

Intracranial magnetic resonance imaging findings in the surviving fetus after spontaneous monochorionic cotwin demise

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OBJECTIVE: This study was undertaken to evaluate intracranial magnetic resonance imaging abnormalities in the surviving fetus after a cotwin demise.

STUDY DESIGN: This is a retrospective observational study evaluating the intracranial findings of surviving twins after demise of a monochorionic cotwin. A total of 47 cases of cotwin demise were identified from a magnetic resonance imaging database consisting of all fetal magnetic resonance imaging performed at the University of California San Francisco. Twenty-one of these cases were monochorionic twins who had not undergone an intervention (fetal radiofrequency ablation and placental laser ablation) and these comprised the study group. The magnetic resonance imaging were reviewed by a pediatric neuroradiologist who was blinded to the ultrasound and clinical findings.

RESULTS: The mean gestational age at the time of cotwin demise was 19^{6/7} weeks (range 12^{4/7} weeks–26^{5/7} weeks) with an average interval of 4^{3/7} weeks between the time of cotwin demise and fetal magnetic resonance imaging (range 0–12^{1/7} weeks). Nine cases (41%) were associated with diagnosed twin-twin transfusion syndrome. Abnormal findings, including polymicrogyria, germinolytic cysts, intracranial hemorrhage, ventriculomegaly, and delayed sulcation were identified by fetal magnetic resonance imaging in 7 (33%) cases, the majority of which had a normal ultrasound.

CONCLUSION: Prenatal magnetic resonance imaging is a valuable tool in evaluating the fetal brain after a cotwin demise.

Key words: cotwin demise, intracranial, magnetic resonance imaging, monochorionic twins

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Demise of a cotwin in a monochorionic pregnancy places the surviving twin at significant risk for neurologic sequelae.^{1,2} Subsequent death of the surviving twin occurs in 12% of cases³ and neurologic abnormalities on ultrasound are found at birth in up to 46% of cases.⁴ Some hypothesize that intracranial hy-

popoerfusion of the surviving twin at the time of cotwin demise results in ischemic insult. The association of surviving cotwin brain damage with twin reversed arterial perfusion (TRAP) and twin-twin transfusion syndrome (TTTS) supports this hypothesis.^{5,6}

Intracranial abnormalities after cotwin demise have most commonly been detected sonographically.^{6,7} Few case reports of fetal magnetic resonance imaging (MRI) findings after cotwin demise are present in the literature.^{8,9} Fetal MRI is being used increasingly to identify brain abnormalities¹⁰ and is more sensitive than ultrasound in detecting ischemic injury,^{11,12} which is the most common insult occurring with a monochorionic cotwin demise. Adequate prenatal diagnosis by imaging is especially important in the setting of invasive fetal procedures such as radiofrequency ablation (RFA), laser ablation, and amnioreduction (AR). The ideal timing of imaging is still under investigation as lesions may appear as early as 1 day to as late as 2 weeks after the insult. The sensitivity of

MRI may lend itself to earlier detection of developing lesions.⁶ The purpose of this study is to evaluate intracranial abnormalities in the surviving fetus after a cotwin demise using fetal MRI.

MATERIALS AND METHODS

A total of 47 cases of cotwin demise in monochorionic twin pregnancies were identified from a database consisting of all fetal MRI examinations performed at the University of California San Francisco (UCSF) between 1997–2007. Twenty-five of these cases were associated with an intervention (fetal RFA or placental ablation) and were excluded from the study. An additional case was excluded because of the lack of a comparison ultrasound after cotwin demise. The remaining 21 cases comprise our study group. One case has been reported previously.⁸

A 1.5-T MR magnet was used to obtain ultrafast T2-weighted images (single-shot fast spin echo, SSFSE) of the fetal brain. Images were obtained in the axial, coronal, and sagittal planes using

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TABLE
MRI vs ultrasound results by GA at time of cotwin death

