

●Original Contribution

DOPPLER COLOUR FLOW MAPPING OF FETAL INTRACEREBRAL ARTERIES IN THE PRESENCE OF CENTRAL NERVOUS SYSTEM ANOMALIES

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Abstract—The adjunctive role of Doppler colour flow mapping in the evaluation of intracerebral morphology and arterial blood flow in the presence of normal and abnormal central nervous system morphology was determined. A total of 59 fetuses with suspected central nervous system pathology between 14 and 37 weeks of gestation was studied (median 31 weeks). One hundred and one fetuses with normal central nervous system anatomy between 14 and 37 weeks (median 19 weeks) served as controls. Visualisation of blood flow in one or more intracerebral arterial vessels was successful in more than 80% of normal fetuses. For the anterior, middle and posterior cerebral artery, the percentages were 63%, 89% and 45%, respectively, at 14–25 weeks and 74%, 100% and 55%, respectively, at 26–37 weeks of gestation. Intracerebral arterial flow identification was attempted in 52/59 (88%) affected fetuses. Identification of blood flow in one or more intracerebral arterial vessels was successful in 40/52 (77%) fetuses. End-diastolic flow velocities were present in at least one of the intracerebral arteries in 39/40 fetuses, absent in one case of hydrocephaly and raised in the presence of an intracerebral vascular tumour. Doppler colour flow mapping seems to provide only limited additional information on intracranial structural pathology.

Key Words: Doppler colour flow mapping, Intracerebral morphology, Central nervous system pathology.

INTRODUCTION

Since the introduction of Doppler velocimetry in the study of fetal cerebral blood flow (Wladimiroff et al. 1986), a host of information has become available on flow velocity waveforms from various intracerebral vessels both in appropriate for gestational age (AGA) (Wijngaard van den et al. 1989) and small for gestational age fetuses (SGA) (Arduini et al. 1987; Wladimiroff et al. 1988). Contradictory findings have been reported on intracerebral flow velocities in hydrocephaly (Kirkinen et al. 1988; Wijngaard van den et al. 1988).

The objectives of the present prospective study were 1) to determine the adjunctive role of Doppler colour flow mapping in successfully obtaining waveforms from intracranial arterial vessels; and 2) to see if there was absence of discernible blood flow in these vessels in central nervous system anomalies.

MATERIAL AND METHODS

Doppler colour flow mapping was used in 59 women with suspected structural fetal central nervous system anomalies between 14 and 38 weeks of gestation (median 31 weeks). The nature of the central nervous system anomalies is presented in Table 1. Hydrocephaly was diagnosed through measurement of the ventricular–hemisphere (V/H) ratio. Mild-to-moderate hydrocephaly was defined as a V/H ratio $< 3 \times$ upper confidence interval, and severe hydrocephaly as a V/H ratio $\geq 3 \times$ upper confidence interval (Van Egmond et al. 1986). One hundred and one fetuses with normal central nervous system anatomy served as controls. Here, gestational age varied between 14 and 37 weeks (median 19 weeks). The technique of colour flow mapping to identify the intracranial vasculature has been described previously (Vyas et al. 1990a).

A Toshiba SSA 270A with a curved-linear 3.75 MHz probe was used. In each woman, an attempt was made to document Doppler colour flow patterns in the fetal internal carotid artery (ICA), anterior cerebral artery (ACA), middle cerebral artery (MCA) and

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Table 1. Nature of the central nervous system anomalies ($n = 59$).

Hydrocephaly	
Mild	11
Severe	16
Hydrocephaly + other anomalies [†]	
Mild to moderate	7
Severe	10
Encephalocele	2
Holoprosencephaly	2
Porencephaly	1
Anencephaly	4
Exencephaly	3
Microcephaly	3

[†] Spina bifida (10); encephalocele (4); corpus callosum agenesis (2); intracerebral vascular tumour with multiple A-V shunts (1).

posterior cerebral artery (PCA). Structural information was defined as that information which was acquired only as a result of the Doppler colour flow mapping overlay. Functional information was defined as that which was obtained by using pulsed Doppler as an adjunct to the Doppler colour flow mapping.

RESULTS

Fetuses without central nervous system anomalies

Bilateral visualisation of blood flow in the ICA was achieved in $\geq 80\%$ throughout pregnancy. For ACA, MCA and PCA, the percentages were 63%, 89% and 45%, respectively, at 14–25 weeks and 74%, 100% and 55%, respectively, at 26–37 weeks of gestation. Doppler flow velocity waveforms were always characterised by positive end-diastolic flow velocities. The time spent on recognition of intracerebral arteries using Doppler colour flow mapping was approximately 70% of the time spent using conventional real-time ultrasound.

