CONGENITAL ANOMALIES OF PEDIATRIC NEUROIMAGING

Jennifer W Mcvige MD

I. INTRO

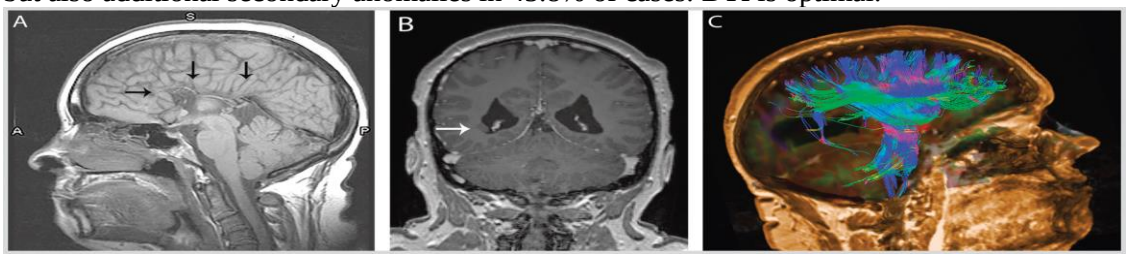
- Intracranial congenital malformations are anomalies of brain development caused by genetic and environmental influences.
- Advances in neuroimaging techniques and genetic research = better understanding of the pathogenesis of many congenital malformations.
- There is an intricate relationship between critical periods of development, genetic predisposition, and environmental insults.
- The classification of congenital malformations is challenging because many brain structures develop simultaneously and no two malformations are exactly alike.
- This discussion uses a newer classification system suggested by Barkovich and Raybaud.

II. ANOMALIES OF THE DORSAL PROSENCEPHALON (FOREBRAIN)

- Involves agenesis of the corpus callosum and other cerebral cortical malformations with supratentorial changes in the cortex or the fibers that connect the cortex together (commissure).
- Anomalies of cerebral commissures occur in 1.8 of 10,000 live births and are some of the most common developmental brain abnormalities.
- Incidence is increased in children born prematurely, born to mothers of advanced maternal age, and in children with genetic or other neurologic disorders.

A. The largest commissure is the **corpus callosum**. **Agenesis can be complete or partial.**

- It is divided into five sections and develops ventral to dorsal/anterior to posterior. The sections of the corpus callosum are the rostrum, genu, body, isthmus, and splenium.
- Dysgenesis of the **anterior corpus callosum** = an insult, such as infection or vascular event.
  Dysgenesis of the **posterior corpus callosum** = arrested development.
- Fetal ultrasound is not optimal, prenatal MRI is more helpful. Antenatal imaging was able to identify the agenesis but also additional secondary anomalies in 45.8% of cases. DTI is optimal.

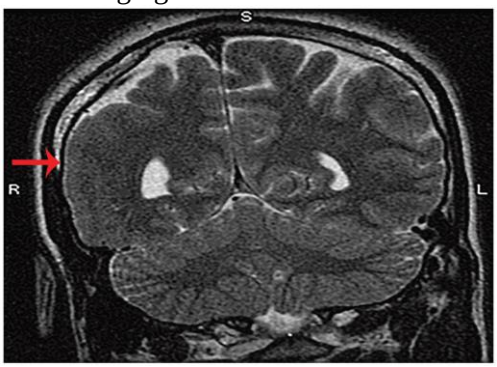


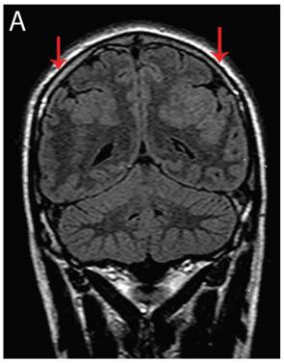
A. Complete agenesis of the corpus callosum. B. gray matter heterotopia. C. Abnormal DTI.

