

Prenatal diagnosis of cerebral arteriovenous malformation using color Doppler ultrasonography: case report and review of the literature

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ABSTRACT

Aneurysms of the vein of Galen are rare, representing less than 1% of all intracranial arteriovenous malformations. In the fetus, however, almost all cerebral arterial malformations involve the vein of Galen, usually presenting in the neonatal period with severe cardiac failure leading to neonatal death. In this report we present a case of arteriovenous malformation involving the vein of Galen detected prenatally at 35 weeks with the use of color Doppler ultrasonography. The literature is reviewed in an attempt to delineate the role of prenatal ultrasonography in the diagnosis and its impact on perinatal outcome.

INTRODUCTION

Vascular malformations of the brain are rare but potentially disastrous abnormalities, which during fetal life are frequently associated with increased blood flow through the midline venous system, causing aneurysmal dilatation of the vein of Galen^{1–3}. In neonates, arteriovenous malformation involving the vein of Galen is a well documented cause of congestive heart failure; presenting symptoms include cyanosis, systolic murmur, cardiomegaly and increased intracranial pressure with hydrocephaly or cranial bruit^{1–3}. The reported mortality rate in neonates is higher than 90%, the majority dying within 1 week of diagnosis or treatment¹. Prior to the advent of ultrasonography, the diagnosis of this condition was made at postmortem examination in approximately 85% of cases⁴.

In this report we present a case of arteriovenous malformation of the vein of Galen diagnosed prenatally at 35 weeks' gestation with color Doppler ultrasonography. The literature is reviewed for similar cases, in an attempt to delineate the role of prenatal ultrasonography in the diagnosis and its impact on perinatal outcome.

CASE REPORT

A 29-year-old primigravida was referred to our unit at 35 weeks' gestation for fetal evaluation, because of intrauterine growth retardation and suspected occipital horn dilatation. The woman had a maternal serum screening test at 15 weeks, which gave her a high risk for Down syndrome of 1:50 (α -fetoprotein, 1.98 MoM; free β -human chorionic gonadotropin, 2.81 MoM; and unconjugated estriol, < 0.29 MoM). Subsequent amniocentesis revealed a normal 46,XY fetal karyotype. Detailed ultrasonographic examination at 19 weeks in another center showed suboptimal fetal growth, reduced amniotic fluid volume, hyperechogenic bowel, but no structural anomalies. Both the increased echogenicity of the fetal bowel and oligohydramnios resolved by 22 weeks, although subsequent scans still showed progressive growth retardation. At 35 weeks, the suspicion of hydrocephaly prompted referral to our institution. Ultrasonographic examination at referral revealed a singleton fetus in cephalic presentation with asymmetric growth retardation and an estimated fetal weight of 1810 g. The placenta was posterior in location and the amniotic fluid volume normal. Umbilical and middle cerebral artery flow velocity waveforms were normal. Detailed examination of the fetal anatomy revealed several anomalies, including a two-vessel umbilical cord, transverse limb reduction defect at the level of the left forearm, and an anechoic supratentorial structure in the fetal brain measuring 20 × 25 × 15 mm, just to the right of the falx, with no associated ventriculomegaly or other cerebral lesions (Figure 1). Color Doppler ultrasonography (Acuson 128XP/10, Acuson, Mountain View, CA) confirmed the suspicion of an aneurysm of the vein of Galen by demonstrating turbulent arterial and venous blood flow within the mass (Figure 2). There were no signs of cardiomegaly or enlargement of the neck vessels. The

