Case Report

Utility of Sonography of Cranium as Diagnostic Modality in Paediatric Intracranial Pathologies

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A B S T R A C T

Introduction: Ultrasonography of the cranium is an easily available, non-invasive technique for the assessment of neonatal intracranial structures.

Case reports: In this article, we present 4 representative cases of paediatric intracranial pathology diagnosed with USG cranium in our institute and later confirmed with MRI

1. Germinal matrix haemorrhage
2. Periventricular leucomalacia
3. Hydrocephalus due to aqueductal stenosis.
4. Dandy Walker malformation

Conclusion: Ultrasonography of the cranium is an excellent modality for imaging a wide array of intracranial pathology in the newborn. In a number of diseases it may be diagnostic alone without need of additional imaging evaluation

Keywords: Sonography of Cranium, Diagnostic Modality, Paediatric Intracranial Pathologies

INTRODUCTION

Ultrasonography of the cranium is an easily available, non-invasive technique for the assessment of neonatal intracranial structures. The four major groups of abnormalities that can be evaluated with USG Cranium in neonates include

1. Germinal matrix haemorrhage
2. Periventricular leukomalacia
3. Hydrocephalus
4. Cerebral malformations

In this article, we present 4 representative cases of each of the above groups of paediatric intracranial pathology diagnosed with USG cranium in our institute and later confirmed with MRI.

This is followed by discussion of the utility & basic technique of USG cranium and also the normal imaging anatomy of neonatal brain on USG.

CASE REPORTS

Case 1

An 8 day old sick preterm baby was advised USG cranium. On USG, hyperechogenic area was detected in the region of the right caudothalamic groove & considering the clinical picture(preterm sick child), a diagnosis of germinal matrix haemorrhage was suggested. The child was subsequently advised MRI brain where the caudothalamic groove bleed was confirmed (Figure1a,b).

Case 2

A 7 day old low birth weight preterm baby(birth weight of 2.1 kg) was advised ultrasonography of the cranium. The mother of the child complained that the baby had difficulty suckling.

On USG, small anechoic cystic spaces were seen in periventricular regions bilaterally & a diagnosis of Periventricular leukomalacia was suggested (Figure-2a,b). The patient was subsequently put for MRI (figure-2c)

Figure-1: (a) USG cranium shows hyperechoic area in the region of right caudothalamic groove (as marked by arrow)

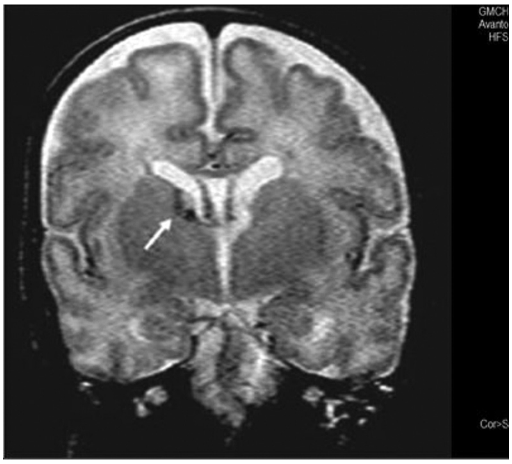

Figure-1: (b) T2WI image demonstrates germinal matrix hemorrhage evidenced as low-signal intensity material in the subependymal zone of right caudothalamic groove(arrow).

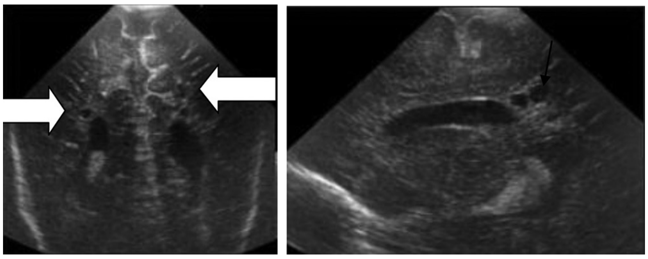

Figure-2: (a) Transverse & 2(b) sagittal images of the cranium demonstrate small periventricular cysts

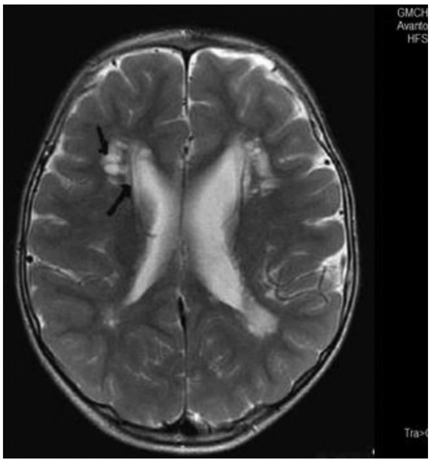

Figure-2: (c) T2 W MRI confirms bilateral periventricular leukomalacia in the child

