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Prenatal diagnosis and outcome of fetal posterior fossa fluid collections

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KEYWORDS: cerebellar anomalies; Dandy–Walker malformation; fetus; megacisterna magna; prenatal diagnosis; ultrasound

ABSTRACT

Objective *To evaluate the accuracy of fetal imaging in differentiating between diagnoses involving posterior fossa fluid collections and to investigate the postnatal outcome of affected infants.*

Methods *This was a retrospective study of fetuses with posterior fossa fluid collections, carried out between 2001 and 2010 in two referral centers for prenatal diagnosis. All fetuses underwent multiplanar neurosonography. Parents were also offered fetal magnetic resonance imaging (MRI) and karyotyping. Prenatal diagnosis was compared with autopsy or postnatal MRI findings and detailed follow-up was attempted by consultation of medical records and interview with parents and pediatricians.*

Results *During the study period, 105 fetuses were examined, at a mean gestational age of 24 (range, 17–28) weeks. Sonographic diagnoses (Blake's pouch cyst,* n = *32; megacisterna magna,* n = *27; Dandy–Walker malformation,* n = *26; vermian hypoplasia,* n = *17; cerebellar hypoplasia,* n = *2; arachnoid cyst,* n = *1) were accurate in 88% of the 65 cases in which confirmation was possible. MRI proved more informative than ultrasound in only 1/51 cases. Anatomic anomalies and/or chromosomal aberrations were found in 43% of cases. Blake's pouch cysts and megacisterna magna underwent spontaneous resolution* in utero *in one third of cases and over 90% of survivors without associated anomalies had normal developmental outcome at 1–5 years. Isolated Dandy–Walker malformation and vermian hypoplasia were associated with normal developmental outcome in only 50% of cases.*

Conclusion *Prenatal neurosonography and MRI are similarly accurate in the categorization of posterior fossa fluid collections from mid gestation. Blake's pouch cyst and megacisterna magna are risk factors for associated anomalies but when isolated have an excellent prognosis, with a high probability of intrauterine resolution and normal intellectual development in almost all cases. Conversely, Dandy–Walker malformation and vermian hypoplasia, even when they appear isolated antenatally, are associated with an abnormal outcome in half of cases.*

INTRODUCTION

Fluid collections in the fetal posterior fossa encompass a wide spectrum of different entities, ranging from normal variants to severe anomalies[1]. They may have a similar anatomic as well as sonographic appearance, and diagnostic errors with significant implications for counseling and management have been described[2].

More recently, several reports have shed light on the normal and abnormal development of the posterior fossa contents, leading to a new clinical classification of fluid collections[3–7]. In addition, new advances in prenatal imaging have allowed more detailed evaluation of these contents from mid gestation[3,6–14].

The aim of our study was to evaluate the diagnostic accuracy of fetal neurosonography[15] and magnetic resonance imaging (MRI) in cases of posterior fossa fluid collections and to assess the outcome of affected infants.

PATIENTS AND METHODS

This was a retrospective study conducted between December 2001 and January 2010 in two referral centers for prenatal diagnosis. All fetuses diagnosed with an abnormal

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fluid collection in the posterior fossa were included. In all cases a detailed neurosonographic evaluation, including multiplanar visualization of the posterior fossa, was performed as described previously[6,8,12,14–16]. The categorization of sonographic findings was based on recent studies[3,4,7] and is summarized in Table 1 and Figure 1. In each case we attempted to evaluate the integrity of the cerebellar vermis, as this has been reported to have a major impact on outcome[9,17]. Whenever possible, serial sonograms and prenatal MRI were also performed and fetal karyotype was obtained. Prenatal diagnosis was compared with autopsy or postnatal MRI findings. A detailed follow-up was attempted in each case by consultation of medical records and interview with the parents and with the pediatricians taking care of the infants.

