

# Prenatal Diagnosis of Polymicrogyria by Fetal Magnetic Resonance Imaging in Monochorionic Cotwin Death

Orit A. Glenn, MD, Mary E. Norton, MD,  
Ruth B. Goldstein, MD, A. James Barkovich, MD

**F**etal magnetic resonance imaging (MRI) is being used increasingly for confirmation and further characterization of brain abnormalities detected on routine prenatal sonography. It offers improved contrast resolution and direct visualization of both sides of the developing brain and is not susceptible to the limitations of sonography such as fetal position and amniotic fluid volume. With fetal MRI, more sensitive imaging of the cortical and sulcal development<sup>1-7</sup> of the fetus can be obtained. Although most brain abnormalities occurring in cases of complicated monochorionic twin pregnancies are characterized by localized or diffuse areas of parenchymal destruction, cortical abnormalities have also been described postnatally or on fetal autopsy.<sup>8-21</sup> We report a case in which fetal MRI showed not only encephalomalacia but also associated polymicrogyria in a survivor of a monochorionic intrauterine cotwin death.

## Case Report

A 32-year-old woman, gravida 4, para 3, was referred for fetal MRI because of the fetal death of 1 twin of a monochorionic, diamniotic pregnancy. An initial ultrasound examination performed at 15 weeks 1 day showed living twins of a monochorionic, diamniotic twin pregnancy. The fetal size and amniotic fluid volume were concordant, and there was no hydrops in either twin. A routine diagnostic ultrasound examination performed at 18 weeks 5 days, showed the death of 1 twin whose gestational age was calculated to be 15 weeks 5 days and who had severe oligohydramnios. The gestational age of the surviving twin was calculated to be 18 weeks 2 days; this twin had mild polyhydramnios. The diagnosis of twin-twin transfusion syndrome was not made previously. The surviving twin had a heart rate of 151 beats per minute, normal rhythm, normal heart size, and a normal umbilical cord Doppler waveform. The patient returned for follow-up sonography at 20 weeks 4 days, and appropriate interval

## Abbreviations

MRI, magnetic resonance imaging

Received January 10, 2005 from the Departments of Radiology (O.A.G., M.E.N., R.B.G., A.J.B.) and Obstetrics and Gynecology (M.E.N.), University of California, San Francisco, San Francisco, California USA. Revision requested January 11, 2005. Revised manuscript accepted for publication January 13, 2005.

Address correspondence to Orit A. Glenn, MD, Department of Radiology, Neuroradiology Section, University of California, San Francisco, 505 Parnassus Ave, Box 0628, San Francisco, CA 94143-0628 USA.

E-mail: orit.glenn@radiology.ucsf.edu

growth as well as resolution of the mild polyhydramnios for the surviving twin were documented. Another ultrasound examination performed at 22 weeks 6 days showed a slight interval decrease in head growth (head circumference calculated to be 21 weeks 1 day); however, the brain anatomy, including the visualized “downside” left cerebral ventricle, was normal (Figure 1), and amniotic fluid volume was normal. Amniocentesis was performed and showed a normal karyotype, 46,XY. Because of the death of the cotwin, the concern for potential brain damage to the survivor of a monochorionic twin death, and the slight decrease in head growth, the patient was referred to us for further evaluation with MRI.

