Cerebrospinal fluid (CSF): A-Z. Overview of Imaging modalities for the ventricular system and CSF pathways

A Megahed, R Sulaiman, M Elbanan, M Kureti, S Smith · Bridgeport Hospital-Yale New Haven Health

Introduction: Radiology plays an integral role in the assessment of the anatomical structures through which CSF is produced, circulated and drained. A vast array of congenital anomalies and pathologies can involve the ventricles, CSF spaces, and draining sinuses. Ultrasound, CT and MRI are beneficial in the assessment and follow up of these CSF related pathologies.

Anatomy of the ventricular system and subarachnoid space

CSF is produced by the choroid plexus, which is produced in specific locations within the ventricular system, circulated in the subarachnoid space and drains primarily by the subarachnoid granulations into the dural venous sinuses, and to a lesser extent by cerebral veins and the lymphatic system.

Figure 1. Adapted from Core Radiology: Overview of the ventricular system

Figure 2. Adapted from Osborn's Brain: Imaging pathology and anatomy

Congenital anomalies of the ventricular system and subarachnoid spaces

- Anatomic variants: Asymmetry of lateral ventricles, cavum septum pellucidum and interpositum, benign enlargement of the subarachnoid spaces
- Abnormalities of size: Colpocephaly, ventriculomegaly
- Dandy walker malformations and posterior fossa malformations
- Meningoceles and myelomeningocele

Figure 3: Fetal ultrasound showing dilatation of the posterior horns of the lateral ventricle: Colpocephaly

Figure 4: Left: Axial CT image, Right: Sagittal image of a meningocoele

Role of ultrasound in the diagnosis of congenital anomalies of the ventricles and CSF spaces

Figure 5: Coronal views of the fetal head on ultrasound showing dilatation of the lateral ventricles and third ventricle and enlarged cisterna magna

Figure 6: Axial view of the fetal head on ultrasound showing absent vermis and dilated fourth ventricle communicating with an enlarged cisterna magna: Dandy walker malformation

Figure 7: Axial view of the fetal head on ultrasound showing asymmetric lateral ventricles

Role of low dose CT in the assessment of

Ventriculomegaly/Hydrocephalus:

- Diagnosis and follow up
- Causes of ventriculomegaly/ hydrocephalus
- Types of hydrocephalus
- Complications: Transependymal edema

Figure 8: Axial and coronal CT of the brain showing communicating hydrocephalus

Figure 9: Axial CT of the brain showing a post-operative pseudomeningocele

Figure 10: Axial CT of the brain showing: left to right: a) Normal brain with no hydrocephalus, b) Dilatation of the lateral and third ventricles, c) Post placement of ventriculostomy with subsequent subdural collection, d) resolution of hydrocephalic changes

Additional techniques for assessment of CSF pathology eg: CSF cisternography, CT myelography, guidance for lumbar puncture

Figure 11. Fluoroscopy guided lumbar puncture via a sublaminar approach

Figure 12. Fluoroscopy guided lumbar puncture for intrathecal chemotherapy administration via a sublaminar approach

Role of MRI in the assessment of the ventricular system:

Limited radiation exposure with superior anatomical assessment of the CSF pathway, allowing for repeated evaluation in post treatment in the pediatric population.

Figure 13. Fetal MRI showing agenesis of the corpus callosum with ventriculomegaly

Figure 14. T1WI demonstrating colpocephaly

Figure 16. Post contrast T1WI demonstrating hydrocephalus with an enhancing a frond like mass in the left lateral ventricle: Choroid plexus papilloma with subsequent hydrocephalus

Figure 15. Coronal T2WI demonstrating hydrocephalus with Evan's ratio of 0.49: Ratio of maximum width of the frontal horns of the lateral ventricles and the maximal internal diameter of the skull at the same level. (Normally less than 0.3)

Role of different MR techniques for the assessment of the ventricles and CSF spaces

-FAST sequence MRI (fsMRI): The average time for the scan is 3.5 minutes, allowing the assessment of the ventricle size, configuration, absence or presence of transependymal flow, providing superior anatomical details and with limited radiation exposure.

-CSF flow studies: CSF flow studies are performed using a variety of MRI techniques and can qualitatively assess and quantify pulsatile CSF flow. The most common technique used is time-resolved 2D phase contrast MRI with velocity encoding. It is beneficial to quantify flow in cases of aqueduct stenosis, normal pressure hydrocephalus, patency of third ventriculostomy and to assess flow at the cervicomedullary junction.

-MRI cisternography: MR Cisternography using T2 weighted FSE (Fast Spin Echo) and CISS (Constructive Interference In Steady State) techniques is noninvasive, accurate and highly useful in the diagnosis of CSF rhinorrhoea especially due to nontraumatic cause.

Figure 18. MRI cisternography study showing possible CSF leak at the left posterior cribriform plate (orange arrow)