Original paper

Role of Neurosonography in the Management of Neonatal Intracranial Lesions

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Abstract

Background: Neurosonography is an important test in the diagnosis of hemorrhage and other acquired and congenital brain pathology of the newborn, despite the advances in computed tomography (CT) and magnetic resonance imaging (MRI), ultrasound is still the only modality able to image the brain at the bedside, which can be vitally important in the case of the critically ill infant. Whereas CT and MRI require sedation for optimal imaging, US can be done without incurring the risks associated with sedation. Also of benefit to the newborn is that ultrasound is easily reproducible and does not produce any ionizing radiation.

Aim of the study:

1. To analyze prospectively the value of neurosonography versus CT scan for the assessment of suspected intracranial lesions.
2. To evaluate the significance of CT imaging after brain ultrasound and whether it change the patient management.

Methods: This is a cross sectional descriptive study in which a forty two full-term neonates were prospectively studied in Kerbela teaching hospital for children between April 2015, and September 2016. Brain ultrasound was done for them for various presentations (seizure, big head, small head, birth asphyxia, bulging fontanel, declining hemoglobin, central apnea/bradycardia, and lethargy)

Then CT scan requested for them by radiologist, pediatrician or neurosurgeon.

Results: There were 26 male and 16 female neonates.

The main findings on US were

Hydrocephaly (14), Intracranial bleeding (9), Cystic lesions (8), Brain edema (6), Normal (5)

In the present study, 14 cases of hydrocephalus were diagnosed by US, and were confirmed by CT scan of brain, the results were completely similar in 6/14 of cases, and were partially concordant in the remaining 8 cases.

Regarding intracranial hemorrhage in 6 of 9 cases, there is complete concordance between ultrasound and CT findings while there is partial concordance in the remaining 3 cases.

For cystic brain lesion, in 6 of 8 cases there is no concordance between the findings, one of 8 showed complete concordance while the last one showed partial concordance.

In brain edema, 6 detected by ultrasound, 5 of them confirmed by CT scan, while the 6th were normal.

In the present study 5 cases appeared normal by ultrasound and CT.

Conclusions: Transfontanellar ultrasound is the first step when performing an intracranial evaluation in neonates as it is informative, bed side, cheep and available.

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Introduction

Sonography

Neurosonography is an important test in the diagnosis of hemorrhage and other acquired and congenital brain pathology of the newborn. Premature neonates are especially at risk for intracranial problems, and it is important for the sonographer to have a thorough knowledge of the normal anatomy and sonographic appearance of the neonatal brain.

Despite the advances in computed tomography (CT) and magnetic resonance imaging (MRI), ultrasound (US) is the most commonly used modality for examining the newborn brain.

Ultrasound is still the only modality able to image the brain at the bedside, which can be vitally important in the case of the critically ill infant. Whereas CT and MRI require sedation for optimal imaging, US can be done without incurring the risks associated with sedation. Also of benefit to the newborn is that ultrasound is easily reproducible and does not produce any ionizing radiation [(1)].

Of the three modalities, however, ultrasound is by far the most operator-dependent. While 3D volume acquisition can reduce or eliminate most of the interoperator variability, most neonatal neurosonography is still performed with free hand 2D imaging [(2)].

Aim of the Study

1. To analyze prospectively the value of neurosonography versus C/T scan for the assessment of suspected intracranial lesions.
2. To evaluate the significance of C/T imaging after brain ultrasound and whether it change the patient management.

Patients and Methods

This is a cross sectional descriptive study in which a forty two full-term neonates were prospectively studied in Kerbela teaching hospital for children between April 2015, and September 2016.

Indications for admission were one or more of the following

(Seizure, big head, small head, birth asphyxia, bulging fontanel, declining hemoglobin, central apnea/bradycardia, lethargy)

Sonography was performed in the pediatric radiology department, by one of two pediatric radiologists using voluson E6 using 2 types of probes convex (3.5 Mhz) and linear (7 Mhz) standard images in sagittal and coronal planes were obtained through anterior and posterior fontanels.