Table 1 Categorization of posterior fossa fluid collections

Findings	*Diagnosis*
Upward rotation of an intact vermis with normal torcular	Blake's pouch cyst
Cisterna magna depth > 10 mm with intact and normally positioned cerebellum	Megacisterna magna
Upward rotation of the vermis (normal or hypoplastic) with elevated torcular	Dandy–Walker malformation
Hypoplastic vermis with normal torcular	Vermian hypoplasia
Large cisterna magna with small cerebellum	Cerebellar hypoplasia
Cyst with a mass effect resulting in distortion of the cerebellum	Posterior fossa arachnoid cyst

RESULTS

A total of 105 fetuses were included in the study (Table 2). The mean gestational age at diagnosis was 24 (range, 17–28) weeks. There were associated malformations in 46 (43%) cases, in two of which the associated anomalies were only discovered after birth. These associated malformations included other cerebral abnormalities in 23, chromosomal aberrations in nine (trisomy 18, $n = 3$; trisomy 21, $n = 2$; trisomy 13, $n = 1$; triploidy, $n = 1$; unbalanced translocation, $n = 1$; mosaic 45X/46XX, $n = 1$), genetic syndromes in three (one each of Opitz, PHACE and oral-facial-digital syndromes) and miscellaneous conditions in 13.

The greatest difficulties we encountered in the sonographic categorization of posterior fossa fluid collections included assessment of the position of the

