The MCA Doppler and its Role in the Evaluation of Fetal Anemia and Fetal Growth Restriction

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KEYWORDS

• MCA • Doppler • IUGR • Fetal anemia

DIAGNOSIS OF FETAL ANEMIA BEFORE THE USE OF THE MIDDLE CEREBRAL ARTERY PEAK SYSTOLIC VELOCITY

Before the widespread use of the middle cerebral artery (MCA) peak systolic velocity (PSV), the management of maternal red cell alloimmunization was based on an indirect measurement of fetal hemolysis using spectrophotometric analysis of the amniotic fluid (optical density [OD] at 450 nm).[1] The method to predict the severity of the hemolytic disease of the fetus and neonate was introduced by Liley in 1961.[2] The only option in the diagnosis of anemia from causes other than red cell alloimmunization was the percutaneous umbilical cord sampling that was initially performed with fetoscopy and, since 1983, under ultrasound guidance.[3]

FETAL MCA: 23 YEARS OF LITERATURE

Woo and colleagues[4] reported serial Doppler flow velocity-time waveforms of the MCA at its origin from the internal carotid arteries in 14 patients with normal singleton pregnancies. The A/B ratio showed a progressive decrease with advancing gestational age. Kirkinen and colleagues[5] recorded blood flow velocity waveforms from intracranial arteries in 83 normal and 84 high-risk pregnancies. They concluded that there was a decrease in the resistance index (RI) toward the end of the pregnancy and that continuous forward flow during diastole was always present in normal cases. Furthermore, they stated that an RI below the tenth percentile was associated with

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newborns that were small for gestational age (SGA) and/or the appearance of subsequent cardiotocographic abnormalities.

By 1990, there were 9 published studies in the literature focused on characterizing the fetal MCA Doppler flow velocity waveform in normal pregnancies, abnormal pregnancies (primarily intrauterine growth-restricted [IUGR] fetuses), and pregnancies in which fetal distress was present.[6–13] In 1989, Mari and colleagues[10] determined the pulsatility index (PI) in the middle cerebral, anterior cerebral, and internal carotid arteries in 30 fetuses (12 normal, 14 IUGR, and 4 post–in utero blood transfusion as part of the treatment of Rh isoimmunization) between 23 and 37 weeks of gestation. Their work demonstrated the importance of knowing which cerebral vessel is being insonated, because the PI was significantly different in the middle cerebral and internal carotid arteries when compared with the anterior cerebral artery. Since the introduction of the MCA Doppler to fetal medicine, more than 600 studies have been published, covering divergent topics from better known areas (eg, IUGR and fetal anemia) to less-explored areas, such as the effects of medications on the MCA[14–21] and fetal intracranial hemorrhage.[22–24]

MCA-PSV FOR THE DIAGNOSIS OF FETAL ANEMIA: A BRIEF HISTORY OF ITS CONCEPTION

The use of the MCA-PSV for the diagnosis of fetal anemia is considered one of the few practice-changing discoveries in fetal medicine. One of the most important contributions of the MCA-PSV to clinical practice has been the dramatic reduction in the number of invasive procedures performed in the management of red cell alloimmunized pregnancies.[25]

Mari and colleagues[26] reported that the PI of the MCA decreases within 2 hours after intrauterine blood transfusion and that the MCA-PSV was a better parameter than the PI in the assessment of pregnancies complicated by fetal anemia.[27] Vyas and colleagues[28] studied 24 Rh-isoimmunized pregnancies and noted an increase in the MCA mean blood velocity, hypothesizing that the increase of blood flow could be attributed to a decrease in blood viscosity, as previously suggested by experimentation in dogs.[29] A few years later, the same group reported that the MCA mean blood velocity was not an optimal parameter to assess fetal anemia.[30]

The reference range for the MCA-PSV was reported in 1995 (**Fig. 1**).[31] In the same study, it was reported that all the anemic fetuses had an MCA-PSV greater than the mean of the range of normal values. The false-positive rate was 50%; although high, had this rate been applied in clinical practice at that time, it would have eliminated 50% of the invasive procedures.

In 1997, MCA Doppler waveforms were examined before and after intrauterine blood transfusion. It was noted that the increase of the fetal hematocrit was associated with a decrease in the MCA-PSV, and the results were later reproduced.[32,33]

A study of 111 fetuses at risk for anemia because of red cell alloimmunization and 265 normal fetuses later changed the practice of how the former were evaluated.[25] The hemoglobin concentrations in blood obtained by cordocentesis and MCA-PSV were measured. A reference range for hemoglobin concentrations in fetuses from 18 to 40 weeks of gestation was established from samples obtained by cordocentesis from 265 normal fetuses (values are shown in **Table 1**). Previously reported nomograms of the normal values of the MCA-PSV by gestational age were used.[31] The study demonstrated that, based on traditional criteria, approximately 70% of the fetuses undergoing a cordocentesis were either nonanemic or mildly anemic. Of the remaining 30%, 40% were hydropic at the time the transfusion was performed.