Unenhanced CT was performed for all the studied neonates with Siemens spiral scan using 120 kev for topogram then 100 kev /slice

For all patients CT brain was ordered by one of the following

- Treating specialist pediatrician
- Neurosurgeon

Neonates who underwent sonography had their CT study performed after variable time but within 72 hours of sonography.

Results

There were 26 male and 16 female full term neonates.

The main findings on U/S were illustrated in table 1

Table 2 illustrates the hydrocephalic findings in US and CT of the patients and whether they are completely concordant, partially concordant, or not concordant.

Table 3 illustrates the types of intracranial bleeding by U/S and C/T scan of the patients and whether they are completely concordant, partially concordant, or not concordant.

Table 4 illustrates the cystic lesions in US and CT of the patients and whether they are completely concordant, partially concordant, or not concordant.

Table 1. Illustrates the number and percent of each finding

Findings	Number	Percent %
Hydrocephaly	14	33.3
Intracranial hemorrhage	9	21.4
Cystic lesion	8	19
Brain edema	6	14.2
Normal	5	11.9

Table 2. The hydrocephalic findings in US and CT brain

No.	US	CT	Concordance
1	Severe dilatation of the lateral and third ventricles	Dilatation of the lateral and the third ventricles plus intraventricular, intraparanchymal, and subdural hemorrhage	Partial concordance
2	Dilated 3rd and 4th ventricles + Fluid collection in post. fossa	Cystic lesion of post.fossa + large post. Fossa and 4th ventricle, normal lat,&3rd ventricles, aplasia of vermis and hypoplasia of both cerebral hemispheres (Dandy Walker)	Partial concordance
3	Moderate dilatation of lat. & 3rd ventricles	Severe dilatation of lat. & 3rd ventricles	complete concordance
4	Enlarged post. Fossa &dilated 4th ventricle (Dandy Walker)	Enlarged post. Fossa &dilated 4th ventricle (Dandy Walker)	complete concordance
5	Dilated lat.ventricles	Dilated lat.ventricle + bilateral periventricular and basal ganglia calcifications	Partial concordance
6	Severe dilatation of all ventricles	Severe dilatation of all ventricles	complete concordance
7	Severe dilatation of all ventricles	Severe dilatation of all ventricles	complete concordance
8	Severe dilatation of lat.ventricles with normal 3rd &4th ventricles	Dilated both lat.+3rd &4th ventricles+periventricular calcification	Partial concordance
9	Severe hydrocephalus	Severe dilated lat.ventricles & less 3rd (Chiari malformation)+ agenesis of corpus callosum	Partial concordance
10	Mild to moderate hydrocephaly	Mild to moderate dilated both lat. Ventricles+dysgenesis of corpus callosum (Chiari malformation)	Partial concordance
11	Moderate hydrocephaly with no obvious IVH	Dilated ventricular system + acute parenchymal hemorrhage	Partial concordance
12	moderate hydrocephaly affecting lat.ventricles with agnesis of corpus callosum	Moderate to severe dilatation of ventricular system effaced 4thventricle+meningioencephalocele	Partial concordance
13	Moderate hydrocephaly(all venticles) with compressed brain tissue	Severe dilatation of lat. &3rd ventricles+4th ventricular cyst+chronic ischaemic changes	complete concordance
14	Dandy walker + cephalomeningocele	Dandy walker + cephalomeningocele	complete concordance

Discussion

In the present study, 14 cases of hydrocephalus were diagnosed by US, and were confirmed by CT scan brain.