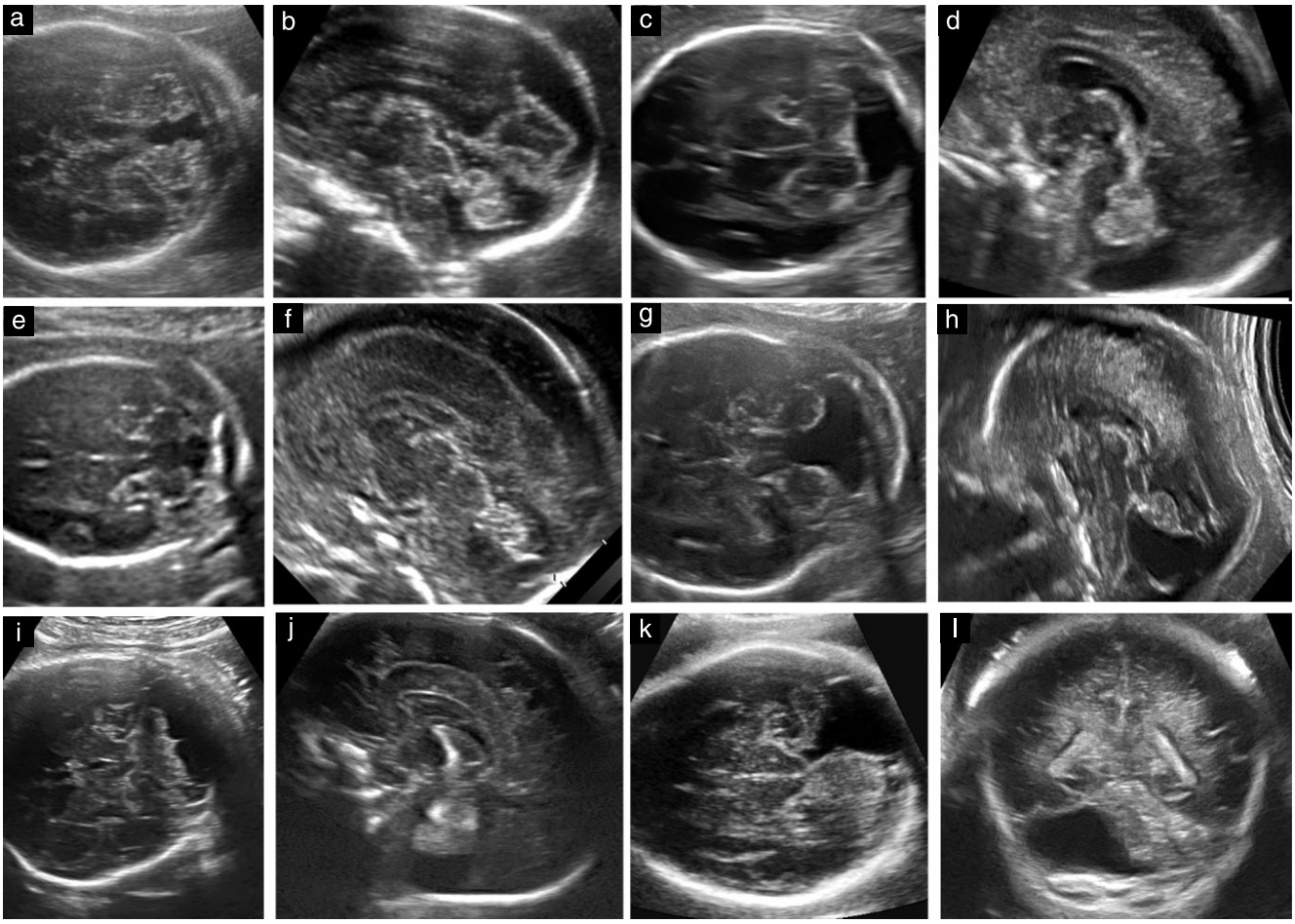

Figure 1 Categorization of posterior fossa fluid collections on ultrasound: (a,b) Blake's pouch cyst; (c,d) megacisterna magna; (e,f) vermian hypoplasia; (g,h) Dandy–Walker malformation; (i,j) cerebellar hypoplasia; (k,l) arachnoid cyst of the posterior fossa.

Table 2 Sonography in fetuses with posterior fossa fluid collections (PFFC), associations with other anomalies, intrauterine regression, outcome and accuracy of prenatal diagnosis

Prenatal sonographic diagnosis	*Total cases* (n)	*Cases with associated anomalies* (n)	*Lost to follow-up* (n)	*TOP* (n)	*Regression* in utero (n)*	*Sonographic diagnosis confirmed*† (n)	*Abnormal neurological development postnatally*‡ *Isolated PFFC* (n)	*Abnormal neurological development postnatally*‡ *PFFC with associated anomalies* (n)
Blake's pouch cyst	32	8	3	2	11/27	16/18	1/20	1/5
Megacisterna magna	27	9	4	2	6/21	16/17	2/16	1/4
Dandy–Walker malformation	26	16§	7	11	0/8	16/19	3/5	2/2
Vermian hypoplasia	17	11§	9	2	0/6	6/8	1/3	2/2
Cerebellar hypoplasia	2	2	0	2	0/0	2/2	0	0
Arachnoid cyst	1	0	0	0	0/1	1/1	1/1	0
Total (*n* or *n* (%))	105	46	23	19/105 (18)	17/63 (27)	57/65 (88)	8/45 (18)	6/13 (46)

*Denominator excludes cases lost to follow-up and terminations of pregnancy (TOP). †Confirmation postnatally or at autopsy; denominator excludes cases lost to follow-up and those that underwent intrauterine regression. ‡Number of cases with abnormal neurological development/number of cases that underwent neurological examination at 1–5 years. §In one case in each group the presence of associated anomalies was detected only postnatally.

torcular and evaluation of the integrity of the cerebellar vermis. The torcular *Herophili* cannot be imaged clearly with sonography due to acoustic shadowing from the skull bones and we inferred its position by observing the angulation of the tentorium (Figure 2). To evaluate the cerebellar vermis we used a combination of qualitative findings (visualization of fastigium and fissures)[3,6,13,14] as well as biometry[8,10]. Nevertheless, frequently we were uncertain about vermian integrity, particularly in the context of Dandy–Walker malformation, because of upward compression by the posterior fossa cyst (Figure 3).

Twenty-three (22%) cases were lost to follow-up because the parents declined to provide information or could not be reached, or autopsy reports were not available. Intrauterine regression of the abnormal posterior fossa findings was noted in 27% of cases. Of the remaining 65 cases, prenatal diagnosis was confirmed postnatally or at autopsy in 88%.

There was one false-positive diagnosis of vermian hypoplasia and seven incorrect diagnoses (Table 3). In at least two of these cases, the presence of cortical

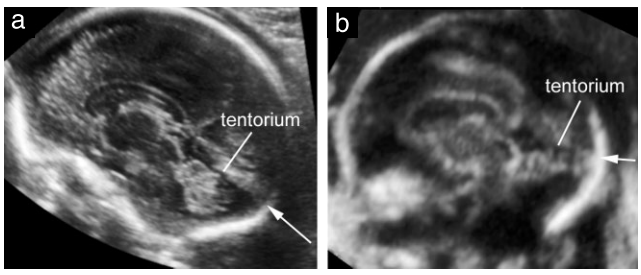

Figure 2 The position of the torcular *Herophili* (arrows) is inferred on ultrasound by the direction of the tentorium cerebelli. In (a) the torcular is found in a normal position, at about the same level as the site of insertion of the neck muscles on the posterior skull; this is a Blake's pouch cyst. In (b) the torcular is displaced higher than usual, indicating that this is a Dandy–Walker malformation.