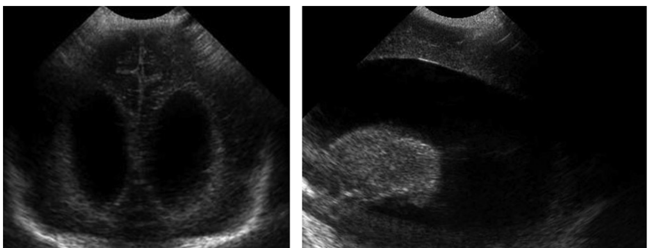

Figure-3: (a) Coronal & 3(b) sagittal ultrasonography images show marked ventricular dilatation in a newborn infant. The lateral ventricles are enlarged, as is the third ventricle.

CASE 3

A newborn infant (3 weeks) was sent for ultrasonography of the cranium with an antenatal diagnosis of hydrocephalus. On USG, both the lateral & the third ventricles were found to be dilated. However there was no significant thinning of the cerebral parenchyma (figure 3 a,b,c).

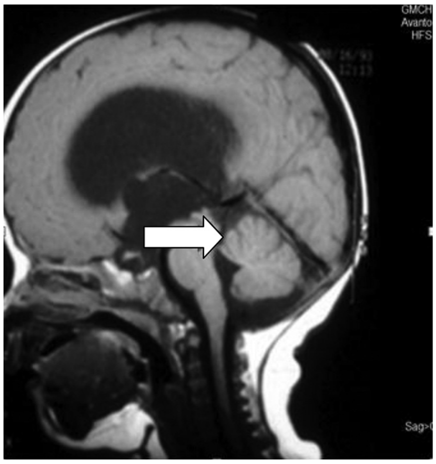

Figure-3: (c) T1W MR image demonstrating hydrocephalus due to aqueductal stenosis.

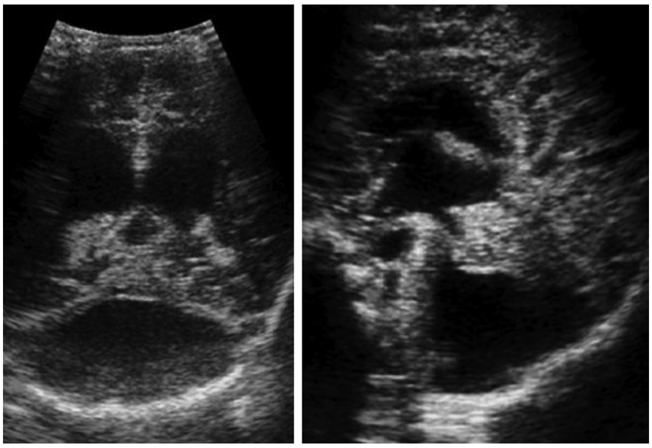

Figure-4: (a) Coronal and 4(b) sagittal USG demonstrating large posterior fossa cyst communicating with the fourth ventricle associated with moderate hydrocephalus. A diagnosis of Dandy Walker malformation was suggested

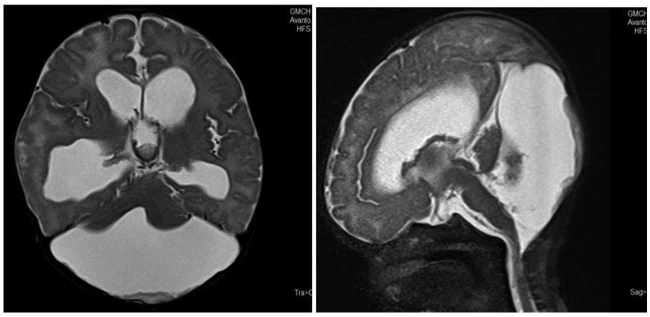

Figure-4: (c) Axial & 4(d) sagittal T2WI demonstrating a large posterior fossa cystic lesion communicating with the fourth ventricle associated with hydrocephalus. In addition, there is cerebellar hypoplasia---features consistent with Dandy Walker malformation.

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Case 4

A 22 day old child was advised ultrasonography of the cranium with the complains of an enlarged head. The child was later put for MRI (figure-4 a,b,c).