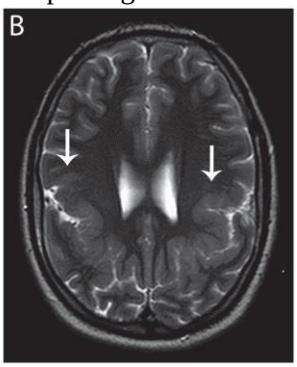
B. Cerebral cortical malformations.

- Cortical development can be affected by anything that inhibits neuronal or glial proliferation, migration, or organization. This can include gene mutations, insult from infection or bleeding, exogenous toxins (eg, alcohol or drugs), and endogenous toxins (eg,metabolic disorders).
- Can be seen on fetal ultrasound at 20 weeks GA. MRI much better than CT.
- Study found 10.7% of children with spastic cerebral palsy were found to have anomaly on MRI, including schizencephaly, agenesis of the corpus callosum, polymicrogyria, holoprosencephaly, and lissencephaly as well as cerebral atrophy.
- **Lissencephaly** = decreased sulci and gyri, resulting in a smooth cortex. It is complete (agyria) or incomplete (pachygyria -thickened flat gyri).

- The disorder is associated with the LIS1or DCX gene mutation 40% to 75% of the time.
- Band heterotopia/double cortex lissencephaly - mildest form, assoc with seizures.
  Cobblestone lissencephalies - pebbly appearance, assoc with congenital muscular dystrophies.
- **Polymicrogyria** = irregular cortex, several small convolutions looks like tiny miniature gyri on top of each due to abnormal migrational and postmigrational develop ment.
- Associated with genetic mutation in homeobox gene PAX6.
- Approximately 78% to 87% of patients with polymicrogyria have epilepsy.
- Neuroimaging can assist with localization of the seizure foci and aid in presurgical assessments.

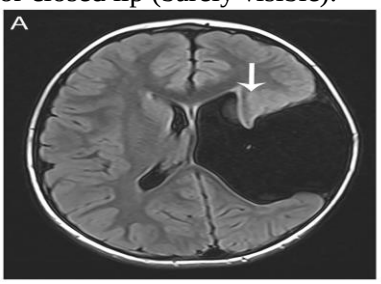


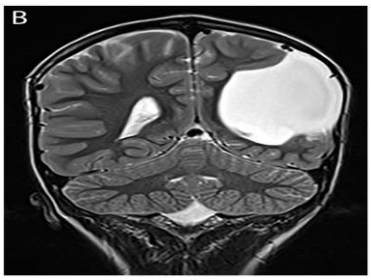




Lissencephaly A Open lip schizencephaly B Pachygyria

- **Schizencephaly =** gray matter lined cleft extends from the ependyma of the ventricle to the pial surface of the cortex.
- Gray matter is disorganized, without the proper cortical layers, and the septum pellucidum is typically absent.
- The clefts are classified as unilateral (60%) or bilateral (40%) and open lip (visible) or closed lip (barely visible).

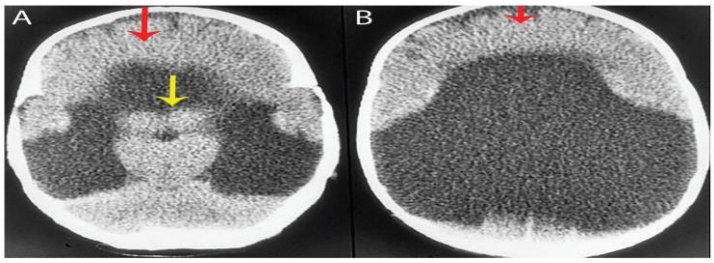




Open lip Schizencephaly.

III. ANOMALIES OF THE VENTRAL PROSENCEPHALON (FOREBRAIN)

- Malformations include anencephaly and holoprosencephaly,
- Anencephaly is a complete absence of the majority of the cerebral cortex and the skull, while holoprosencephaly is the absence of different parts of the cerebral cortex.
- **Anencephaly =** occurs when the cephalic end of the neural tube fails to close or reopens after closure and is usually not compatible with life.
- Fetal ultrasound is typically used to diagnose anencephaly, combined with elevated maternal levels of alpha fetoprotein and low maternal levels of estriol.
- **Holprosencephaly =** the failure of the division of the forebrain into two hemispheres. The severity of the depends on the extent of the development of the hypothalamus, low frontal regions, and anterior corpus callosum.3
- Subtypes = a.) **alobar** which is the most severe, no midline differentiation and fused basal ganglia
  b.) **semilobar** ‘‘ace of spades’’ appearance
  c.) **lobar** some development of the hypothalamus, frontal lobe, and anterior corpus callosum.