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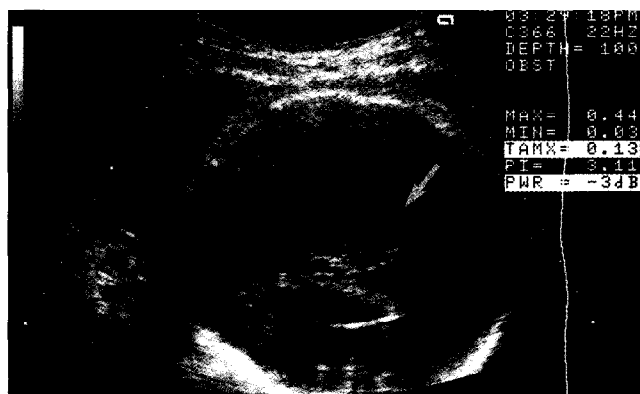


Figure 1 Cross-sectional view of the fetal head at 35 weeks' gestation, showing an anechoic lesion just to the right of the midline (arrow), with no associated brain abnormalities

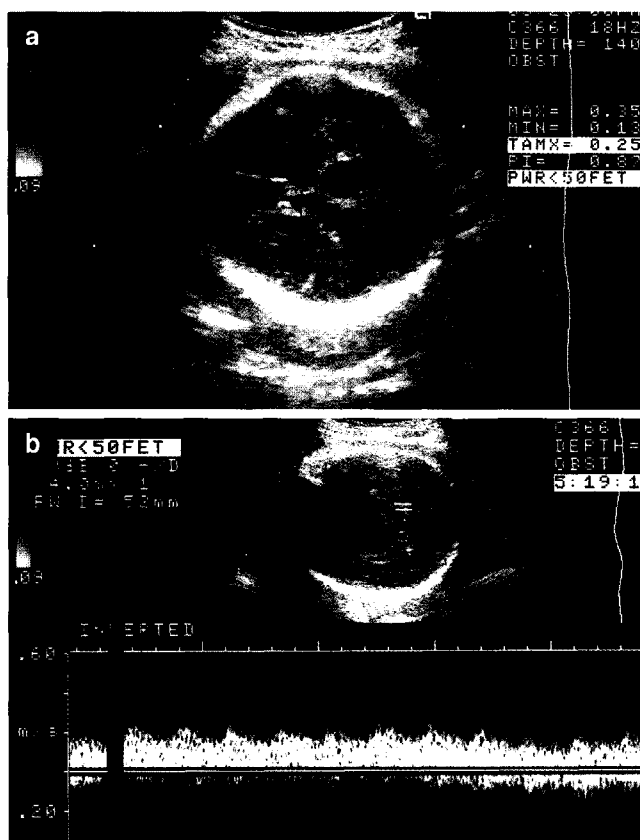


Figure 2 Color Doppler ultrasonography of arteriovenous malformation involving the vein of Galen at 35 weeks' gestation. (a) Color flow imaging clearly demonstrates the vascular nature of the lesion; (b) pulsed Doppler demonstrates turbulent flow within the vessel

parents were counselled by a multidisciplinary team and decided to terminate the pregnancy under the UK Abortion Act, clause E, which allows termination at any gestation for fetuses at substantial risk of serious mental or physical handicap. Intracardiac potassium chloride injection was performed to achieve fetal asystole, and labor induced by vaginal prostaglandins. A stillborn male infant weighing 1940 g was delivered spontaneously. Postmortem examination showed an arteriovenous malformation involving the vein of Galen (Figure 3), absent left hand, single umbilical artery as well as a small