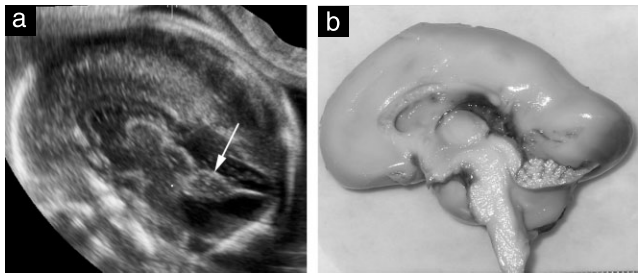

Figure 3 Dandy–Walker malformation in a 21-week fetus. The transvaginal sonogram (a) failed to demonstrate the anatomic landmarks of the cerebellar vermis (arrow), fastigium and fissures, and we were uncertain whether this reflected hypoplasia. After termination of pregnancy, autopsy revealed a normally lobulated vermis (b).

malformations that had escaped prenatal diagnosis resulted in a worse outcome than had been predicted antenatally.

The earliest diagnosis of a posterior fossa fluid collection was made with sonography at 17 weeks. At this time a considerable superior rotation of the vermis was noted. At 21 weeks a final diagnosis of Dandy–Walker malformation was made, with a seemingly intact cerebellar vermis (Figure 4). The fetal karyotype was normal, no other anomalies were identified, and the parents elected to continue the pregnancy. After birth a further diagnosis of Opitz syndrome was made.

One fetus was diagnosed *in utero* with a Dandy–Walker malformation by both ultrasound and MRI and was found after termination of pregnancy to have a severe posterior fossa hemorrhage with secondary hydrocephalus (Figure 5).

Modifications of the sonographic findings throughout gestation were noted in several cases. Most frequently this consisted of the resolution of a Blake's pouch cyst or megacisterna magna. In one case, interpretation of the sonographic findings was particularly difficult at mid

Table 3 Discordances between fetal sonographic and magnetic resonance imaging (MRI) diagnoses and postnatal diagnoses in eight fetuses with posterior fossa fluid collections

Fetal sonography	*Fetal MRI*	*Postnatal diagnosis*
Blake's pouch cyst	Blake's pouch cyst	Arachnoid cyst
Blake's pouch cyst	Megacisterna magna	Megacisterna magna
Megacisterna magna	Megacisterna magna	Arachnoid cyst
Dandy–Walker malformation	Dandy–Walker malformation	Dandy–Walker malformation and cortical malformation
Dandy–Walker malformation	Dandy–Walker malformation	Joubert syndrome
Dandy–Walker malformation	Dandy–Walker malformation	Hemorrhage
Vermian hypoplasia	Vermian hypoplasia	Vermian hypoplasia and cortical malformation
Vermian hypoplasia	Vermian hypoplasia	Normal brain