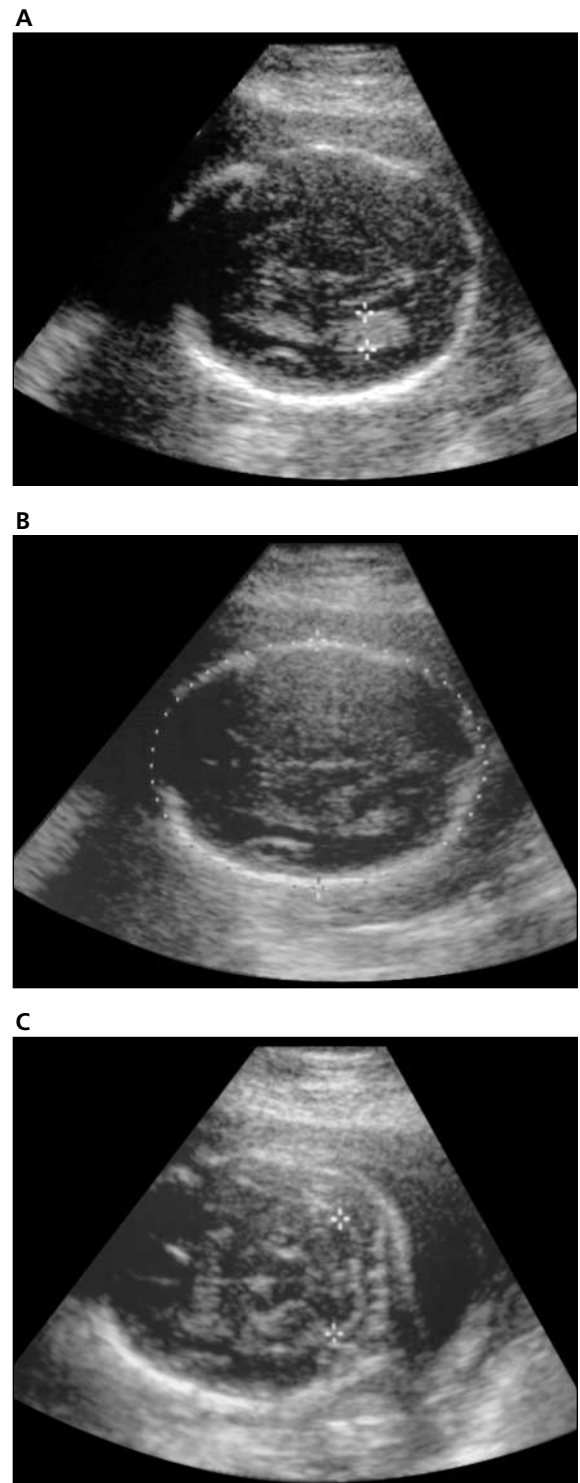
Magnetic resonance imaging performed at 23 weeks 3 days, showed a large area of encephalomalacia involving the left parietal and frontal lobes (Figure 2). There were multiple abnormal infoldings of the overlying developing cortex in the left frontal and parietal lobes consistent with polymicrogyria. The ipsilateral thalamus was also slightly small, possibly because of decreased connections between the left frontal and parietal lobes and the thalamus. Postnatal MRI performed at 5 months showed extensive polymicrogyria involving the left frontal and parietal lobes (Figure 3). Clinically, the child, who was 2 years old at the time of this writing, has a congenital right hemiparesis as well as a gross motor delay. He sat at 11 to 12 months, crawled at 15 months, and began walking with holding on at 18 months. Seizures developed at 20 months of age.

## Discussion

Improved prenatal detection of malformations of cortical development is now possible with prenatal MRI. Although sonography can show abnormalities in ventricular size and morphologic features, as well as abnormalities of the corpus callosum and posterior fossa, it is limited in its ability to visualize the developing cortex and therefore to show cortical malformations.<sup>22</sup> In contrast, fetal MRI has been shown to depict malformations of cortical development that are sonographically occult, including polymicrogyria.<sup>23–27</sup> To our knowledge, our case is the first report of prenatally diagnosed polymicrogyria in a survivor of monochorionic cotwin death.

Multiple brain abnormalities have been described in complicated monochorionic twin pregnancies.<sup>8–21</sup> Most of the brain abnormalities

**Figure 1.** Images from prenatal sonography performed at 22 weeks 6 days. **A** and **B**, Axial sonograms at the level of the lateral ventricles show no discernible cortical abnormality. The left side is down. The left ventricular atrium is normal in size (7.4 mm). **C**, Axial sonogram through the posterior fossa shows a normal appearance of the cerebellum (calipers).