The results were completely similar in 6/14 of cases, and were partially concordant in the remaining 8 cases.
Causes of partial concordance in our study were

- Dandy walker malformation
- Periventricular and basal ganglia calcifications
- Chiari malformation
- Acute parenchymal hemorrhage

Table 3. The types of intracranial bleeding in US and CT brain

No.	US	CT	Concordance
1	Left tempro-occipital intracerebral	Left tempro-paranchymal+left Subdural+left lat.ventricle	Partial concordance
2	Intra-cerebral+intra-ventricular	Intracerebral+intraventricular	complete concordance
3	Epidural hematoma	Epidural hematoma	complete concordance
4	Right fronto-parietal	Right fronto-parietal	complete concordance
5	Right subdural	Right subdural along fronto-parieto-temporal lobes+epidural hematoma	complete concordance
6	Right periventricular near occiput+midline shift &obliteration of right ventricular system	Right occipito-temporal periventricular+intraventricular extension +no midline shift	Partial concordance
7	Subdural & subarachnoid	Subdural & subarachnoid	complete concordance
8	Subdural & subarachnoid	Subdural & subarachnoid	complete concordance
9	Left subependymal	Left intraparanchymal &perilateral ventricle+ minimal bilat.subarachnoid	Partial concordance

Table 4. The types of cystic lesions in US and CT brain

no	US	CT	Concordance
1	Right supra-ventricular multi-septated cystic lesions	Right encephalomalacia porencephaly+basal ganglia hemorrhage	No concordance
2	choroid plexus cyst &calcification at anterior end of corpus callosum ,thalamus, and caudate	Periventricular calcification	Partial concordance
3	Para-sagital multi-loculated cyst	Para-sagital multi-loculated cyst	complete concordance
4	Single choroid plexus cyst	normal	Not concordant
5	Single choroid plexus cyst	normal	Not concordant
6	Single choroid plexus cyst	normal	Not concordant
7	Single choroid plexus cyst	normal	Not concordant
8	Single choroid plexus cyst	normal	Not concordant

Table 5. other findings

others	Number	ultrasound	CT scan
Brain edema	6	6	5
normal	5	5	5

Table 6. illustrate the number of partial and complete concordance for each lesion

findings	No.	Partial concordence	Complete concordence	No concordence
hydrocephaly	14	8	6	
Intracranial hemorrahge	9	3	6	
Cystic lesion	8	1	1	6
Brain edema	6		5	1
normal	5		5	

Dilated ventricular system was elicited by US in all cases and since most cases of hydrocephalus require extracranial shunts, particularly a ventriculoperitoneal shunt [3]. CT examinations can be replaced by another, non–radiation-producing, non-invasive, cheap, and always available modality like US, and the MRI could be ordered by the neurosurgeon in few selected cases of hydrocephalus.

If we consider the value of complete and partial concordance are the same, regarding the line of surgical management, then the sensitivity of US in the diagnosis of hydrocephalus is 100%, and in most cases CT scan is not needed.

The most common site for neonatal intracranial hemorrhage is the subependymal region, a special portion of the lateral ventricles in neonates which houses the germinal matrix in the thalamocaudate groove. This is a frequent site of hemorrhage, which can remain subependymal or rupture into the ventricles. In either case, these hemorrhages initially appear as hyperechoic structures, either limited to the immediate subependymal brain or extending into the ventricle [4].

In the present study 1 of 9 was subependymal. Subependymal hemorrhage SEH occurs wherever there is a germinal matrix. Thus, it seems likely that some aspect of this highly cellular and fragile growth zone of the developing brain must account for
the inverse relationship of SEH to birthweight and gestational age [5], and since all our cases are full-term, that is why it is not the most common cause of intracranial hemorrhage in our study.

Intra-cerebral hemorrhage was found in 4 out of 9. Ultrasound can rather easily locate intraparenchymal hemorrhage. These hemorrhages, again, begin as hyperechoic structures which eventually have more echolucent centers.

The final resolution can be complete disappearance of the clot so that no sonographic appearance remains. Alternatively, a small cyst or slit-like hole at the site of the prior hematoma may persist [6].

One of 9 had intraventricular hemorrhage by US, while by CT scan; there were 3 out of 9 cases. This could be explained by the delayed timing of CT scan after the US examination which gives time for the hemorrhage to extend to the ventricles, and also to the higher sensitivity of the CT scan [7,8].