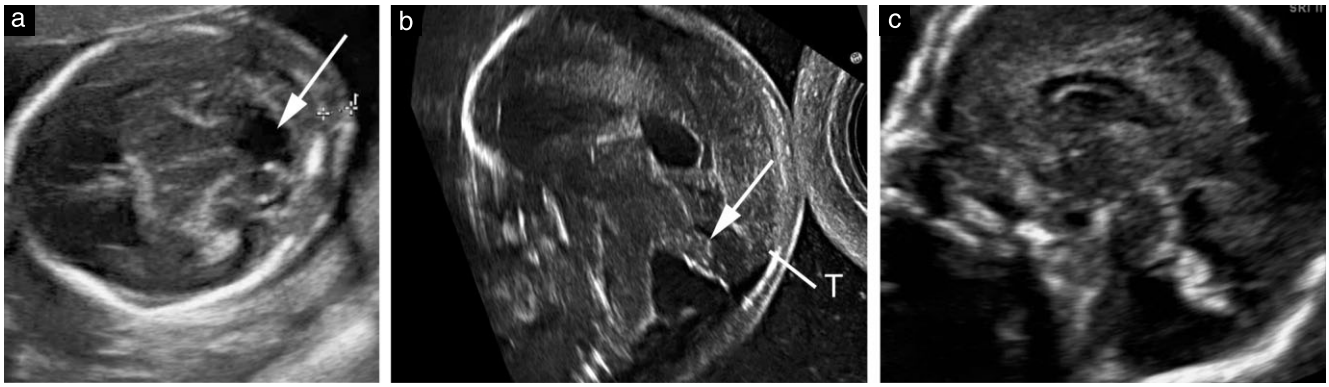

Figure 4 Ultrasound imaging in a patient referred at 17 weeks because of abnormal appearance of the posterior fossa. The axial scan (a) revealed an open fourth ventricle (arrow), a normal finding prior to mid gestation. However, the transvaginal sagittal scan (b) identified rotation of the cerebellar vermis (arrow) that was greater than usual and a high-positioned tentorium (T), and we favored the hypothesis of a posterior fossa malformation. At 20 weeks (c) Dandy–Walker malformation was confirmed.

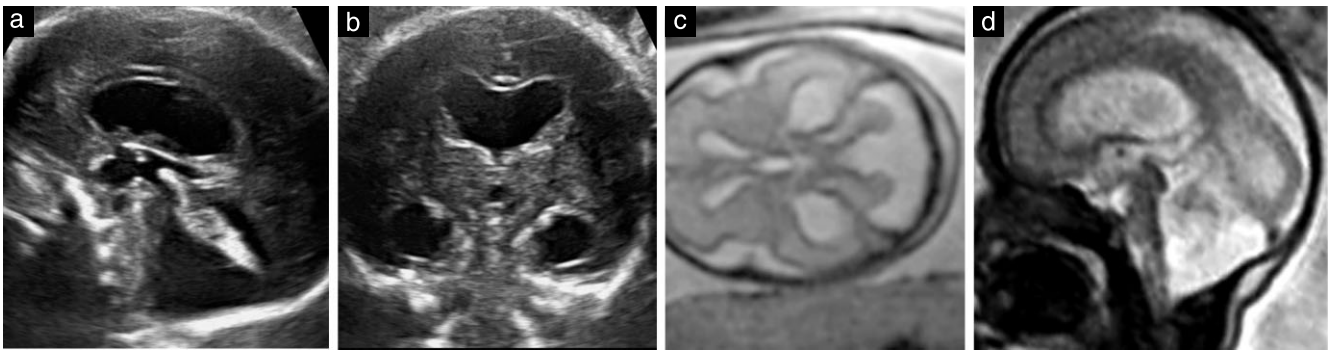

Figure 5 Prenatal imaging in a patient referred because of severe ventriculomegaly. Additional findings on ultrasound included a posterior fossa fluid collection with superior displacement of the cerebellar vermis (a) and absence of the septum pellucidum (b), which were confirmed by magnetic resonance imaging (MRI) (c,d). A diagnosis of Dandy–Walker malformation with obstructive hydrocephalus and absence or disruption of the septum pellucidum was considered. After termination of pregnancy a severe cerebellar hemorrhage was demonstrated. In retrospect, the normal position of the tentorium conflicted with the diagnosis of Dandy–Walker malformation. A T1-weighted MRI sequence was not obtained, which would have easily demonstrated the presence of blood in the posterior fossa.

gestation. In this case an elevated but seemingly intact cerebellar vermis with a normal torcular was seen initially at 21 weeks, and a tentative diagnosis of Blake's pouch cyst was made. At 25 weeks, however, an expansion of the posterior fossa with elevation of the torcular was noted, indicating a Dandy–Walker malformation that was confirmed by prenatal MRI as well as postnatally (Figure 6). One fetus with cerebellar hypoplasia and associated cortical malformation had an unremarkable sonogram at 21 weeks' gestation.

Fetal MRI was performed in 51 cases at a mean gestational age of 26 (range, 22–34) weeks, with results very similar to those of sonography, providing a more accurate diagnosis in only one case (Table 3, second case). The main advantage of MRI over ultrasound was better visualization of the torcular, while assessment of the integrity of the vermis remained difficult, particularly in mid gestation (Figure 7).

