Cerebellar disruptions and neurodevelopmental disabilities

The cerebellum (“little brain”) is a part of the brain that is located in the back of the skull, dorsally to the brain stem, below the cerebrum, and above the spinal cord. The cerebellum consists of two lobes or hemispheres that are connected by a midline structure known as the vermis which resembles a worm. Although the cerebellum accounts only for about 10% of the weight and volume of the entire brain, it contains about 50 billion granule cells that represent about 75% of the total number of neurons in the brain and is connected with almost all other regions within the brain. Therefore, the cerebellum plays an important role in many functions of the brain including motor control, cognitive functions such as attention and language, and behavior such as regulation of feat and pleasure responses. The development of the cerebellum is a highly complex and prolonged process that starts in the early embryonic period and lasts into the first postnatal years. The protracted duration of the development makes the cerebellum vulnerable to a wide range of disruptions. Cerebellar disruptions refer to events that typically occur during the prenatal life and impair, interfere and subsequently alter the normal development of the cerebellum. There are many potential causes of cerebellar disruptions including focal bleeding, ischemia, or infection. A wide spectrum of congenital morphological cerebellar abnormalities may be seen, which depend on the timing and nature of the disruptive event in relation to the gestational age.

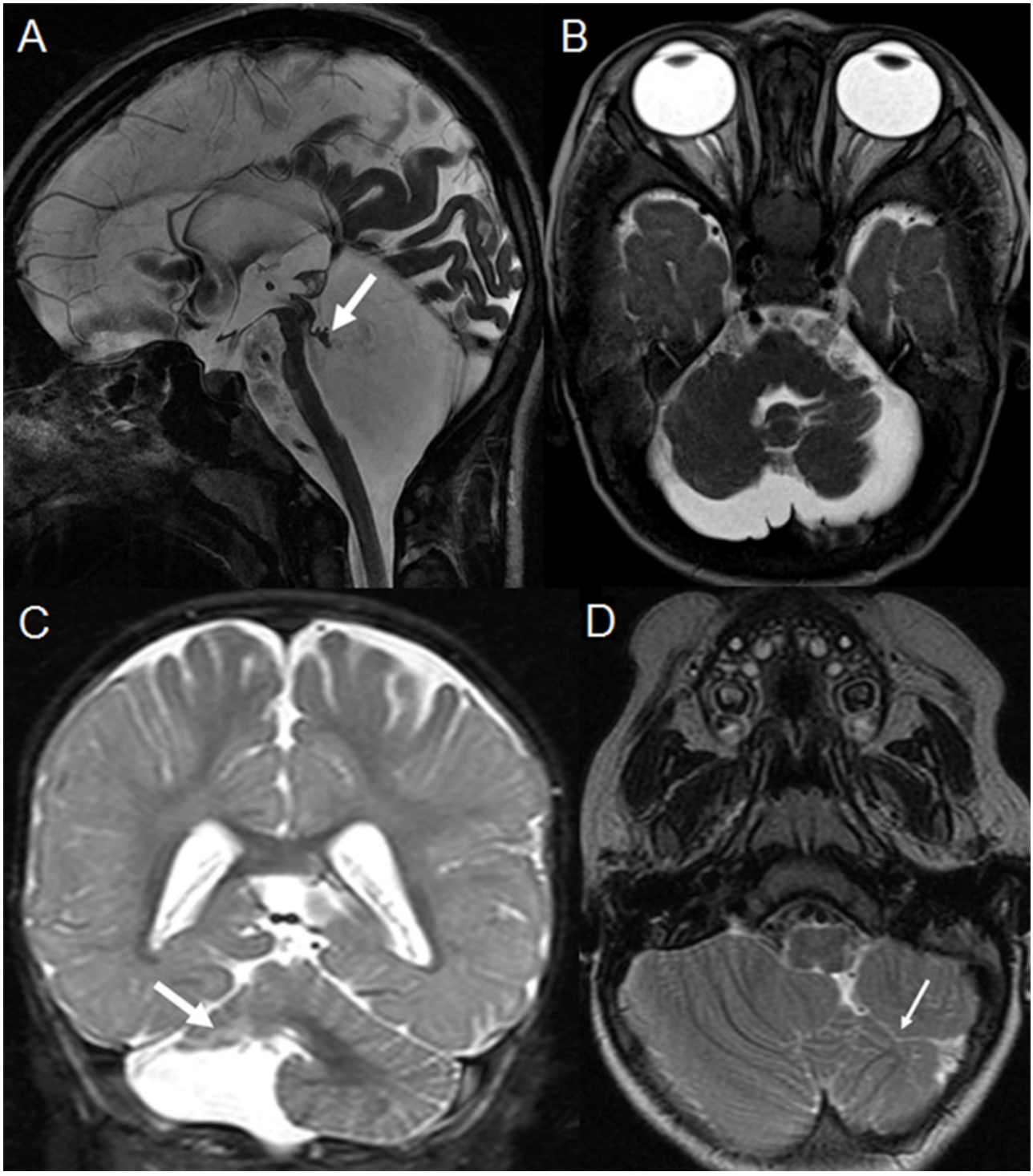

Fig. 1. A. Sagittal magnetic resonance (MR) image of a child with cerebellar agenesis shows near-complete absence of the cerebellum except for a rudimentary remnant (arrow); B, Axial MR image of a child with global hypoplasia due to prenatal cytomegalovirus infection shows global reduction in size of the cerebellum; C, Coronal MR image of a child with unilateral cerebellar hypoplasia shows almost complete absence of the right cerebellar hemisphere (arrow); D, Axial MR image of a

child with cerebellar cleft shows a cleft in the left cerebellar hemisphere (arrow) (reprinted with permission from Bosemani T and Poretti A, Cerebellar disruptions and neurodevelopmental disabilities, Semin Fetal Neonatal Med, 2016: S1744-165).