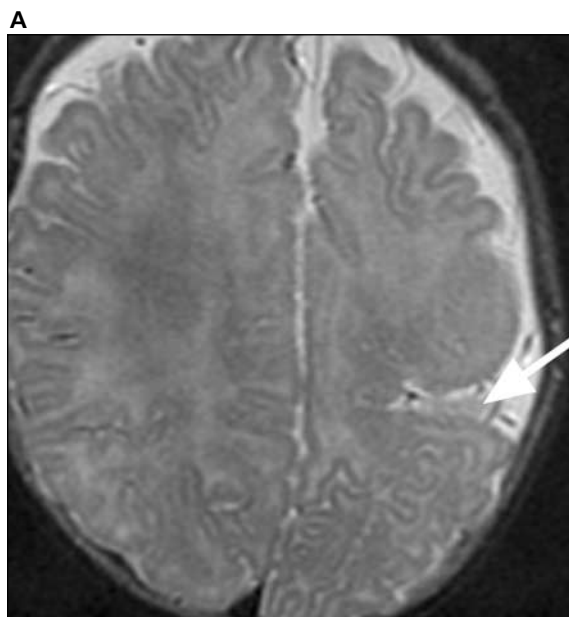
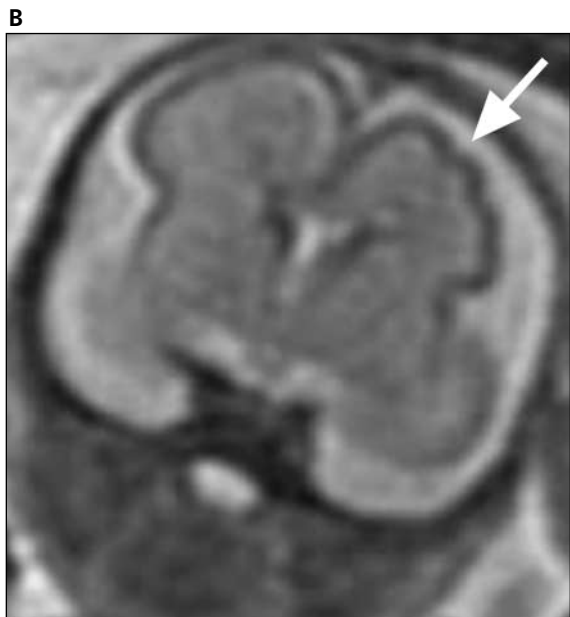
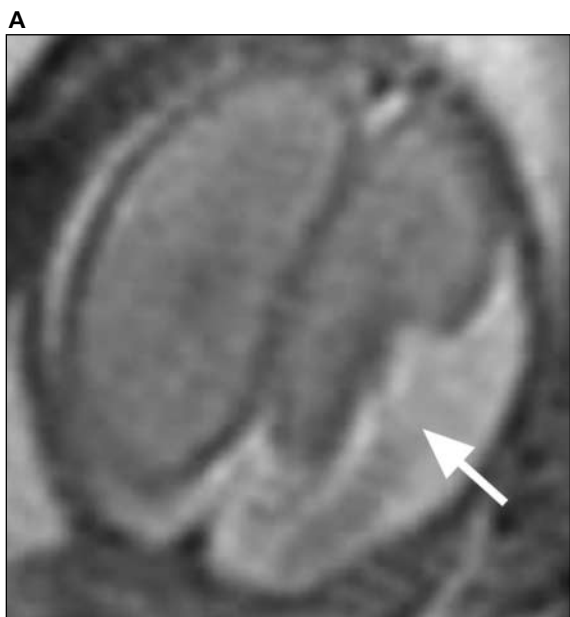


occurring in such cases involve localized or diffuse areas of parenchymal destruction, such as porencephaly, multicystic encephalomalacia, and periventricular white matter injury,<sup>11,17,21</sup> and are most likely the result of hypoperfusion

and resultant hypoxia-ischemia.<sup>11</sup> In cotwin death, it has been postulated that the intrauterine death of 1 twin leads to acute hemodynamic changes in the surviving fetus, resulting in hypoxic-ischemic lesions.<sup>11,12,14,15,28</sup>

**Figure 2.** Images from fetal MRI performed at 23 weeks 3 days. **A**, Axial single-shot fast spin echo T2-weighted image above the level of the lateral ventricles shows a large area of encephalomalacia involving the left parietal and frontal lobes (arrow). **B**, Coronal single-shot fast spin echo T2-weighted image through the frontal lobes shows a diminished volume of the left frontal lobe with several abnormal cortical infoldings (arrow) consistent with polymicrogyria.

**Figure 3.** Images from postnatal MRI performed at 5 months of age. **A**, Axial dual-echo T2-weighted image shows a diminished volume of the left frontal and parietal lobes with an abnormal sulcal pattern. An abnormally deep sulcus is also identified (arrow). **B**, Coronal fast spin echo T2-weighted image shows abnormal thickening of the perisylvian cortex consistent with polymicrogyria.