DISCUSSION

Utility of USG cranium

Ultrasound of the cranium is a widely used imaging modality for assessment of neonatal intracranial structures specially in high risk & preterm neonates. It is of particular importance for diagnosis of germinal matrix haemorrhage as preterm babies with this condition are frequently asymptomatic or demonstrate only subtle signs that may be overlooked. Besides a clue to the initial diagnosis, these cases can be followed up with USG avoiding the risks of exposing the newborn to radiation (as in CT scans) or sedation (required for CT & MRI scans)[1]. With portable USG, there is also no need to transfer the baby outside the critical care setting for evaluation. Because of these features as well as its easy availability, neonatal neurosonography has become an essential armamentarium in newborn care.

Besides haemorrhage, certain other pathological conditions like hydrocephalus, congenital structural defects, ischemic insults can also be diagnosed and monitored with USG.

The four major groups of abnormalities that can be evaluated with USG Cranium in neonates include

1. Germinal matrix haemorrhage
2. Periventricular leukomalacia
3. Hydrocephalus
4. Cerebral malformations

(1) Germinal matrix hemorrhage

Germinal matrix hemorrhages were classified into four categories by Papile based on the extent of hemorrhage.

Grade 1 Germinal matrix hemorrhage

Grade 2 Blood within the ventricular system, but not distending it

Grade 3 Intraventricular hemorrhage with ventricular dilatation

Grade 4 Parenchymal involvement

Routine screening cranial USG should be performed in all infants of under 30 weeks gestation, once between 7 and 14 days of age and should be optimally repeated between 36 and 40 weeks postmenstrual age.

In the above mentioned case no 1, hyperechognic area in caudothalamic groove (figure 1 a) represents germinal matrix haemorrage. This is in accordance to the article by Alessandro Parodi et al[2] which says that when bleeding is limited to the germinal matrix (GMH), the typical CUS finding is a subependymal hyperechoic globular thickening detected during the first week of life, which usually remains visible for a few weeks

(2) Periventricular leukomalacia

Sonographic grading of PVL was described by Di Vries.

Grade 1 PVL generally presents as an increase in the parenchymal echoes in the periventricular region, mainly around the trigone, lasting less than 7 days. These early sonographic findings are described as periventricular flare.

Grade 2 PVL presents as persistent periventricular hyperechogenicity lasting more than 7 days.

Grade 3 PVL presents with relatively advanced parenchymal changes leading to microcyst formation.

Grade 4 PVL represents with multiple coalescing cystic areas in the cerebral parenchyma.

The periventricular cysts in the case no 2 was localized to frontal & parieto occipital regions (figures 2 a,b,and c)

According to a study by V. Pierrat et al[3], localisation of the cysts was in the parieto-occipital region in 8/39 infants. The frontal or parietal white matter was affected in 24 cases, and in seven infants the cysts were diagnosed in the occipital periventricular white matter.

(3) Hydrocephalus

Hydrocephalus contributes to a large number of cases that can be diagnosed and followed up by neurosonography. According to article by Venkatraman Bhat et al[4], extent of hydrocephalus, level of obstruction, and thickness of the cerebral mantle can be obtained for subsequent follow-up. Biventricular, bifrontal ratio is measured at the level of foramen of Monro for quantitative follow-up of hydrocephalus

(4) Cerebral Malformations

Some of the congenital structural anomalies of the barin that can be diagnosed with ultrasonography of cranium include Dandy Walker malformation, Arnold Chiari malformation,agenesis of corpus callosum as well as vascular malformations such as vein of Galen malformation

A Dandy-Walker malformation comprises of the triad of:

hypoplasia of the vermis and cephalad rotation of the vermian remnant

cystic dilatation of the fourth ventricle extending posteriorly

enlarged posterior fossa with torcular-lambdoid inversion (torcular lying above the level of the lambdoid due to abnormally high tentorium)

It is at the severe end of the spectrum denoted by the term Dandy-Walker continuum

According to Lutfi Incesu et al[5], on US, a large posterior fossa midline cyst that communicates with the fourth ventricle is best demonstrated on midline sagittal sections as shown in our case no 4 (figure 4b).

Technique of Neurosonography

The procedure must be carried out under aseptic & antiseptic precautions because of the vulnerable immunity of premature neonates.

Windows

The neonatal brain is primarily evaluated through the anterior fontanelle that functions as acoustic window to view brain structures.[6]

Alternative windows for adequate examination include the posterior and mastoid fontanelles.[7] These views should be utilized for optimal visualisation of the posterior fossa structures as the standard anterior frontanelle view has limitations in demonstrating these structures. In addition, the posterior frontanelle and mastoid views allow adequate demonstration of blood collection in the dependent occipital horns of lateral ventricles as these may be missed with the anterior frontanelle view.