The morphological spectrum of prenatal cerebellar disruptions includes cerebellar agenesis (near-complete absence of the cerebellum), global cerebellar hypoplasia (cerebellum with a globally reduced volume, but a normal shape), unilateral cerebellar hypoplasia (complete absence or reduction in size of one cerebellar hemisphere), cerebellar cleft (cleft or slit located in one cerebellar hemisphere), and "vanishing or disappearing cerebellum" related to Chiari type II malformation (complete absence or marked reduction in size of one cerebellar hemisphere in children with an open back) (Fig. 1). Cerebellar agenesis, unilateral cerebellar hypoplasia, and cerebellar cleft are believed to result from an ischemia or bleeding of both or a single cerebellar hemisphere between 18 and 24 weeks of pregnancy. Global cerebellar hypoplasia may also be caused by prenatal infections such as cytomegalovirus or Zika virus. A "vanishing cerebellum" related to Chiari type II malformation is likely caused by chronic cerebellar tissue damage secondary to a downward movement of the cerebellum and vasculature into the upper spinal canal secondary to the small posterior fossa, which is part of the Chiari II malformation.

Children with prenatal cerebellar disruptions may present with motor, cognitive, and language impairments, as well as socialization and behavioral difficulties. Motor impairments include balance issues, gait abnormality, lack of coordination, imprecise and slow movements difficulty with eye movements, and impairment with proper speech (articulation difficulties). Cognitive impairments refer to deficits of executive functions such as problems with planning, set-shifting, abstract reasoning, verbal fluency, and working memory, as well as spatial cognition. In addition, distractibility and impaired attention are common. Behavioral difficulties may result in personality disorders causing blunting of affect or disinhibited and inappropriate behavior.

Awareness of prenatal cerebellar disruptions is important for an accurate counseling of the affected children in terms of management and outcome. In addition, prenatal cerebellar disruptions are acquired injuries that are typically not due to genetic factors and, hence, have a low recurrence risk within the affected family.

Andrea Poretti, Thierry A.G.M. Huisman
Section of Pediatric Neuroradiology, Division of Pediatric Radiology, Russell H. Morgan Department of Radiology and Radiological Science, The Johns Hopkins University School of Medicine, Baltimore, MD, USA

Publication

Pediatric Neurocutaneous Syndromes with Cerebellar Involvement.
Bosemani T, Huisman TA, Poretti A
Neuroimaging Clin N Am. 2016 Aug