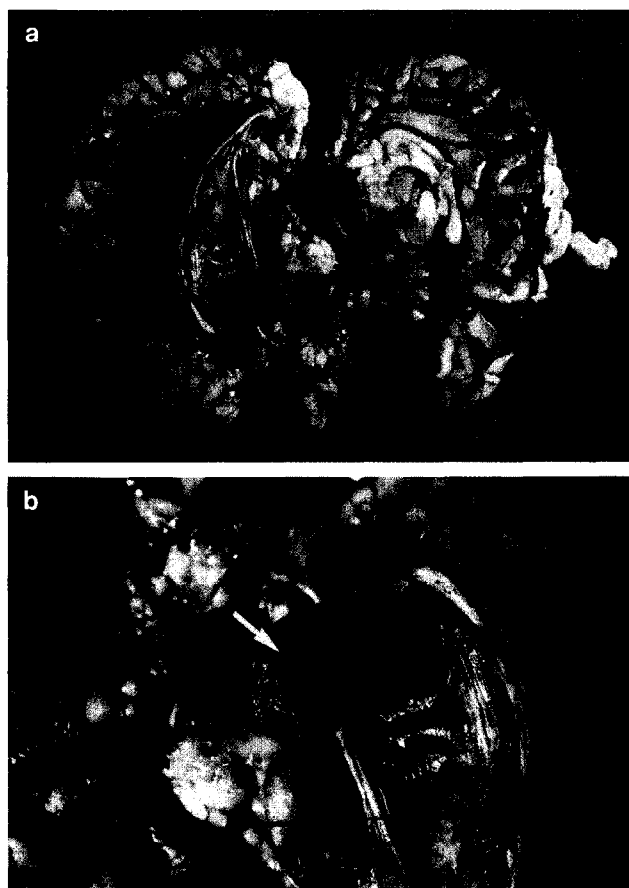


Figure 3 (a) Postmortem of the fetal brain confirmed aneurysmal dilatation of the vein of Galen; (b) detail of the aneurysm

placental hemangioma. The heart size was normal, weighing 15.1 g (normal range for a 2000-g fetus, 14.9 ± 4.2 g)⁵, and was situs solitus with normal concordance. There was no histological evidence of myofiber hypertrophy.

DISCUSSION

This report documents the prenatal diagnosis of arteriovenous malformation involving the vein of Galen, with the use of color Doppler ultrasonography. An extensive literature search revealed only 42 reported cases of arteriovenous malformation of the fetal brain prenatally diagnosed by ultrasonography⁶⁻²⁷. Of these, a recent series of 18 cases was excluded from subsequent analysis, because no individual information was available in the report²⁷. Table 1 displays the clinical and ultrasonographic characteristics of the remaining cases, and includes the one reported here. In 23 (92%), the arteriovenous malformation involved the vein of Galen, the most striking finding being the presence of a posterior, midline or slightly lateral supratentorial anechoic structure in the fetal brain. In some of these cases the straight sinus was dilated as well, giving this lesion a tubular appearance resembling a 'keyhole'¹⁹. In the two cases in which the arteriovenous malformation did not involve the vein of Galen, the lesion was located in the frontal lobe^{17,25}.

Table 1 Prenatal diagnosis of arteriovenous malformation of the fetal brain. Review of the literature

