RESEARCH ARTICLE

A Study of Fetal Middle Cerebral Artery Peak Systolic Velocity to Diagnose Fetal Anemia in Rural Obstetric Population

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ABSTRACT

Globally, fetal middle cerebral artery peak systolic velocity (MCA-PSV) is used for noninvasive diagnosis of fetal anemia. Although, incidence of anemia is common in rural setup, scientific studies describing utilization of this modality are lacking. This study throws light on how the use of fetal MCA-PSV to diagnose fetal anemia can help in the decision-making process even in a rural setup.

Context: Fetal anemia can be adequately tackled only if it is diagnosed on time. Fetal MCA-PSV has the potential to reliably predict fetal anemia. Scientific studies across the globe are testimony to this fact. As such studies from rural setups are lacking, this study was initiated.

Aims: A study of fetal middle cerebral artery peak systolic velocity to diagnose fetal anemia in rural obstetric population.

Settings and design: The study was conducted in the ultrasound section of a rural medical college. Clearance from institutional ethical and research committee was obtained. Written informed consent was obtained from the pregnant mother. A prospective observational study was conducted over the last 12 months.

Materials and methods: Fetal MCA-PSV was measured in 26 pregnant women referred for ultrasound due to clinical suspicion of fetomaternal abnormality. Middle cerebral artery peak systolic velocity was measured by a single experienced radiologist on color Doppler ultrasound machine.

Statistical analysis used: The observations were entered in Microsoft Excel sheet, and statistical analysis was done by comparing with internationally accepted values at that gestational age. Karl Pearson's correlation coefficient was used to study the relation between fetal MCA-PSV and gestational age. Standard t-test was used to study the significance of difference.

Results: There was a steady increase in MCA-PSV with rising gestational age suggestive of positive correlation between them. When compared with internationally accepted values, significantly raised fetal MCA-PSV values were seen in six patients. These patients were followed up and the cause of fetal anemia in each was identified.

Conclusion: Fetal MCA-PSV can be successfully used to evaluate for anemia in fetuses in a rural setup provided correct methods are followed. An attempt to measure fetal MCA-PSV in face of every fetomaternal adversity is recommended so that none of the cases of fetal anemia go undiagnosed.

Keywords: Fetal anemia, Middle cerebral artery peak systolic velocity, Doppler.

Key messages: Proper knowledge and routine measurement of fetal MCA-PSV value can be a life saving noninvasive practice to diagnose fetal anemia in a rural setup.

INTRODUCTION

The exact incidence of fetal anemia is unknown as many cases go unsuspected, unreported or undiagnosed. It is therefore possible that fetal anemia is one of the important causes of intrauterine and perinatal mortality and morbidity. Hence, it will be a blessing in disguise if fetal anemia can be suspected, suggested or diagnosed by non-invasive testing, especially in a rural setup.

Not very long ago, amniocentesis[1] made liquor available for spectrophotometry to assess for bilirubin—a product of hemolysis was the only method. Later the procedure of cordocentesis[2] made blood available for hemoglobin assessment. As both of these methods were invasive, a noninvasive method to determine fetal anemia was eagerly awaited.

Doppler ultrasound demonstration of elevated fetal middle cerebral artery peak systolic velocities (MCA-PSV) in anemic fetuses filled this void.[3,4] As fetal MCA-PSV can rise in a variety of causes leading to fetal anemia, we wanted to evaluate how far this noninvasive test would help us in suggesting a diagnosis of fetal anemia in a rural setup, where many times the cause of intrauterine and perinatal deaths remain unknown.

MATERIALS AND METHODS

A total of 26 pregnant women with one or the other feto-maternal problems were included in this study after their informed written consent. Institutional ethical and research committee clearance was also obtained. The site of study was the ultrasound section in radiodiagnosis department of this institute.

INCLUSION CRITERIA

Maternal indications—primigravida with one or more of following:

Severe anemia, hypertension, diabetes, bleeding per vaginum, consanguineous marriage, family history of hemoglobinopathy, medical and surgical condition complicating pregnancy.

Fetal indications—growth retardation, abnormal free fluid in body cavities, structural abnormality.

Other indications—cord around neck, uterine structural abnormality, anhydramnios, polyhydramnios and abnormalities of placenta or cord.