Fetuses with central nervous system anomalies

Intracerebral arterial blood flow identification was attempted in 52/59 (88%) affected fetuses. In the remaining seven cases, the presence of anencephaly ($n = 4$) and exencephaly ($n = 3$) ruled out intracerebral flow visualisation. Identification of one or more intracerebral arteries was successful in 40/52 (77%) fetuses. Also here, recognition of intracerebral arterial blood flow was less time-consuming than using conventional real-time ultrasound. Blood flow in the ICA was identified in 24/40 (60%) fetuses, in the MCA in 36/40 (90%) fetuses and in the ACA and PCA in 10/40 (25%) fetuses. Failure to identify intracerebral arterial blood flow was not related to a specific central nervous system anomaly, the severity of the anomaly,

or gestational age. In four cases, there was associated polyhydramnios.

Doppler colour flow mapping did not play an adjunctive role in the evaluation of intracerebral morphology apart from one case of A-V shunting suggesting the presence of a vascular tumour. In this instance, end-diastolic flow velocities were clearly raised. End-diastolic velocities were only absent in one case of marked hydrocephaly.

DISCUSSION

Doppler colour flow mapping allows visualisation of intracerebral arterial blood flow as early as 14 weeks of gestation. Whereas in the presence of normal cerebral anatomy bilateral identification of the ICA and MCA blood flow was feasible in more than 80% of cases, this was less so for the ACA and PCA. This was often determined by the relatively large interrogation angle between the Doppler beam and flow direction in these two vessels as a result of the occipito-lateral position of the fetal head. There was only a slight improvement in the identification of intracerebral arteries with advancing gestational age, the MCA being visualised in every instance after 25 weeks. Of interest is that the success rate in identifying intracerebral arterial vasculature using Doppler colour flow mapping was not essentially different from that established by conventional real-time ultrasound. Using the latter technique, visualisation of blood flow in the ICA, ACA, MCA and PCA was achieved 89%, 64%, 91% and 58% (Wijngaard van den et al. 1989).

Identification of cerebral arterial blood flow in the presence of central nervous system anomalies was rather disappointing. Whereas the MCA was the vessel most often identified (90%), the ICA was documented in just over half of the cases and the ACA and PCA were visualised in only one-quarter of the cases. The reason for the poor success rate in identifying blood flow in the latter two vessels is not immediately clear, although the often abnormal position of the vessel due to intracranial pathology and an unfavourable interrogation angle between vessel and Doppler beam may have played a role. Also, no relationship existed between the success rate in blood flow identification and severity of the anomaly. Altogether, colour Doppler flow mapping did not substantially contribute to the diagnosis of intracranial structural pathology.

The presence of end-diastolic arterial flow velocities in abnormal intracranial morphology in the vast majority of cases is at variance with previous reports (Kirkinen et al. 1988; Wijngaard van den et al. 1988) in which high resistance of cerebral blood flow in

some cases of hydrocephaly has been suggested. Increased intracranial pressure has been implicated as the underlying cause of the reported waveform alterations in intracerebral vessels with hydrocephaly. However, in the present study despite the normality of the arterial waveforms, marked hydrocephaly was present in 21 out of 59 cases (Table 1). Vyas *et al.* (1990b) demonstrated that application of pressure on the ultrasound transducer during Doppler examinations may result in an increase in impedance to flow in the cerebral circulation. These changes were proportional to the pressure applied. The question arises as to what extent transducer pressure could have been responsible for the observed waveform changes in previous flow studies on hydrocephaly. The continuous visualisation in colour of a particular intracerebral vessel may perhaps result in less transducer pressure being exerted on the fetal cranium as otherwise would happen during a more intensified search for the intracerebral vessels using conventional real-time equipment.

The markedly raised end-diastolic flow velocities in the MCA observed in the presence of a large intracranial vascular tumour are easily explained by the numerous A-V shunts visible during Doppler colour flow mapping.

CONCLUSION

Doppler colour flow mapping generally seems to provide only limited additional information on intracranial morphology in the presence of intracranial

structural pathology. Moreover, in contrast to earlier studies, intracranial pathology is generally associated with positive end-diastolic flow velocities.

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