<i>Authors</i>	<i>Gestational age at diagnosis (weeks)</i>	<i>Additional ultrasonographic findings</i>	<i>Pulsed Doppler</i>	<i>Color Doppler</i>	<i>Outcome</i>
Hirsch <i>et al.</i> (1983) ⁶	32		(+)		cardiac failure; NND
Mao and Adams (1983) ⁷	38	intrauterine growth retardation			cardiac failure; NND
Mendelsohn <i>et al.</i> (1984) ⁸	34	ventriculomegaly, cardiomegaly			cardiac failure; NND during surgery
Vintzileos <i>et al.</i> (1986) ⁹	37	hepatomegaly, cardiomegaly, umbilical vein dilatation, polyhydramnios			cardiac failure in treatment; alive at 10 months
Reiter <i>et al.</i> (1986) ¹⁰	34	ventriculomegaly, cardiomegaly, hepatomegaly, ascites, enlarged neck vessels	(+)		stillborn
Rizzo <i>et al.</i> (1987) ¹¹	37		(+)		awaiting embolization
Mizejewski <i>et al.</i> (1987) ¹²	37	ventriculomegaly			cardiac failure; NND
Hata <i>et al.</i> (1988) ¹³	32		(+)	(+)	alive and well
Ordorica <i>et al.</i> (1990) ¹⁴	27	hydrops, cardiomegaly, polyhydramnios, and placentomegaly at 35 weeks			cardiac failure; NND
Jeanty <i>et al.</i> (1990) ¹⁵	NS	cardiomegaly, enlarged neck vessels	(+)		cardiac failure; embolization complicated by intracranial hemorrhage and seizures; died at 6 months
Ishimatsu <i>et al.</i> (1991) ¹⁶	37	cardiomegaly	(+)	(+)	cardiac failure; successful embolization
Comstock and Kirk (1991) ¹⁷	34	ventriculomegaly, cardiomegaly, enlarged neck vessels	(+)		cardiac failure; NND
	37	ventriculomegaly, cardiomegaly, enlarged neck vessels	(+)		cardiac failure; NND
	37	cardiomegaly, enlarged neck vessels	(+)		cardiac failure; NND
	30	enlarged neck vessels	(+)	(+)	cardiac failure; NND
Yamaguchi <i>et al.</i> (1991) ¹⁸	34		(+)		cardiac failure; NND
Strauss <i>et al.</i> (1991) ¹⁹	35	cardiomegaly	(+)		cardiac failure in treatment; awaiting embolization
Evans and Twining (1991) ²⁰	33	cardiomegaly	(+)	(+)	cardiac failure; died at 5 weeks (2 days after embolization)
Dan <i>et al.</i> (1992) ²¹	38			(+)	cardiac failure at 22 h; no follow-up reported
Koven <i>et al.</i> (1992) ²²	33	cardiomegaly, enlarged neck vessels		(+)	no information given
Worswick <i>et al.</i> (1992) ²³	29	cardiomegaly, polyhydramnios, scalp edema and hydronephrosis at 35 weeks	(+)		cardiac failure; NND
Lin <i>et al.</i> (1992) ²⁴	41				cardiac failure; NND after surgery
Lee <i>et al.</i> (1994) ²⁵	23	ventriculomegaly, cardiomegaly, enlarged neck vessels, polyhydramnios	(+)	(+)	TOP
Ballester <i>et al.</i> (1994) ²⁶	25	cardiomegaly, hydrops	(+)	(+)	stillborn
Current report	35	absent left hand, single umbilical artery, intrauterine growth retardation	(+)	(+)	TOP

NND, neonatal death; TOP, termination of pregnancy

Seventy-six per cent (19 of 25) of the fetuses had associated anomalies, the most common being ventriculomegaly, cardiomegaly and enlarged neck vessels (Table 2). Ventriculomegaly was noted in six of the 25 cases (24%), in association with aneurysmal dilatation of the vein of Galen in four^{8,10,12,17}, and in both cases associated with a frontal arteriovenous malformation^{17,25}. This finding is not consistent with the general belief that ventriculomegaly in these cases is due to a mass effect, compressing the aqueduct^{1,3}, but instead suggests that abnormal spinal fluid dynamics may play a role. Cardiomegaly, with or without ventricular wall hypertrophy, was present in 64% of cases, being by far the most common associated prenatal finding. Prenatal detection of cardiomegaly is therefore a warning, although not specific, sign of this condition in the third trimester. The high incidence of cardiomegaly in fetuses with arteriovenous malformation also suggests that high output cardiac failure is already present in a significant number of cases during the third trimester, and therefore treatment *in utero* may need to be considered to improve hemodynamic status. Enlarged neck vessels were noted in one-third of the cases^{10,15,17,22,25}, and this seems to be a pathognomonic sign. In our case, none of the above features were present during prenatal ultrasonography or at postmortem examination. However, several associated vascular abnormalities were noted, such as single umbilical artery and placental chorioangioma. It is noteworthy that a severe limb reduction affecting the left arm was present in our case, an association not previously reported. A vascular steal effect from an arteriovenous malformation with reverse flow in the aortic arch affecting left subclavian blood flow has been documented both *in utero*^{16,28} and postnatally²⁹. However, this process should be present very early in pregnancy to cause the reduction defect seen in our case, and therefore we consider it unlikely that these two anomalies were related.