	MRI Result	US result	Additional diagnosis	*GA demise	GA MRI	GA US
1	Normal brain	Normal brain	None	12 4/7	24 4/7	24 4/7
2	Normal brain	Normal brain	None	14	19 3/7	18 2/7
3	Normal brain	Normal brain	TTTS	15 5/7	19 3/7	18 4/7
4	Unilateral infarct with developing PMG	Normal brain	Probable TTTS	15 5/7	23 3/7	22
5	Normal brain	Normal brain	None	16	28 1/7	25
6	Normal brain	Normal brain	Probable TTTS	17	23	21 4/7
7	Shallow sylvian fissures; focal injury in left parietal lobe with dilation of adjacent ventricle	Normal brain	TTTS	17 5/7	20 1/7	20
8	Normal brain	Normal brain	Acardiac, anenceph TRAP	18	22	18 1/7
9	Normal brain	Normal brain	None	18 6/7	21 6/7	18 6/7
10	Normal brain	Normal brain	Probable TTTS	19 2/7	21 3/7	21 1/7
11	Bilateral germinolytic cysts	Normal brain	Acardiac, anenceph TRAP	19 6/7	20	19 6/7
12	Bilateral mild VM; delayed sulcation	Mild ventriculomegaly	None	20	27 3/7	29 4/7
13	Normal brain	Normal brain	TTTS	20 2/7	22 5/7	21 2/7
14	Sylvian fissures slightly shallow for age vs lower limits of normal	Normal brain	Probable TTTS	21	23 2/7	21
15	Normal brain	Normal brain	TTTS	21 3/7	26 4/7	25 1/7
16	Severe destruction of supratentorial brain with cystic change and hemorrhage/calcification	"Twin embolization" syndrome with developing hydranencephaly	TTTS	21 6/7	25 1/7	25 1/7
17	Normal brain	Normal brain	TTTS	22 6/7	28 3/7	28 3/7
18	Normal brain	Normal brain	None	25 1/7	28 2/7	25 3/7
19	Normal brain	Normal brain	TTTS	26 2/7	28 3/7	26 2/7
20	Hemorrhage in bilateral choroid plexus and GM with mild right VM and borderline left VM; hemorrhage in posterior fossa consistent with subdural hematoma vs thrombosed transverse sinus; subarachnoid hemorrhage adjacent to cerebellum; prominent primary vermian fissure	Intraventricular hemorrhage, periventricular ischemia	TTTS	26 2/7	27 4/7	27 2/7
21	Normal brain	Normal brain	TTTS	26 5/7	30 5/7	29 3/7

Anenceph, anencephalic; *GM*, germinal matrix; *GA*, gestational age; *MRI*, magnetic resonance imaging; *PMG*, polymicrogyria; *TRAP*, twin reversed arterial perfusion; *TTTS*, twin-to-twin transfusion syndrome; *US*, ultrasound; *VM*, ventriculomegaly.

^a Gestational age of demise estimated by earliest ultrasound after demise and clinical data.

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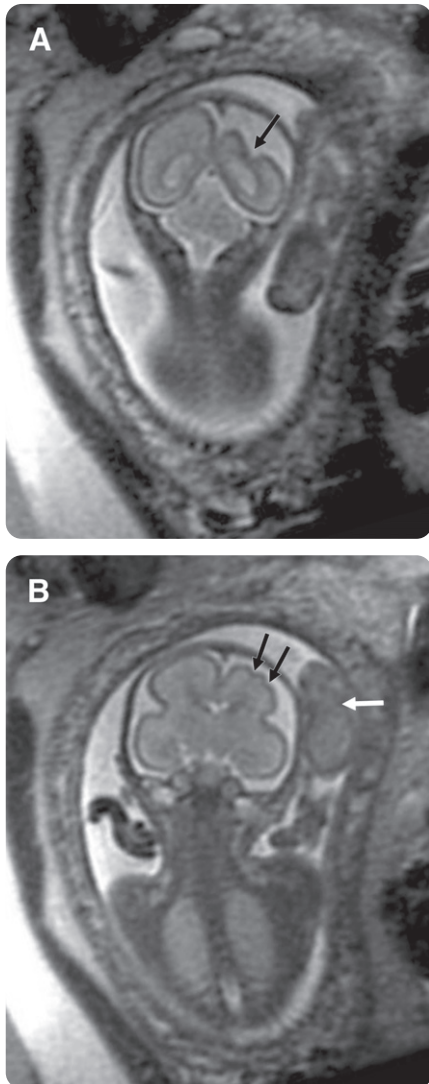
thin slices (slice thickness of 3-4 mm with no spacing between slices). In 10 cases, T1-weighted gradient echo axial images were obtained to evaluate for intracranial hemorrhage (slice thick-

ness 5 mm with 0-1 mm spacing between slices).