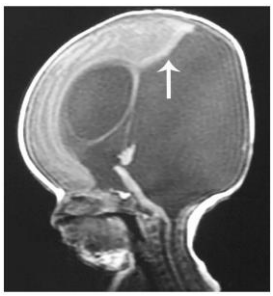
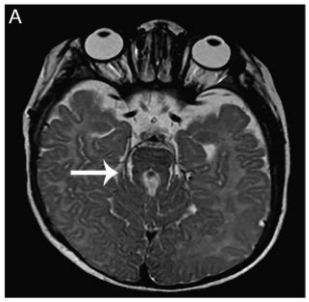


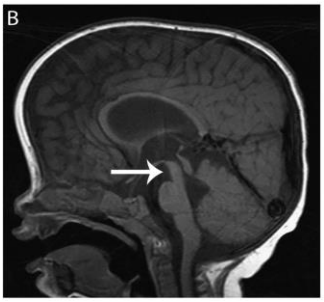
CT scan: Alobar holoprosencephaly (most severe and most common form)

- The mildest form of lobar holoprosencephaly is septooptic dysplasia which includes hypoplastic optic nerves and the absence of the septum pellucidum, which gives the frontal horns a boxlike appearance.

IV. ANOMALIES OF THE MIDBRAIN AND HINDBRAIN

- Disorders include Dandy-Walker malformation and related disorders termed Dandy-Walker variants as well as Joubert syndrome.
- Disorders in these areas have been challenging to identify with the limitations of conventional CT and MRI. The advent of high resolution thin-slice MRI and DTI has shed light on the extent and pattern of dysmorphology.
- **Dandy-Walker malformation** and related disorders are spectrum disorders that involve varying degrees of cerebellar hypoplasia, mega cisterna magna, and retrocerebellar arachnoid cysts.
- Most children present in the first year of life with increased intracranial pressure, macrocephaly (90% to 100%), and cognitive delays (one-third).
- **Joubert syndrome** rare autosomal recessive disorder that can be associated with abnormal SHH gene mediated cell proliferation.
- Neonatal patients present with tachypnea and apnea, while older patients present with hypotonia, cerebellar ataxia, and oculomotor apraxia.
- Neuroimaging is essential for a diagnosis. The molar tooth sign is a pathognomonic neuroimaging finding for this disorder - describes thickened and elongated superior cerebellar peduncles that give the appearance of a molar tooth.

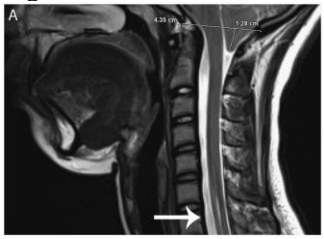



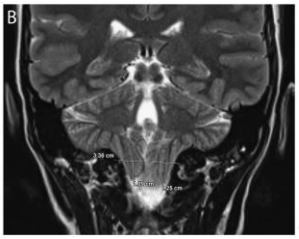


Dandy Walker Joubert Syndrome

V. ANOMALIES OF THE CRANIOCERVICAL JUNCTION

Occur when the space between the cerebellum, posterior occipital area, and upper cervical area is compromised.
Chiari Malformation Caudal displacement of at least one of the cerebellar tonsils through the foramen magnum as measured below the basion opisthion line (from the base of the clivus to the base of the foramen mag num) on sagittal MRI.





Chiari malformation with Syrinx.

- Chiari type I malformation is defined as cerebellar tonsillar extension of 5 mm or more in individuals 15 years of age and older and 6 mm or more in individuals younger than 15 years of age.
- MRI and CINE CSF flow studies have helped to redefine criteria and select surgical candidates.

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