Almost invariably, the diagnosis of arteriovenous malformation has been made during the third trimester, with two-thirds of cases diagnosed at ≥ 34 weeks and only three cases diagnosed in the second trimester^{14,25,26}.

Table 2 Associated ultrasonographic findings in prenatally diagnosed cases of cerebral arteriovenous malformation ($n = 25$). Several fetuses had more than one finding

	<i>n</i>	%
Cardiomegaly	16	64
Enlarged neck vessels	8	32
Ventriculomegaly	6	24
Polyhydramnios	4	16
Hepatomegaly	3	12
Ascites	3	12
Intrauterine growth retardation	2	8
Umbilical vein dilatation	1	4
Placentomegaly	1	4
Scalp edema	1	4
Hydronephrosis	1	4
Single umbilical artery	1	4
Upper limb reduction defect	1	4
No associated findings	6	24

The earliest diagnosis was made at 23 weeks' gestation with color Doppler ultrasonography in a frontal lobe arteriovenous malformation associated with ventriculomegaly²⁵. Differential diagnoses include cystic lesions of the fetal brain, such as arachnoid cyst, choroid plexus cyst, porencephalic cyst, pineal tumor, intracerebral hematoma and choroid papilloma¹⁵. As expected, a frequent referral diagnosis was the detection of an anechoic lesion in the fetal brain, but three cases were initially mistaken as hydrocephaly. As arteriovenous malformation is the only vascular lesion, the prenatal diagnosis has been greatly improved with the use of Doppler techniques. To date, pulsed Doppler ultrasonography has been used alone to establish the vascular nature of the abnormality in ten cases^{6,10,11,15,17,19,23}. In nine, including ours, color flow imaging provided a simple and highly reliable method to establish the final diagnosis^{13,16,17,20,22,25,26}.

The prognosis in the prenatally diagnosed cases has been uniformly poor. According to the available information in the literature, eight of the 21 infants born alive had congestive heart failure. Of these, 14 subsequently died, one was alive at 10 months on medical treatment⁹, one was awaiting embolization¹⁹, one had successful embolization with no physical or neurological impairment at 2.5 years^{16,28} and no follow-up information was available in the other²¹. Of the three in whom no cardiac failure was mentioned in the original report, one was alive at 3 months and awaiting embolization¹¹, one was alive and well¹³, and no neonatal information was given in the other²². In most of the survivors, however, there was no information regarding long-term neurological and cardiovascular follow-up. The information on outcome compiled from the literature suggests that, when an arteriovenous malformation is large enough to be detected prenatally, it is likely to lead to cardiac failure either during the antenatal period or soon after birth. Cessation of the blood flow at birth to a low resistance territory such as the placenta will increase the vascular shunt at the level of the head, producing hemodynamic decompensation, cardiac failure and eventually death.

According to the available literature, early prenatal recognition of this condition is important, as it allows early medical treatment of cardiac failure and reduces the need for complex neuroradiological techniques to establish the diagnosis in critically ill neonates. Nevertheless, the final prognosis of this condition depends mainly on neurosurgical interventions, such as ligation or embolization of the feeding vessels^{1,3,27,30}.

In conclusion, prenatal detection of arteriovenous malformation of the fetal brain has been greatly facilitated by modern color Doppler techniques. Although this condition still carries a very poor prognosis, prenatal ultrasonography has a role in reducing unnecessary delay in treatment, thus decreasing the chance of neonatal cardiac failure and increasing the chance of successful neurosurgical intervention. Fetuses diagnosed as having an arteriovenous malformation should be delivered in centers capable of handling complex cases of cardiac

failure and with neuroradiological and neurosurgical facilities. Improvements in neurosurgical techniques should improve the present poor prognosis of such fetuses in the future.

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