EXCLUSION CRITERIA

Fetus with excess activity, nonconsenting mothers and patients who could not cooperate due to their severe discomfort.

An experienced sonologist recorded fetal MCA-PSV on Siemens G60 Doppler ultrasound machine. The examination was performed on supine patient using a 3.5 MHz curvilinear transducer to achieve a transverse section of fetal head demonstrating biparietal diameter. Fetal MCA arising from the internal carotid arteries was localized using color flow and sampled at 0° angle using pulse Doppler. When satisfactory consistent MCA velocity waveforms were obtained, the image was set at freeze option and using the caliper function, the peak of systolic velocity was measured. Each study took roughly 5 to 15 minutes.

The values of MCA-PSV measured in this study were tabulated in Microsoft Excel 2007 spreadsheet. The value of each observation was compared to the cut-off value for diagnosing fetal anemia for that gestational age as published in literature[3] and provisional diagnosis of fetal anemia was put forth when it was significantly elevated. The outcome of these pregnancies was followed and tabulated (Table 1).

RESULTS

The observed MCA-PSV values were compared with standard published values[3] to label the fetus as anemic and the follow-up of these pregnancies indicated that out of 26 patients in this study, elevated MCA-PSV values were recorded in six fetuses that were then labelled as anemic.

Figure 1 scatter diagram depicting relationship between fetal MCA-PSV and gestational age. With advancing gestational age, value of MCA-PSV also rises indicating a positive correlation between the two as shown by the solid green line.

Gestational age (weeks)	Observed MCA-PSV value cm/s	Cut-off value[3] of MCA-PSV	Fetal anemia	Relevant maternal history and findings	Final diagnosis and follow-up
15	32	30.3	Present	Consanguinity	Thalassemia
16	—	31.7	—	—	....
17	28	33.2	Absent	Diabetes	Normal fetus
18	28.3	34.8	Absent	Sickle cell disease	Normal fetus
19	—	36.5	—	—	....
20	22	38.2	Absent	Diabetes	Normal fetus
21	22	40.0	Absent	Hepatitis	Normal fetus
22	46.3	41.9	Present	Hypertensive Mother	Materno-fetal Insufficiency-IUD
23	25.6	43.9	Absent	Bleeding P/V	Normal fetus
24	31.1	46.0	Absent	Absent right fetal kidney	Normal fetus
25	28.5	48.2	Absent	Severe maternal anemia	Normal fetus
26	51.7	50.4	Present	Bleeding P/V	IUD due to large retroplacental hematoma
27	38.8	52.8	Absent	Bicornuate uterus	Normal fetus
28	56.0	55.4	Present	Maternal parvovirus B19 infection	Parvovirus B19 infection, IUD
29	59.8	58.0	Present	Anhydramnios	Preterm delivery
30	—	60.7	—	—	—
31	66.9	63.6	Present	Hypertensive Mother	Materno-fetal Insufficiency
32	43.4	66.6	Absent	Polyhydramnios	Normal fetus
33	49.1	69.8	Absent	IUGR	Normal fetus
34	—	73.1	—	—	—
35	—	76.6	—	—	—
36	51.3	80.2	Absent	Cord around neck	Normal fetus
37	49.7	84.0	Absent	Diabetes	Normal fetus
38	—	88.0	—	—	—
39	61.8	92.2	Absent	Hypertension	Normal fetus
40	62.3	96.6	Absent	Severe maternal anemia	Normal fetus

Table 1: Summary of findings of this study

Out of the six fetuses that were labeled as anemic due to their abnormally raised MCA-PSV, follow-up demonstrated thalassemia in one, materno-fetal insufficiency in two, anhydramnios in one, parvovirus B19 infection in one and large retroplacental hematoma in one.

Thus, the presence of fetal anemia could be accurately predicted in all of them.

DISCUSSION

Fetal anemias can occur due to red blood cell alloimmunization, homozygous alpha-thalassemia, massive fetomaternal hemorrhage, parvovirus B19 infection and twin-twin transfusion syndrome.[3-6]

Defective synthesis of alpha-globin chains results in alpha-thalassemia and it can be confirmed by DNA analysis of the amniotic fluid. Fetal anemia suggested by elevated MCA-PSV is confirmed by cordocentesis anemia.[6]

Mechanisms[6] leading to raised MCA-PSV in fetal anemia are as follows:
1. Reduced blood viscosity due to lowered hematocrit causing increase in blood flow velocities.
2. Increase in cardiac output has to compensate for reduced oxygen carrying capacity of the blood due to fetal anemia.

