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Foetal peak systolic velocity in the middle cerebral artery: an Asian reference range

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ABSTRACT

Introduction: The aim of this study was to establish reference values of peak systolic blood flow velocity measurement in the foetal middle cerebral artery (MCA-PSV) in the local Asian obstetric population and to compare our reference ranges with those of previously-published studies.

Methods: 329 normal pregnant women attending the outpatient antenatal clinics of the Department of Obstetrics and Gynaecology in the Singapore General Hospital underwent Doppler ultrasonography at least once between 16 and 40 weeks' gestation. The blood flow velocity recordings from the foetal middle cerebral artery were obtained. New reference ranges were constructed by regressing each parameter on gestational age.

Results: New reference ranges for foetal middle cerebral artery with gestation were constructed for an Asian population. Our reference curves were compared with that of a previously-constructed one.

Conclusion: MCA-PSV increases with advancing gestational age. There appear to be differences between Asian and non-Asian reference ranges for MCA-PSV.

Keywords: anaemia, foetal anaemia, foetal middle cerebral artery, peak systolic blood flow velocity, prenatal ultrasonography

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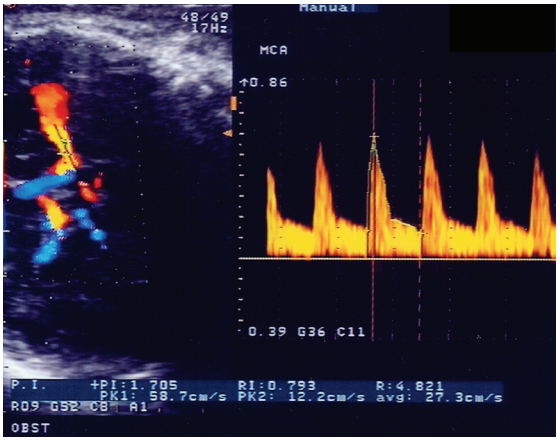

Fig.1 US image (transverse view) of the foetal head taken at the level of the cerebral peduncles, and Doppler waveform of the normal middle cerebral artery at its origin from the internal carotid arteries.

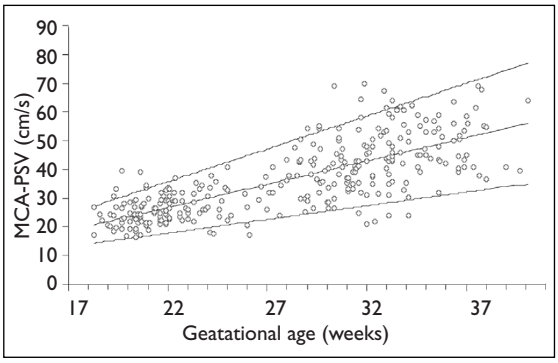

Fig. 2 Scatterplot shows the raw data for peak systolic blood flow velocity in the foetal maiddle cerebral artery (MCA-PSV) with fitted 5th, 50th and 95th percentiles.

INTRODUCTION

The prenatal diagnosis and intrauterine management of foetal anaemia arising from maternal red-cell alloimmunisation have been revolutionised with the advent and advance of ultrasonogaphy. Various researchers have found a correlation between middle cerebral artery peak systolic velocity (MCA-PSV) and gestational age, as well as with foetal haemoglobin and haematocrit concentrations.[1] The use of the MCA-PSV for the diagnosis of foetal anaemia has led to a more than 70% reduction in the number of invasive tests, and their concomitant foetal risks, used in the assessment of red-cell alloimmunised pregnancies.[2] The reproducibility of MCA-PSV has been shown to be consistent for both intra-observer and inter-observer reliabilities, with the best result shown when the proximal MCA, 2 ml after its origin from the internal carotid artery, is measured.[3]

Several authors have also constructed reference ranges for MCA-PSV with respect to gestation, and have

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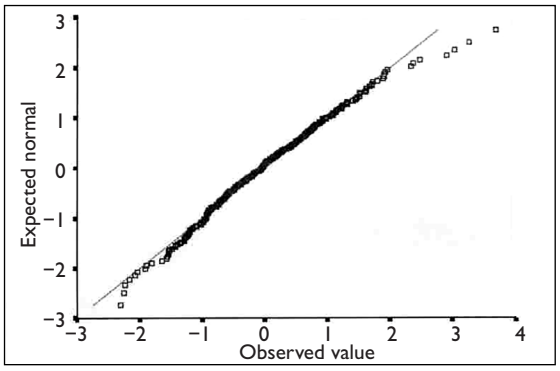

Fig. 3 Normal scatterplot of standard deviations resulting from a fitted model for peak systolic blood flow velocity in the foetal middle cerebral artery (MCA-PSV) data.

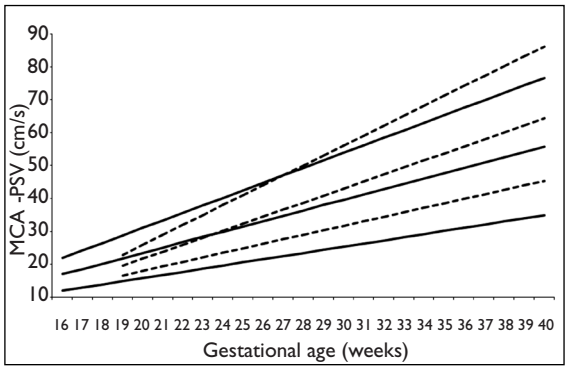

Fig. 4 Comparison of our peak systolic blood flow velocity in the foetal middle cerebral artery (MCA-PSV) and the 5th, 50th and 95th percentiles (solid lines) with those of Kurmanavicius et al[4] (dotted lines).

found that it has a significant positive association with gestation.[3-5] Current data, however, has been derived from non-Asian obstetric populations and there has been, to date, no local nomogram for Asian obstetric populations. The aim of this study was to establish reference values of peak systolic blood flow velocity measurements in the foetal MCA-PSV in the local Asian obstetric population and to compare our reference ranges with those of previously-published studies.