The foramen magnum serves as a supplementary window for evaluating the inferior posterior fossa including brainstem, cranio-cervical junction as well as upper cervical spine. It is thus a useful adjunct in cases of posterior fossa malformations (e.g., Chiari malformation, Dandy Walker malformation).

In presence of burr hole, craniotomy defect etc, additional views may be obtained through these windows.

Transducers

A small footprint sector (or curvilinear) transducer and/ or high frequency linear-array transducer (5-8 MHz) is utilized. The appropriate frequency of the transducer should be selected to ensure that the superficial and deep structures are well depicted.[8]

Planes of scanning

Sequential coronal views should be obtained by sweeping through the entire brain, from anterior to posterior through the anterior fontanelle.

In addition, midline & paramedian sagittal views of the neonatal brain can also be obtained through the anterior frontanelle.[9]

Structures to be evaluated in coronal planes from anterior to posterior

1. Frontal lobes with orbits
2. Frontal horns & bodies of lateral ventricles and interhemispheric fissure.
3. Corpus callosum (to be traced in its entirety from anterior to posterior), septum pellucidum or cavum septi pellucidi,
4. Caudate nuclei, putamina, globi pallidi, thalami and Sylvian fissures including the caudothalamic grooves.
5 Trigone & occipital horns of lateral ventricles.
6 Periventricular white matter close to occipital horns.
7. Parietal and occipital lobes
8. Brainstem including pons and medulla
9. Cerebellar hemispheres & vermis
10 Cisterna magna.

The specific structures assessed on sagittal & parasagittal images include

Midline sagittal view for demonstration of the following structures

1. The corpus callosum,
2. Cavum septi pellucidi, and cavum vergae, if present;
3. Third and fourth ventricles;
4. Aqueduct of Sylvius; brainstem;
5. Cerebellar vermis; cisterna magna;
6. Branches of the anterior cerebral artery (pericallosal artery and callosomarginal artery)
7. Superior sagittal sinus with color Doppler, as needed

Right and left parasagittal views to demonstrate

1. The insula,
2. Sylvian fissures,
3. Deep periventricular white matter,
4. Lateral ventricles including caudothalamic groove

Certain pathologies well demonstrated on sagittal images include

1. Germinal matrix haemorrhage in caudothalamic groove
2. Agenesis/ dysgenesis of corpus callosum - Sunburst appearance due to radial orientation of gyri in corpus callosal agenesis can be appreciated on sagittal images
3. Infratentorial pathologies including haemorrhage

Colour Doppler Neurosonography in neonates

In addition to Grey scale imaging, Color Doppler can be utilized for evaluation of the following

1. Intracranial vascular lesions like arteriovenous malformations & aneurysmal alformation of vein of Galen
2. Sinus venous thrombosis.
3. Differentiation between subarachnoid hemorrhage and subdural hemorrhage.

In subarachnoid haemorrhage, with ultrasound Doppler the cortical veins can be demonstrated to be adjacent to the inner table of the calvaria and thus visible traversing the subarachnoid space. While in a subdural hygroma, the veins are displaced away from the inner table because the arachnoid membrane and subarachnoid space are displaced by the subdural fluid collection.

4. Routine imaging of anterior cerebral artery for reconfirmation of corpus callosum presence on sagittal view. Colour Doppler demonstrates unusual course of the anterior cerebral artery in cases of agenesis of the corpus callosum, described as sunburst appearance

4. Pulsed Doppler assessment of resistive index, as needed, especially for infants with suspected hypoxic ischemic encephalopathy or hydrocephalus. Abnormalities in RI have been correlated with prognosis in these conditions.[10]

CONCLUSION

Ultrasonography of the cranium is an excellent modality for imaging a wide array of intracranial pathology in the newborn. Because of the high incidence of pathology in gestationally immature neonates, screening sonography represents the primary modality for the evaluation of the preterm brain. In a number of diseases it may be diagnostic alone without need of additional imaging evaluation. Portability of the study,non invasiveness, lack of need to transport baby to radiology services, lack of sedation and the wealth of diagnostic information available from USG cranium makes this a highly useful diagnostic tool. The technique of neonatal neurosonography is still being improved with the use of higher transducer frequencies (upto18 MHz), 3D applications & advances in vascular imaging.[11]

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