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Andria M. Powers, Christina White, Ilana Neuberger, John A. Maloney,  
Nicholas V. Stence, and David Mirsky

Fetal MRI is a safe, noninvasive examination of the fetus and placenta, a complement to ultrasonography. MRI provides detailed CNS evaluation, including depicting parenchymal architecture and posterior fossa morphology, and is key in prenatal assessment of spinal dysraphism, neck masses, and ventriculomegaly. Fetal MRI is typically performed after 22 weeks gestation, and ultrafast T1 and T2-weighted MRI sequences are the core of the exam, with advanced sequences such as diffusion weighted imaging used for specific questions. The fetal brain grows and develops rapidly, and familiarity with gestational age specific norms is essential to MRI interpretation.

**Imaging of Congenital Malformations of the Brain** **587**

Laura Z. Fenton

Brain formation is a continuous and complicated process that is historically categorized by the timing of development. The earliest disorders of dorsal induction occur in the first month of gestation and include anencephaly and cephalocele. Disorders of ventral induction occur during the second month of gestation and include the holoprosencephaly and septo-optic dysplasia spectrums. The third and longest timeframe include the disorders of neuronal migration and proliferation (gestational weeks eight-25) and include malformations of cortical development: lissencephaly, polymicrogyria, schizencephaly, gray matter heterotopia, and corpus callosal dysgenesis. This review will highlight the neuroimaging of these malformations.

**Congenital Malformations of Cerebellum** **603**

Ali Moosavi and Sangam Kanekar

Advances in pre and postnatal neuroimaging techniques, and molecular genetics have increased our understanding of the congenital malformation of the brain. Correct diagnosis of these malformations in regards to embryology, and molecular neurogenetics is of paramount importance to understand the inheritance pattern and risk of recurrence. Lesions detected on prenatal imaging require confirmation either with postnatal ultrasound and/or with MR imaging. With the advent of the faster (rapid) MRI techniques, which can be conducted without sedation, MRI is commonly used in the

evaluation of congenital malformation of the brain. Based on neuroimaging pattern, the congenital malformations of the posterior fossa are classified into 4 main categories: (a) predominantly cerebellar, (b) cerebellar and brainstem, (c) predominantly brainstem, and (d) predominantly midbrain malformations.

### **Imaging of Congenital Spine Malformations**

623

Christina White, Sarah Sarvis Milla, John A. Maloney, and Ilana Neuberger

Congenital malformations of the spine and spinal cord reflect a diverse collection of clinical and phenotypic malformations resulting from aberrations in embryologic development. The term "spinal dysraphism" is often used broadly in the clinical setting but should be reserved for mishaps in primary neuralation. For the sake of completeness, this article will also discuss imaging features of other abnormalities demonstrating incomplete midline closure of mesenchymal, osseous, and nervous tissue, occurring at any point during embryologic development. In addition, this article will review normal spinal embryology, a clinical approach for classification of congenital spine malformations, and recommendations for appropriate imaging.

### **Imaging of Premature Infants**

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Abigail Locke and Sangam Kanekar

According to the World Health Organization (WHO), 15 million babies are born preterm each year. Preterm infants are those born at less than 37 weeks, while extremely and very preterm neonates include those born at 22 to less than 32 weeks gestational age. Infants that fail to make it to term are missing a key part in neurodevelopment, as weeks 24 to 40 are a critical period of brain development. Neonatal brain injury is a crucial predictor for mortality and morbidity in premature and low birth weight (<1500 g) infants. Although the complications associated with preterm birth continue to be the number one cause of death in children under 5, the survival rates are increasing (Volpe, 2019). Despite this, the incidence of comorbidities, such as learning disabilities and visual and hearing problems, is still high. The functional deficits seen in these infants can be contributed to the white matter abnormalities (WMA) that have been found in 50% to 80% of extremely and very preterm neonates. While numerous, the etiology of the neonatal brain injury is essential for determining the mortality and morbidities of the infant, as there is an increased risk for both intraventricular hemorrhage (IVH) and periventricular leukomalacia (PVL), which can be attributed to their lack of cerebrovascular autoregulation and hypoxic events. Neuroimaging plays a key role in detecting and assessing these neurologic injuries that preterm infants are at risk for. It is essential to diagnose these events early on to assess neurologic damage, minimize disease progression, and provide supportive care. Brain MRI and cranial ultrasound (CUS) are both extensively used neuroimaging techniques to assess WMA, and it has become ever more important to determine the best imaging techniques and modalities with the increasing survival rates and high incidence of comorbidities among these infants.