Polymicrogyria has also been described in monozygotic twin pregnancies, usually associated with intrauterine cotwin death and twin-twin transfusion syndrome.<sup>9,15,16,18,29–31</sup> Polymicrogyria is a malformation of cortical development and is characterized by abnormal cortical organization and numerous small gyri.<sup>32</sup> Barth and van der Harten<sup>9</sup> reported bilateral posterior polymicrogyria on autopsy in a term neonate in the setting of twin-twin transfusion syndrome with intrauterine cotwin death at 13 to 16 weeks. Larroche et al<sup>15</sup> described 3 fetuses with twin-twin transfusion syndrome, 2 of whom also had cotwin death, with polymicrogyria on autopsy. Baker et al<sup>30</sup> reported a case of bilateral parietal polymicrogyria and arthrogryposis multiplex congenita in a monozygotic twin pregnancy complicated by intrauterine cotwin death during the first trimester. Congenital bilateral perisylvian polymicrogyria was reported in a monozygotic twin pregnancy complicated by intrauterine cotwin death.<sup>18</sup>

Polymicrogyria can result from perfusion abnormalities, intrauterine infection, toxins, and genetic causes.<sup>33–39</sup> There are several reports of polymicrogyria occurring in singleton pregnancies complicated by maternal hypotension, severe maternal trauma, and maternal ingestion of ergotamine, all presumably resulting in impaired fetal perfusion.<sup>35,40–42</sup> Changes in fetal perfusion are also the most likely cause of polymicrogyria in complications of monozygotic twin pregnancies, including this case. Indeed, in their study of 5 pairs of fetuses with twin-twin transfusion syndrome, Larroche et al<sup>15</sup> found evidence of hypoxic-ischemic lesions in all 3 fetuses in which they observed layered polymicrogyria; 2 of the fetuses were also survivors of intrauterine cotwin death. Bordarier and Robain<sup>29</sup> also reported necrotic lesions of the white matter and cortex in 2 fetuses with polymicrogyria. Similarly, the large area of encephalomalacia associated with the development of the polymicrogyria in this case is also indicative of parenchymal injury.

Polymicrogyria can be associated with developmental delay, cognitive impairment, epilepsy, and focal neurologic deficits.<sup>36,43–46</sup> The clinical symptoms depend, in part, on the location and extent of the polymicrogyria. Patients with unilateral polymicrogyria involving the perirolandic cortex (as in our patient) tend to have congenital hemiparesis as well as epilepsy.<sup>36,46,47</sup>

Survivors of intrauterine cotwin death have a 20% risk of cerebral impairment, and this risk is higher in monozygotic twin pregnancies.<sup>20,48–50</sup> In a review of the literature, neurologic abnormalities were reported in 72% of survivors of monozygotic cotwin death.<sup>10</sup> The risk of cerebral palsy is also greater in survivors of cotwin death compared with other twin and singleton pregnancies.<sup>48,50</sup> Our patient had congenital hemiparesis, which is considered a type of cerebral palsy.

In summary, we report a case of monozygotic twin pregnancy with cotwin death in which fetal MRI showed polymicrogyria in the surviving twin that was presumably due to hemodynamic impairment related to the death of the cotwin. The only prenatal sonographic abnormality was mild delay in head growth compared with a prior sonogram, which prompted the fetal MRI at 23 weeks 3 days. Because fetal MRI can show sonographically occult cortical malformations such as polymicrogyria, it should be strongly considered in complicated monozygotic twin pregnancies.

## References

1. Girard N, Raybaud C, Dercole C, et al. In vivo MRI of the fetal brain. *Neuroradiology* 1993; 35:431–436.
2. Brisse H, Fallet C, Sebag G, Nessmann C, Blot P, Hassan M. Supratentorial parenchyma in the developing fetal brain: in vitro MR study with histologic comparison. *AJNR Am J Neuroradiol* 1997; 18: 1491–1497.
3. Girard N, Raybaud C, Poncet M. In vivo MR study of brain maturation in normal fetuses. *AJNR Am J Neuroradiol* 1995; 16:407–413.
4. Garel C, Chantrel E, Brisse H, et al. Fetal cerebral cortex: normal gestational landmarks identified using prenatal MR imaging. *Am J Neuroradiol* 2001; 22:184–189.
5. Garel C, Chantrel E, Elmaleh M, Brisse H, Sebag G. Fetal MRI: normal gestational landmarks for cerebral biometry, gyration and myelination. *Childs Nerv Syst* 2003; 19:422–425.
6. Levine D, Barnes PD, Madsen JR, Abbott J, Mehta T, Edelman RR. Central nervous system abnormalities assessed with prenatal magnetic resonance imaging. *Obstet Gynecol* 1999; 94:1011–1019.
7. Levine D, Barnes PD. Cortical maturation in normal and abnormal fetuses as assessed with prenatal MR imaging. *Radiology* 1999; 210:751–758.