Increased MCA-PSV in fetal anemia is a widely accepted choice of investigation rather than other parameters like liver length and spleen perimeter in homozygous alpha-thalassemia 1.[6] Amniotic fluid DNA analysis is time consuming where as measuring MCA-PSV enables a faster diagnosis of fetal anemia and enables to properly time cordocentesis and intrauterine transfusion. Successful outcome has been reported after intrauterine transfusion, though it is not a standard treatment.[6,7]

Elevated MCA-PSV sheds light on the impending danger of fetal hydrops well in advance to take adequate corrective steps.[6]

Figure 2 shows elevated MCA-PSV in a fetus at 15 weeks of gestation. There was history of consanguinity in the family. After delivery, the fetus was confirmed to have alpha-thalassemia, which is inherited as an autosomal recessive entity and has the potential to manifest as anemia in fetus from first trimester onwards.[5] Africa, south-east Asia and the middle-East are its homelands. Recurrence is seen in one-fourth of the pregnancies.

Figure 3 shows elevated MCA-PSV in a fetus at 22 weeks of gestation with severe materno-fetal insufficiency in a severely hypertensive mother.

Figure 4 shows elevated MCA-PSV in a fetus at 26 weeks of gestation with IUD due to large retroplacental hematoma. Fetomaternal hemorrhage (FMH) is usually seen in patients who notice decreased or absent fetal movements
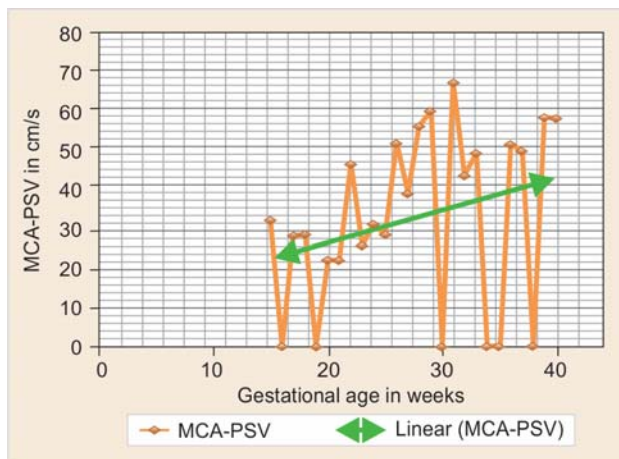

Fig. 1: Scatter diagram depicting relationship between fetal MCA-PSV and gestational age
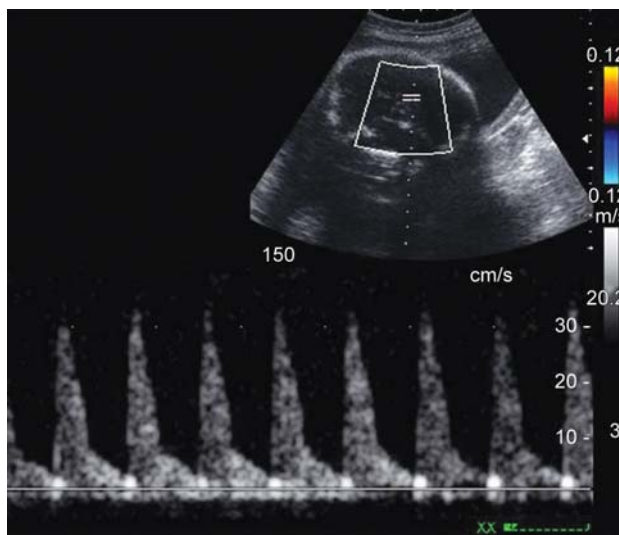