In 58/63 cases a neurologic follow-up at 1–5 years was available, and demonstrated that abnormal development

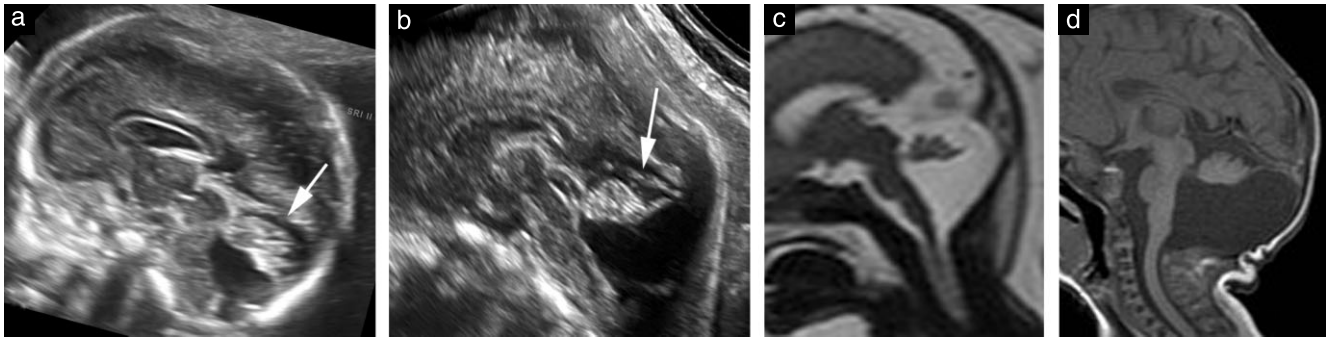

Figure 6 Imaging in a patient referred at 20 weeks' gestation. The transvaginal fetal sonogram (a) demonstrated moderate elevation of the cerebellar vermis but the cisterna magna was not felt to be enlarged and the downslanting tentorium (arrow) suggested a normal position of the torcular. At 25 weeks (b) the cisterna magna had increased in size, the rotation of the vermis was increased and the angle formed by the tentorium (arrow) suggested upward displacement of the torcular. At this time, a diagnosis of Dandy–Walker malformation was made and this was confirmed by prenatal (c) as well as postnatal (d) magnetic resonance imaging.

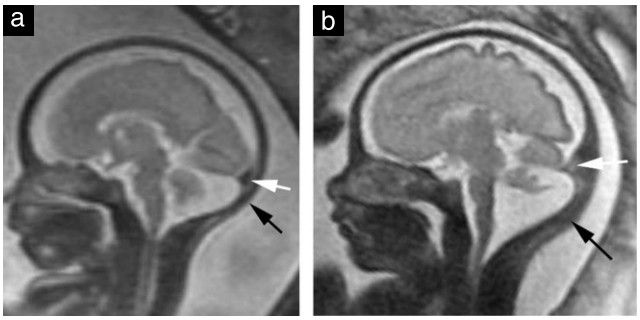

Figure 7 Demonstration of the torcular on fetal magnetic resonance imaging. (a) Fetus with Blake's pouch cyst with the torcular (white arrow) implanted close to the insertion of the neck muscles (black arrow). (b) Fetus with Dandy–Walker malformation with obvious upward displacement of the torcular (white arrow) compared with the neck muscles (black arrow). Notice also the greater size of the cisterna magna and the increased rotation of the cerebellar vermis compared with the fetus in (a).

was more common in cases with associated anomalies (46% versus 18% of cases). About 90% of fetuses with either Blake's pouch cyst or megacisterna magna and no associated anomalies had normal neurologic development compared with only 50% of those with Dandy–Walker malformation and vermian hypoplasia (Table 2).

DISCUSSION

We believe that the most relevant result of our study is the demonstration that fetal neurosonography allows us to categorize accurately from mid gestation fluid collections in the fetal posterior fossa and to distinguish entities that have different clinical implications.

In our hands, prenatal diagnosis with sonography was correct in almost 90% of cases. We believe that the reason for this improvement in accuracy over previous studies[1,2] is our use of a multiplanar approach and particularly upon the documentation of the mid-sagittal plane, which is essential for evaluation of the posterior fossa contents[3,5,11]. Caution is warranted in diagnosing cerebellar anomalies early in gestation because of the incomplete development of the cerebellar vermis[18–20]; however, with meticulous scanning, we were able to document Dandy–Walker malformation from 17 weeks.