8. Norman MG. Bilateral encephaloclastic lesions in a 26 week gestation fetus: effect on neuroblast migration. *Can J Neurol Sci* 1980; 7:191–194.
9. Barth PG, van der Harten JJ. Parabolic twin syndrome with topical isocortical disruption and gastroschisis. *Acta Neuropathol (Berl)* 1985; 67:345–349.
10. Szymonowicz W, Preston H, Yu VY. The surviving monozygotic twin. *Arch Dis Child* 1986; 61:454–458.
11. Larroche JC, Droulle P, Delezoide AL, Narcy F, Nessmann C. Brain damage in monozygous twins. *Biol Neonate* 1990; 57:261–278.
12. Fusi L, Gordon H. Twin pregnancy complicated by single intrauterine death: problems and outcome with conservative management. *Br J Obstet Gynaecol* 1990; 97:511–516.
13. Anderson RL, Golbus MS, Curry CJ, Callen PW, Hastrup WH. Central nervous system damage and other anomalies in surviving fetus following second trimester antenatal death of co-twin: report of four cases and literature review. *Prenat Diagn* 1990; 10:513–518.
14. Fusi L, McParland P, Fisk N, Nicolini U, Wigglesworth J. Acute twin-twin transfusion: a possible mechanism for brain-damaged survivors after intrauterine death of a monozygotic twin. *Obstet Gynecol* 1991; 78:517–520.
15. Larroche JC, Girard N, Narcy F, Fallet C. Abnormal cortical plate (polymicrogyria), heterotopias and brain damage in monozygous twins. *Biol Neonate* 1994; 65:343–352.
16. Sugama S, Kusano K. Monozygous twin with polymicrogyria and normal co-twin. *Pediatr Neurol* 1994; 11:62–63.
17. Weig SG, Marshall PC, Abroms IF, Gauthier NS. Patterns of cerebral injury and clinical presentation in the vascular disruptive syndrome of monozygotic twins. *Pediatr Neurol* 1995; 13:279–285.
18. Van Bogaert P, Donner C, David P, Rodesch F, Avni EF, Szliwowski HB. Congenital bilateral perisylvian syndrome in a monozygotic twin with intra-uterine death of the co-twin. *Dev Med Child Neurol* 1996; 38:166–170.
19. Shafir Y, Latimer M, France M. Multifocal neuronal migration disorder as a probable result of a well-documented ischemic event at 18 weeks gestation [abstract]. *Ann Neurol* 1996; 40:296.
20. van Heteren CF, Nijhuis JG, Semmekrot BA, Mulders LG, van den Berg PP. Risk for surviving twin after fetal death of co-twin in twin-twin transfusion syndrome. *Obstet Gynecol* 1998; 92:215–219.
21. Righini A, Salmona S, Bianchini E, et al. Prenatal magnetic resonance imaging evaluation of ischemic brain lesions in the survivors of monozygotic twin pregnancies: report of 3 cases. *J Comput Assist Tomogr* 2004; 28:87–92.
22. Aubry MC, Aubry JP, Dommergues M. Sonographic prenatal diagnosis of central nervous system abnormalities. *Childs Nerv Syst* 2003; 19:391–402.
23. Sonigo PC, Rypens FF, Carteret M, Delezoide AL, Brunelle FO. MR imaging of fetal cerebral anomalies. *Pediatr Radiol* 1998; 28:212–222.
24. Levine D, Barnes PD, Madsen JR, Li W, Edelman RR. Fetal central nervous system anomalies: MR imaging augments sonographic diagnosis. *Radiology* 1997; 204:635–642.
25. Glenn OA, Goldstein RB, Li KC, et al. Fetal magnetic resonance imaging in the evaluation of fetuses referred for sonographically suspected abnormalities of the corpus callosum. *J Ultrasound Med*. In press.
26. Raybaud C, Levrier O, Brunel H, Girard N, Farnarier P. MR imaging of fetal brain malformations. *Childs Nerv Syst* 2003; 19:455–470.
27. Righini A, Zirpoli S, Mrakic F, Parazzini C, Pogliani L, Triulzi F. Early prenatal MR imaging diagnosis of polymicrogyria. *AJNR Am J Neuroradiol* 2004; 25:343–346.
28. Bajoria R, Wee LY, Anwar S, Ward S. Outcome of twin pregnancies complicated by single intrauterine death in relation to vascular anatomy of the monozygotic placenta. *Hum Reprod* 1999; 14:2124–2130.
29. Bordarier C, Robain O. Microgyric and necrotic cortical lesions in twin fetuses: original cerebral damage consecutive to twinning? *Brain Dev* 1992; 14:174–178.
30. Baker EM, Khorasgani MG, Gardner-Medwin D, Gholkar A, Griffiths PD. Arthrogryposis multiplex congenita and bilateral parietal polymicrogyria in association with the intrauterine death of a twin. *Neuropediatrics* 1996; 27:54–56.