Fig. 2: Elevated MCA-PSV in a fetus at 15 weeks of gestation with thalassemia
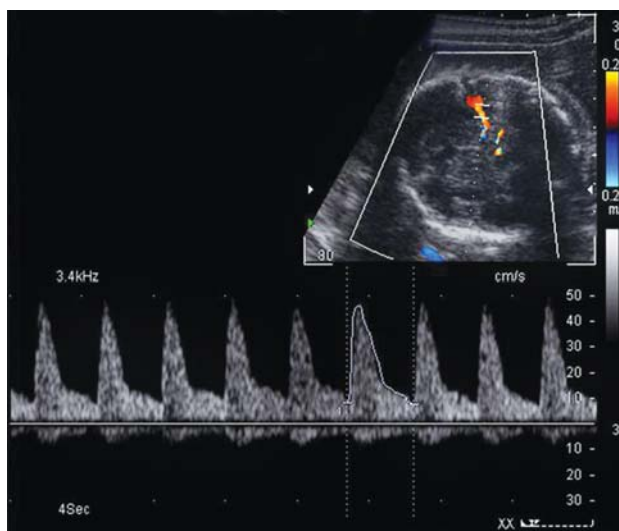

Fig. 3: Elevated MCA-PSV in a fetus at 22 weeks of gestation with severe materno-fetal insufficiency in a severely hypertensive mother

and leads to elevated MCA-PSV.[8] Acute hypovolemia leading to hypoxemia is the underlying mechanism of fetal damage. When massive FMH can cause fetal anemia, hydrops and even death.

Morbid postnatal conditions, like damage to central nervous system as well as respiratory distress, are also possible thereby increasing perinatal mortality range up to 50%.[9]

Figure 5 shows elevated MCA-PSV in a fetus at 28 weeks of gestation with fetal parvovirus B19 infection which can cause fetal anemia, hydrops and even intrauterine deaths.[10] Demonstration of viral DNA in amniotic fluid or blood by means of positive polymerase chain reaction (PCR) indicated an infected fetus whereas positive serum PCR and presence of IgM antibodies in mother indicate maternal infection.[11]

Elevated MCA-PSV in parvovirus B19 infected fetuses has high sensitivity and specificity for diagnosing anemic fetus.[11] Other infective agents, like cytomegalovirus, toxoplasmosis and treponema pallidum too, can infect fetus. However, mild anemia can be caused by all but massive ascites and severe fetal anemia are most common with parvovirus B19 infection.[12]

Figure 6 shows elevated MCA-PSV in a fetus at 29 weeks of gestation with anhydramnios and preterm delivery. Infant was severely anemic after blood and received exchange transfusions before being discharged in satisfactory condition.

Figure 7 shows elevated MCA-PSV in a fetus at 31 weeks of gestation with severe materno-fetal insufficiency in a severely hypertensive mother.
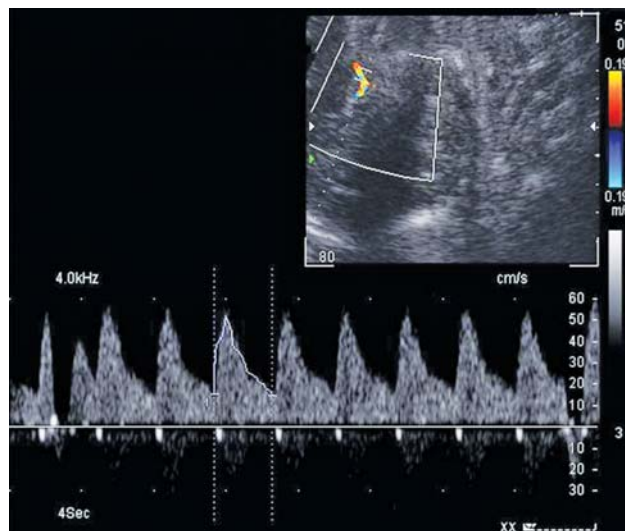

Fig. 4: Elevated MCA-PSV in a fetus at 26 weeks of gestation with IUD due to large retroplacental hematoma
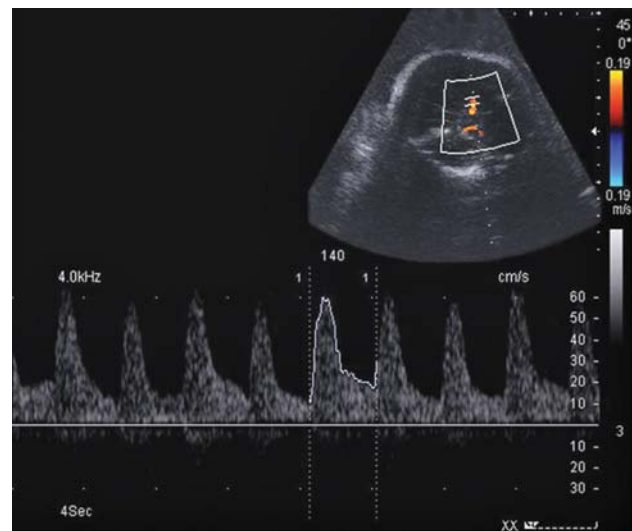