**Imaging of Inherited Metabolic and Endocrine Disorders** 657

Anna V. Trofimova and Kartik M. Reddy

Inherited metabolic disorders represent a large group of disorders of which approximately 25% present in neonatal period with acute metabolic decompensation, rapid clinical deterioration, and often nonspecific imaging findings. Neonatal onset signifies the profound severity of the metabolic abnormality compared with cases with later presentation and necessitates rapid diagnosis and urgent therapeutic measures in an attempt to decrease the extent of brain injury and prevent grave neurologic sequela or death. Here, the authors discuss classification and clinical and imaging findings in a spectrum of metabolic and endocrine disorders with neonatal presentation.

**Perinatal Ischemic Stroke: Etiology and Imaging** 675

Nicholas V. Stence, David M. Mirsky, and Ilana Neuberger

Perinatal ischemic stroke is a common cause of lifelong disability.

**Imaging of Microcephaly** 693

Chukwudi Okafor and Sangam Kanekar

One of the most common definitions of microcephaly cited is that of an occipitofrontal circumference (OFC) of the head that is less than two standard deviations below the average for age (or gestational age, if identified prenatally) and sex. Similarly, severe microcephaly is defined as an OFC that is less than three standard deviations below the average. Microcephaly is not a diagnosis, but rather, a finding that is secondary to a multitude of etiologies that can be categorized as prenatal versus postnatal, genetic versus environmental, and congenital versus acquired.

**Imaging of Macrocephaly** 715

Ilana Neuberger, Nicholas V. Stence, John A. Maloney, Christina White, and David M. Mirsky

Macrocephaly is a common diagnosis in the pediatric population, particularly in the infantile time period. There is a wide range of causes of macrocephaly, from benign to malignant, for which imaging plays a key role in the diagnosis and clinical guidance. Our aim is to review the distinct and prevalent neuroimaging findings in the evaluation of the macrocephalic infant.

**Imaging of Hypoxic-Ischemic Injury (in the Era of Cooling)** 735

Judith A. Gadde, Andrea C. Pardo, Corey S. Bregman, and Maura E. Ryan

Hypoxic-ischemic injury (HII) is a major worldwide contributor of term neonatal mortality and long-term morbidity. At present, therapeutic hypothermia is the only therapy that has demonstrated efficacy in reducing severe disability or death in infants with moderate to severe encephalopathy. MRI and MRS performed during the first week of life are adequate to assess brain injury and offer prognosis. Patterns of injury will depend on the gestation age of the neonate, as well as the degree of hypotension.

**Intrauterine and Perinatal Infections****751**

Jennifer A. Vaughn, Luis F. Goncalves, and Patricia Cornejo

Imaging plays an important role in evaluating patients with suspected intrauterine and perinatal infections. Advances in fetal imaging including both ultrasound and MRI allow for increasingly more specific diagnosis if the radiologist is familiar with specific imaging features and patterns. Early imaging of neonates with suspected central nervous system infection is valuable to enable prompt treatment and differentiate infection from other conditions which can clinically present similarly. Ultrasound is a useful initial modality to screen for abnormalities however MRI with and without contrast remains the optimal examination to characterize infection, evaluate for potential surgical targets, and provide prognostic information.

**Imaging of Congenital Craniofacial Anomalies and Syndromes****771**

Jing Chen and Sangam Kanekar

Craniofacial malformation is one of the most commonly encountered birth defects in the prenatal and postnatal periods. Higher-resolution and 3D antenatal ultrasonography and multidetector computed tomographic scan with 3D reformatted images have improved the definition of the soft tissue and bone structures of the craniofacial anatomy and its malformations. Early diagnosis of these conditions is important to make the clinical decisions and more so in understanding the possibility of malformation recurring in the next pregnancy, which is one of the major concerns for the parents and the treating physicians.

**Special Article****Congenital Anomalies of the Kidneys and Urinary Tract****791**

Deborah Stein and Erin McNamara

Congenital anomalies of the kidneys and urinary tract (CAKUT) are some of the most common abnormalities detected on prenatal imaging assessment. It is estimated that CAKUT comprises 20% to 30% of all major birth defects. More than 200 clinical syndromes currently include CAKUT as a component of the phenotype. This chapter outlines the evaluation and management of the most common forms of CAKUT.