31. Delle Urban LAB, Righini A, Rustico M, Triulzi F, Nicolini U. Prenatal ultrasound detection of bilateral focal polymicrogyria. *Prenat Diagn* 2004; 24:808–811.
32. Barkovich AJ. *Pediatric Neuroimaging*. Philadelphia, PA: Lippincott Williams & Wilkins; 2000.
33. Evrard P, Kadhim H, de Saint-Georges P, Gadiisseux J. Abnormal development and destructive processes of the human brain during the second half of gestation. In: Evrard P, Minkowski A (eds). *Developmental Neurobiology*. New York, NY: Vevey/Raven Press, Ltd; 1989:21–41.
34. Friede RL, Mikolasek J. Postencephalitic porencephaly, hydranencephaly or polymicrogyria: a review. *Acta Neuropathol (Berl)* 1978; 43:161–168.
35. Barth PG. Fetal disruption as a cause of neuronal migration defects. In: Barth PG (ed). *Disorders of Neuronal Migration*. London, England: Mac Keith Press for the International Child Neurology Association; 2003:182–194.
36. Barkovich AJ, Raybaud CA. Neuroimaging in disorders of cortical development. *Neuroimaging Clin North Am* 2004; 14:231–254, viii.
37. Chang BS, Piao X, Bodell A, et al. Bilateral frontoparietal polymicrogyria: clinical and radiological features in 10 families with linkage to chromosome 16. *Ann Neurol* 2003; 53:596–606.
38. Villard L, Nguyen K, Cardoso C, et al. A locus for bilateral perisylvian polymicrogyria maps to Xq28. *Am J Hum Genet* 2002; 70:1003–1008.
39. Barkovich A, Lindan C. Congenital cytomegalovirus infection of the brain: imaging analysis and embryologic considerations. *AJNR Am J Neuroradiol* 1994; 15:703–715.
40. Ferrer I, Catala I. Unlayered polymicrogyria: structural and developmental aspects. *Anat Embryol (Berl)* 1991; 184:517–528.
41. Cohen M, Roessmann U. In utero brain damage: relationship of gestational age to pathological consequences. *Dev Med Child Neurol* 1994; 36:263–268.
42. Barkovich AJ, Rowley H, Bollen A. Correlation of prenatal events with the development of polymicrogyria. *AJNR Am J Neuroradiol* 1995; 16:822–827.
43. Guerrini R, Carrozzo R. Epileptogenic brain malformations: clinical presentation, malformative patterns and indications for genetic testing. *Seizure* 2001; 10:532–547.
44. Kuzniecky RI, Barkovich AJ. Malformations of cortical development and epilepsy. *Brain Dev* 2001; 23:2–11.
45. Montenegro MA, Guerreiro MM, Lopes-Cendes I, Guerreiro CA, Cendes F. Interrelationship of genetics and prenatal injury in the genesis of malformations of cortical development. *Arch Neurol* 2002; 59:1147–1153.
46. Gressens P, Barkovich AJ, Evrard P. Polymicrogyria: role of the excitotoxic damage. In: Barth PG (ed). *Disorders of Neuronal Migration*. London, England: Mac Keith Press for the International Child Neurology Association; 2003:170–181.
47. Pascual-Castroviejo I, Pascual-Pascual SI, Viano J, Martinez V, Palencia R. Unilateral polymicrogyria: a common cause of hemiplegia of prenatal origin. *Brain Dev* 2001; 23:216–222.
48. Grether JK, Nelson KB, Cummins SK. Twinning and cerebral palsy: experience in four northern California counties, births 1983 through 1985. *Pediatrics* 1993; 92:854–858.
49. Pharoah PO, Adi Y. Consequences of in-utero death in a twin pregnancy. *Lancet* 2000; 355:1597–1602.
50. Pharoah PO, Price TS, Plomin R. Cerebral palsy in twins: a national study. *Arch Dis Child Fetal Neonatal Ed* 2002; 87:F122–F124.