Fetal MR images were retrospectively reviewed in a blinded manner by a pediatric neuroradiologist with expertise in

fetal MRI. MR findings were compared with intracranial fetal ultrasounds. Ultrasound was carried out in the standard technique as has been described by other studies. The posterior fossa, magna cis-

FIGURE 1
Fetal magnetic resonance
imaging of unilateral infarct
with developing polymicrogyria



A, Coronal single-shot fast spin echo (SSFSE) T2-weighted image of a 23^{3/7}-week gestational age (GA) fetus with a large area of encephalomalacia (*arrow*) involving the left parietal, temporal, and frontal lobes. **B**, Coronal SSFSE T2-weighted image slightly anterior to the previous image demonstrates abnormal infoldings of the developing frontal lobe cortex (*black arrows*) consistent with developing polymicrogyria. The dead cotwin is also seen (*white arrow*).

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terna, ventricles, septum cavum pellucidum, thalami, and calvarium were examined. This study was approved by our institutional review board.

RESULTS

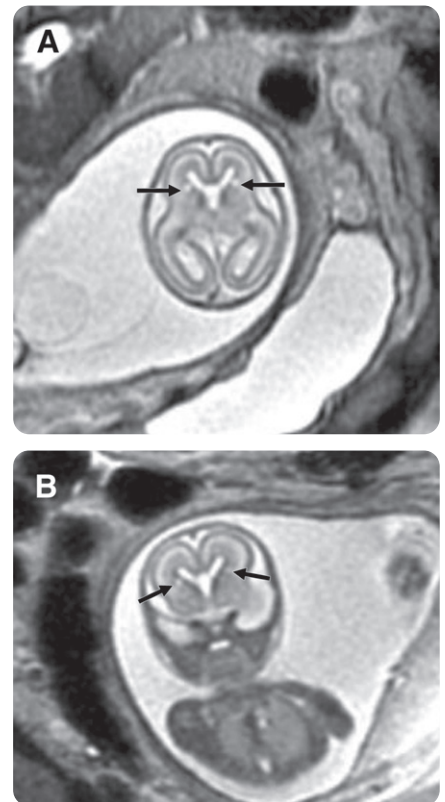
The mean gestational age at the time of cotwin demise was 19^{6/7} weeks (range 12^{4/7} weeks-26^{5/7} weeks) with an average interval of 4^{3/7} weeks between the time of cotwin demise and fetal MRI (range 0-12^{1/7} weeks). Intracranial abnormalities were visualized by antenatal MRI after cotwin demise in 7 of the 21 cases, the majority of which had a normal ultrasound (*Table*). These abnormalities included a unilateral infarct with developing polymicrogyria (*Figure 1*), small focal injury in the left parietal lobe associated with shallow sylvian fissures and dilation of the adjacent ventricle, bilateral germinolytic cysts in the region of the ganglionic eminence (*Figure 2*), and shallow sylvian fissures. Of the 7 cases, 3 also had an abnormal ultrasound, although MRI detected additional abnormalities that were not seen by MRI. The gestational age at the time of cotwin demise ranged from 15^{5/7} weeks to 26^{2/7} weeks (mean age of 20 weeks) in the 7 cases with an abnormal fetal MRI.

Only 9 of the 21 cases in our series carried the diagnosis of TTTS, another 4 carried a probable diagnosis of TTTS by ultrasonographic findings after cotwin demise, 2 had TRAP, and the remaining 6 had no diagnosis other than the presence of cotwin demise. The majority, 71%, of intracranial MRI abnormalities occurred in association with confirmed or probable TTTS, 14% in conjunction with TRAP, and 14% in cases without additional diagnosis.

COMMENT

The ability to predict neurologic sequelae of a surviving twin prenatally by sonographic findings was first reported in 1989.¹³ Since then, several studies have demonstrated a correlation between sonographic findings and neonatal outcomes, including deficits at up to 6 years of age.⁷ Ischemic lesions have vari-

FIGURE 2
Bilateral germinolytic cysts in
the region of the ganglionic
eminence



A, Axial single-shot fast spin echo (SSFSE) T2-weighted image in a 20^{0/7}-week gestational age (GA) fetus with bilateral germinolytic cysts (*arrows*) in the region of the anterior ganglionic eminence consistent with prior germinal matrix injury. **B**, Findings are confirmed on a coronal SSFSE T2-weighted image (*arrows*).

