.3±2.78 | 0.264 |
| Gestational age at birth (week) | | 38.05±1.18 | 35.97±1.98 | < 0.001 |
| Infant birth weight (gr) | | 3079.77±498.88 | 1994.33±427.81 | < 0.001 |
| Type of delivery (C/S) | | 15 (16.7%) | 41 (45.6%) | < 0.001 |
| Admitted to the NICU | | 2 (2.2%) | 26 (28.9%) | < 0.001 |
| Apgar in first minute | | 8.17±0.84 | 7.94±1.22 | 0.137 |
| Infant hemoglobin (gr/dl) | | 12.92±1.22 | 12.95±1.2 | 0.835 |
| ABG | PH | 7.23±0.09 | 7.21±0.09 | 0.111 |
| | Pco2 (mmHg) | 41.71±1.85 | 41.8±1.78 | 0.743 |
| | Hco3 (mEq/L) | 23.12±2.05 | 21.68±2.38 | < 0.001 |
| Doppler assessment | Umbilical artery PI | 0.98±0.18 | 1.11±0.37 | 0.003 |
| | MCA PI | 1.92±0.47 | 1.77±0.44 | 0.028 |
| | PSV | 47.83±11.5 | 48.8±13.25 | 0.592 |

SGA: Small for gestational age, BMI: Body mass index, PMH: Past medical history, C/S: Cesarean section, NICU: neonatal intensive care unit, PI: pulsatility index, MCA: middle cerebral artery, PSV: peak systolic velocity

that PSV was more in SGA group by grouping maternal age ($< 27$ years) ($P = 0.006$), and gestational age ($> 34$ weeks) ($P < 0.001$).

## Discussion

According to our results, Doppler assessment showed that umbilical artery PI was significantly higher in SGA group, while MCA PI was significantly lower in SGA group. On the other hand, PSV did not differ between the groups except by grouping maternal age (age $< 27$ years), and gestational age ($> 34$ weeks), which showed that PSV was significantly higher in SGA group. In the study performed by Giancarlo Mari et al. showed that MCA PI value below normal range was recorded 27.3% of SGA fetuses (27.3%), which increase the incidence of abnormal fetal heart rate and admission into the NICU. Also they found that 33.3% of SGA fetuses with abnormal PI died, while 12.5% of SGA fetuses with normal PI died. (Mari et al., 1992) Moreover, in another study performed by *Nalini* et al. showed that the average birth-weight of neonates with abnormal Doppler study was lower as compared to groups with neonates with normal MCA velocimetry. Furthermore, they demonstrated that study of MCA flow along with UA flows was useful in identifying IUGR and managing them in an appropriate way (Mari et al., 2015). Tongta Nanthakomon et al. showed that SGA fetuses with normal UA PI but abnormal MCA PI had worse outcomes as compared to SGA fetuses with normal UA and MCA PI. On the other hand they demonstrated that MCA and UA PI had high accuracy in predicting SGA. (Mari et al., 2010) Furthermore, Mari et al. showed that high MCA-PSV had higher diagnostic value in predicting perinatal mortality as compared to low MCA-PI. Finally they proposed that MCA-PSV might be valuable in the clinical assessment of SGA fetuses that have abnormal UA Doppler (Mari et al., 2007). However, higher MCA PSV was observed in some subgroups such as maternal age $< 27$ years and gestational age $> 34$ weeks, while MCA PI was lower in most of subgroups.

On the other hand, Fong et al. showed that in suspected IUGR, while an abnormal UA PI is a better predictor of adverse perinatal outcome than an abnormal MCA PI, a normal MCA PI may help to identify fetuses without major adverse perinatal outcome, especially before 32 weeks gestational age. (Fong et al., 1999) Moreover, Sachin Khanduri et al. demonstrated that UA PI was more sensitive than the MCA PI with overall diagnostic accuracy of 75%. (Fong et al., 2013)

## Conclusions

The results of this study suggest that MCA PI decreased significantly in SGA fetuses, while UA PI increased in this group. Moreover, PSV increased in this group when evaluated in different subgroups (based on maternal age and gestational age). Therefore, in fetuses with risk of SGA, we can measure UA and MCA PI and PSV in order to find high risk fetuses and start appropriate treatment sooner.

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## Compliance with ethical standards

The authors declared no conflict of interest. All procedures have been approved by the appropriate ethics committee and have therefore been performed inaccordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was signed prior to participation in the study.

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