METHODS

The study data was obtained from 329 normal pregnant women attending the outpatient antenatal clinics at the Department of Obstetrics and Gynaecology in the Singapore General Hospital. All patients underwent Doppler ultrasonography at least once between 16 and 40 weeks' gestation. Only one examination was accepted for further evaluation. The exclusion criteria included those with chronic medical illnesses like diabetes mellitus, hypertension and renal disease, as well as pregnancies complicated by multiple gestation and congenital malformations. Gestational age was determined from the date of the last menstrual period and confirmed by the first-trimester crown-rump length.

Ultrasonographical measurements were carried out by experienced ultrasonographers using Aloka Prosound SSD5500 and Aloka SSD4000 (Aloka Co, Tokyo, Japan). The blood flow velocity waveforms were recorded after the MCAs were identified with colour Doppler imaging at their origin from the internal carotid arteries, as displayed in the transverse section of the foetal head at the level of the cerebral peduncles (Fig 1). Recordings were made from the first third of the proximal MCA with the angle between the ultrasound beam and the MCA always between 0° and 20°.

The data was analysed and new reference ranges were constructed by regressing each parameter on gestational age. For each measurement, linear regression models were fitted separately to the mean and standard deviation as a function of gestational age. All statistical calculations were made using the Statistical Package for Social Sciences version 10.0 (SPSS Inc, Chicago, IL, USA). We plotted a Q-Q graph for standard deviation and applied the Kolmogorov-Smirnov test for goodness-of-fit. Our reference curve was then compared with a previously-constructed reference curve.

RESULTS

Doppler measurements of PSV in the foetal MCA were obtained in 329 normal pregnant women. These were correlated with their gestational age and a scatter diagram was constructed. Fig. 2 shows the raw data for each measurement superimposed with the fifth, 50th and 95th percentiles. There was a positive correlation between MCA-PSV and increasing gestational age. Table I shows the fitted percentiles for each week of gestation. Fig. 3 shows the normal Q-Q plot for standard deviation, which did not deviate much from a straight line. The Kolmogorov-Smirnov test was applied and $p = 0.2$, confirming the normal distribution. Fig. 4 shows a comparison of our MCA-PSV reference ranges with those of Kurmanavicius et al.[4] Our fifth percentile was consistently lower than theirs. On the other hand, our 50th and 97th percentiles were higher than theirs before 23 and 27 gestational weeks, respectively. The gradients of our curves were less steep than those of Kurmanavicius et al.[4]

DISCUSSION

Researchers like Mari et al, Kurmanavicius et al and Scheier et al have constructed reference values for the foetal MCA peak velocity for non-Asian obstetric populations.[3-5] They have concluded, as we have, that

Table I. Fitted percentiles of peak systolic blood flow velocity in the foetal middle cerebral artery (MCA-PSV).

Gestation (weeks)	5th percentile	50th percentile	95th percentile
16	13.4	18.6	23.8
17	14.1	20.1	26.1
18	14.8	21.6	28.4
19	15.4	23.1	30.7
20	16.1	24.6	33.1
21	16.8	26.1	35.4
22	17.5	27.6	37.7
23	18.2	29.1	40.0
24	18.9	30.6	42.3
25	19.6	32.1	44.7
26	20.3	33.6	47.0
27	21.0	35.1	49.3
28	21.7	36.7	51.6
29	22.4	38.2	53.9
30	23.1	39.7	56.3
31	23.7	41.2	58.6
32	24.4	42.7	60.9
33	25.1	44.2	63.2
34	25.8	45.7	65.5
35	26.5	47.2	67.9
36	27.2	48.7	70.2
37	27.9	50.2	72.5
38	28.6	51.7	74.8
39	29.3	53.2	77.2
40	30.0	54.7	79.5

MCA-PSV increases with advancing gestational age, in the second half of pregnancy. Tongsong et al performed a study on foetuses in the first half of normal pregnancies (11–22 weeks) and similarly, showed a continuous increase in the MCA-PSV over the period of 11–22 weeks.[6] There is therefore evidence to show that MCA-PSV consistently increases in a linear fashion with increasing gestational age from at least 11 weeks' gestation onwards. Mari et al's reference values, however, were obtained from alloimmunised foetuses who were at increased risk for developing foetal anaemia. Kurmanavicius et al and Scheier et al, on the other hand, derived their values, like we have, from a sample of normal foetuses (low risk). These reference values would be helpful in picking out low-risk foetuses with anaemia.

To date, no one has compared reference values for MCA-PSV between Asian and non-Asian obstetric populations. A comparison of our curves with those of Kurmanivicius et al (Fig. 4) seems to suggest that there may be essential differences between Asian and non-Asian populations. Firstly, our fifth percentiles were consistently lower. Secondly, we noted that the gradients of our curves were less steep, compared to those of Kurmanivicius et al. Using a non-local reference range could pick up more false-positives for anaemia, especially in the later gestational ages. However, we note that these postulations have not been validated by a correlation of foetal and neonatal haemoglobin levels in our own Asian population. It is thus hoped that this study will encourage more work to be done to ascertain and validate this local reference range for MCA-PSV, and for it to be utilised in the local setting in future for obstetric practice.

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