Categorization of posterior fossa fluid collections has clinical relevance. Blake's pouch cyst and megacisterna magna, the most frequent diagnoses in our series, had a similar and much more favorable outcome than did Dandy–Walker malformation and vermian hypoplasia. They were less frequently associated with other anomalies, underwent spontaneous resolution during gestation in one third of cases and, when they were not associated with other anatomic or chromosomal anomalies, demonstrated normal postnatal neurodevelopment in about 90% of cases. This agrees well with previous studies and suggests that, when isolated, these conditions should probably be regarded as normal variants[11,21].

The term Blake's pouch cyst was originally introduced into infantile neuroradiology to indicate a type of obstructive hydrocephalus secondary to failure of formation of the foramen of Magendie and Luschka, resulting in a compressive cyst of the posterior fossa displacing superiorly the cerebellar vermis[22–24]. More recently, the term has become popular in fetal imaging studies to indicate cases with a posterior fossa cyst displacing superiorly an intact cerebellar vermis, typically in association with a normal ventricular system and normal size of the posterior fossa[3,7,11,13]. This finding has been interpreted as failed or delayed regression of the Blake's pouch, an embryological structure continuous with the fourth ventricle. The entity described in the original neonatal studies and the one later described in fetal studies are likely to be different, as the latter typically has a normal outcome and appears to be associated rarely with ventriculomegaly. Megacisterna magna may be a variation of Blake's pouch cyst[7]. From a clinical perspective, the two conditions have many similarities.

Dandy–Walker malformation and vermian hypoplasia (previously referred to as Dandy–Walker variant)[4] have been the subject of many postnatal and fetal studies and are probably the best known of the posterior fossa cystic lesions[1,6,9,16,17,25,26]. In agreement with previous studies, we found a high proportion of multiple anomalies and abnormal neurodevelopment in these cases. It has

been suggested that the prognosis of Dandy–Walker malformation is related to the anatomy of the vermis. Patients with normal lobulation on MRI have been found to have no associated brain malformation and to demonstrate a better outcome[9,17]. However, assessing the morphology of the vermis in our cases was usually challenging because of the significant mass effect of the cyst (Figure 3), and frequently we were uncertain. As previously reported, posterior fossa hemorrhage may mimic Dandy–Walker malformation[27].

Intrauterine evolution of posterior fossa fluid collections is common. Apart from the frequent disappearance of Blake's pouch cyst and megacisterna magna, in Dandy–Walker malformation posterior fossa expansion may occur late in gestation (Figure 6). As previously reported, cerebellar hypoplasia may manifest only in the third trimester[6].

The relative accuracy of prenatal ultrasound versus MRI is debated[28,29]. Similar to others[29], we found that when multiplanar sonography is obtained satisfactorily, MRI rarely adds significant information, particularly at mid gestation. We suggest that MRI has the greatest advantage over sonography in its better visualization of the position of the torcular, an important to recognize Dandy–Walker malformation. Conversely, we found that assessment of the integrity of the vermis remained difficult with both techniques, particularly in early gestation. Indeed, the only false-positive diagnosis in our series was of vermian hypoplasia by both ultrasound and MRI. Similar difficulties have been reported previously[30,31]. It should also be stressed that vermian hypoplasia may occur without the presence of a fluid collection, further complicating identification of this condition[6].

To our knowledge, this is the largest series published thus far of posterior fossa fluid collections recognized *in utero* and we believe that our results provide useful information for assessment and counseling in these cases. We do, however, acknowledge the limitations of our study, which are similar to those commonly encountered in clinical series of prenatal diagnosis of abnormal cerebral findings[32]. About one quarter of our patients were lost to follow-up, and the postnatal assessment of survivors was performed by different pediatricians who did not use a standard protocol. This must certainly be kept in mind while interpreting our data.

In conclusion, ultrasound and fetal MRI perform similarly in the characterization of fetal posterior fossa abnormalities, and a correct diagnosis can be made in about 90% of cases. Megacisterna magna and Blake's pouch cysts are the most common antenatal diagnoses. These are frequently associated with other anatomic or chromosomal anomalies but, when isolated, have a good chance of intrauterine resolution, being associated with normal developmental outcome in over 90% of cases. Dandy–Walker malformation and vermian hypoplasia have a guarded prognosis, with a very high likelihood of associated anomalies and/or neurologic impairment.

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