Fig. 6: Elevated MCA-PSV in a fetus at 29 weeks of gestation with anhydramnios and preterm delivery
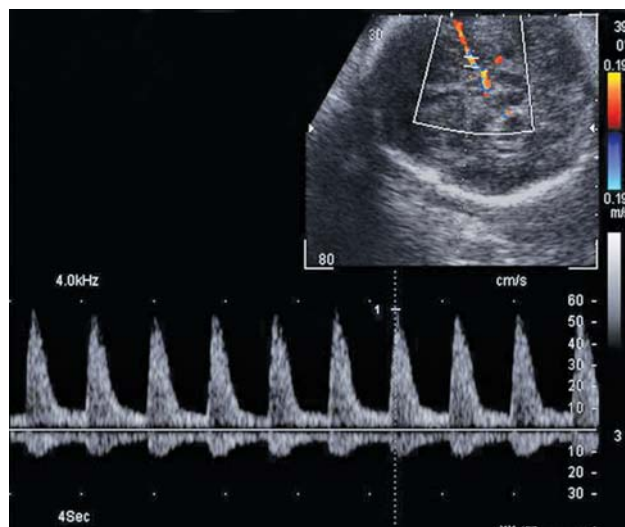

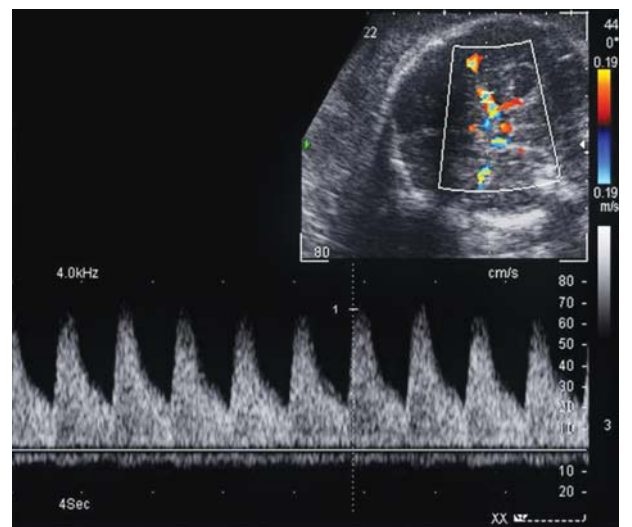**Fig. 5:** Elevated MCA-PSV in a fetus at 28 weeks of gestation with fetal parvovirus B19 infection

Fig. 7: Elevated MCA-PSV in a fetus at 31 weeks of gestation with severe materno-fetal insufficiency in a severely hypertensive mother

Thus as shown in figures 2 to 7, abnormally elevated fetal MCA-PSV can noninvasively suggest and even clinch the diagnosis of fetal anemia. The exact quantification and determination of cause needs invasive procedures, like amniocentesis or cordocentesis. On rectifying the anemia, value of MCA-PSV reduces and hence the incidence of invasive procedures, like amniocentesis and cordocentesis, can be reduced.[13]

Our study is the first from this nation to demonstrate successful usage of MCA-PSV in determining fetal anemia in a rural setup.

The strengths of our study are that MCA-PSV was measured by a single experienced observer and the universally accepted method was followed as shown in all figures. But, the small sample size of this study is a limitation. This study needs to be done not only on a large scale but at different locations to validate the efficacy of MCA-PSV in noninvasive diagnosis of fetal anemia.

CONCLUSION

Fetal anemia can be diagnosed noninvasively by measuring fetal MCA-PSV values. As this is rapid, reproducible, simple and reliable method and the inter or intraobserver variability is minimal; hence, it can be employed in all patients—rural as well as urban—for successful management of fetal anemia.

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