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able presentation on ultrasound, but even subtle abnormalities, such as polymicrogyria, have been reported.¹⁴ Recently, fetal MRI has proven to be a useful modality in the visualization of subtle intracranial abnormalities, including those that result from ischemic injury. MRI is less operator dependent and is possibly more accurate than neurosonography.^{15,16}

The information gathered in our study further confirms the ability of MRI to detect subtle brain abnormalities. In 57% of cases in which abnormalities were visualized on MRI, a normal brain was vi-

sualized on ultrasound. In addition, in 2 of the 3 cases in which abnormalities were reported on ultrasound, additional abnormalities were visualized on MRI. The identification of these types of abnormalities may aid in the surviving twin prognosis. An example is the case of polymicrogyria detected on MRI after the brain appeared normal by neurosonography. Polymicrogyria signifies an event of impaired fetal perfusion¹⁷ and is often associated with hypoxic-ischemic lesions,^{18,19} which are prognostic of clinically significant cerebral impairment.²⁰ As expected, this child has a congenital right hemiparesis, developmental delay, and seizures.

Abnormal sonographic findings may be detected as early as 1 day after cotwin demise.^{6,7} Several reports suggest that evolving ischemic lesions require up to 2 weeks before visualization.¹¹ Generally, our recommendation is to perform MRI at least 2 weeks after cotwin demise to optimize detection of injury. In nearly all cases with abnormal MRI findings, the MRI was carried at least 2 weeks after the date of cotwin demise. One case of bilateral germinolytic cysts in our series demonstrated MRI abnormalities as early as 1 day after the speculated date of demise, suggesting that a 2-week delay period may not be essential in the detection of all lesions. It is also possible, however, that these lesions were present before the demise, although an ultrasound performed 1 day prior did not detect any brain abnormalities. Moreover, in our experience, fetal demise as early as 15^{5/7} weeks was associated with brain abnormalities on a fetal MRI.

Although there are substantial data concerning ultrasound findings after TTTS^{21,22} and some data after TRAP,²³ a paucity of information exists surrounding imaging after the death of a cotwin in the absence of these diagnoses. Some of these cases may have involved undiagnosed chronic TTTS or acute TTTS with cotwin demise. MRI may be a useful tool in the future determination of optimal treatment for TTTS.

This study has several limitations. The number of cases is relatively small, and neither the interval between cotwin demise and MRI nor the interval between

ultrasound and MRI was consistent. Although it is conceivable that some lesions visualized on MRI were not present at the time when the ultrasound was performed, fetal MRI did detect abnormalities when it was performed within 1 day of the ultrasound. Another limitation is that almost 60% of the cases were referred for fetal MRI from an outside hospital. Although we routinely offer fetal MRI for all patients evaluated at our institution for monochorionic cotwin demise, it is not possible to know what percentage of cases of cotwin demise diagnosed at the outside hospitals were ultimately referred for a fetal MRI. As a result, it is impossible to know the actual frequency of new findings on fetal MRI after fetal neurosonography. In those cases identified at UCSF where both targeted fetal sonography and fetal MRI were performed, 56% of the identified intracranial findings were not visualized on ultrasound. We concur with others who advise a fetal MRI in the setting of a monochorionic pregnancy with cotwin demise.^{7,11,14}

Our study is also limited by the lack of correlation of fetal MR findings with neurodevelopmental outcome. Although the child with polymicrogyria on fetal MRI has congenital hemiplegia and epilepsy, at present, we do not precisely know the relationship between the fetal MRI findings and neurodevelopmental outcome. In particular, the significance of more subtle abnormalities, such as delayed sulcation, on neurodevelopmental outcome is not known. Thus, future studies correlating fetal MRI findings with outcome are needed. To provide accurate assessment, it is important that such studies use standardized developmental tests by trained personnel and include longer-term follow-up because some neurodevelopmental abnormalities may not become apparent until school age; these studies are currently underway.

In conclusion, fetal MRI can detect ischemic, developmental, and/or hemorrhagic abnormalities in the developing brain of survivors of monochorionic cotwin demise. Although sonography is helpful in detecting intracranial findings

in this setting, fetal MRI can provide additional information that may aid in prognosis. Future studies that use same-day ultrasound and MRI, as well as assessment of long-term neurodevelopmental outcome, are necessary to make conclusive statements about the true use of intracranial fetal MRI. ■

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