Extra- axial hemorrhage can occur in the subarachnoid space, the subdural space or the epidural space. In the present study, 3 out of 9 had extra- axial hemorrhage, 1 subdural, and 2 subdural and subarachnoid.

The extra- axial hemorrhage were completely concordant by US and CT scan, this raise the sensitivity of US to 100% in the diagnosis of extra- axial hemorrhage (this high sensitivity can be attributed to small number of cases with extra- axial hemorrhage), which help the pediatrician to avoid the risky, invasive, and expensive CT scan.

A choroid plexus cyst is a small fluid-filled structure within the choroid of the lateral ventricles of the fetal brain. Sonographically, choroid plexus cysts appear as echolucent cysts within the echogenic choroid. Choroid plexus cysts may be single or multiple, unilateral or bilateral, and most often are less than 1 cm in diameter. Choroid plexus cysts are identified in approximately 1% to 2% of fetuses in the second trimester and they occur equally in male and female fetuses [9].

A choroid plexus cyst is not considered a structural or functional brain abnormality. Most choroid plexus cysts are isolated and occur in otherwise low-risk pregnancies [10]. The only association of some significance between an isolated choroid plexus cyst and a possible fetal problem is with trisomy 18. Choroid plexus cysts are present in 30% to 50% of fetuses with trisomy 18. Trisomy 18 is characterized by major structural abnormalities and

abnormal sonographic findings [11]. When a fetus is affected by trisomy 18, multiple structural anomalies are almost always evident, including structural heart defects, clenched hands, talipes deformity of the feet, growth restriction, and polyhydramnios. When a structural anomaly is present in addition to choroid plexus cysts, the probability of trisomy 18 is 37%[12].

Choroid plexus cysts were seen in 5 cases by US, for which CT scan was ordered and was negative. Choroid plexus cyst is a thin wall cyst which could be missed easily by CT scan.

Choroid plexus cysts were detected in 8.8% of neonates. Most of the cysts resolved spontaneously. The existence of isolated choroid plexus cysts in the newborn was not associated with abnormal physical findings or with any delay in early childhood development [13].

No need to expose the infant to high risk ionizing radiation because of this simple benign lesion.

One case revealed para-sagital multi-loculated cyst by US, which was completely concordant with CT finding, and no further management was ordered for this patient.

Choroid plexus cyst &calcification at anterior end of corpus callosum, thalamus, and caudate were the findings in one case, while the CT scan revealed periventricular calcification, as we mentioned before, the choroid plexus cyst is usually not detected by the CT scan while the calcification was seen by the 2 imaging studies with some anatomical variation, furthermore the CT scan did not change the line of management.

Right supra-ventricular multi-septated cystic lesions were detected in one patient by US; while the CT findings were right encephalomalacia porencephaly+basal ganglia hemorrhage. In this case there is no concordance by the 2 imaging studies but the management is not changed.

Edema refers to swelling within a tissue due to the accumulation of fluid. Edema occurs as the result of a variety of pathologic conditions. The brain experiences edema as a result of almost any insulting agent, it is seen in and around regions of dead or dying brain, around abscesses, after traumatic injury, or following hypoxic ischemic injury[14].

Edema on ultrasound in the neonate usually occurs around the ventricles in the periventricular white matter. Because this is a watershed territory in newborns, the area around the ventricles and its associated white matter is often involved by ischemic events. The initial examination can be normal. However, in sonography the first detectable abnormality is areas of increased echogenicity around the ventricle.

In the present study, the US of 6 patients showed evidence of brain edema (narrowing of all ventricular system), by CT scan, 5 CT image were consistent with brain edema, while the sixth one was normal which could be explained by the resolution of brain edema when the CT scan was ordered.

The CT and US imaging were almost completely concordant in all cases; the 6 patients were exposed to the risk of ionizing radiation with no change in their management.

In 5 patients, the US and CT imaging were normal, so if the US report of a well-trained and expert sonographer was normal, no need for CT imaging.

Conclusions

Transfontanellar ultrasound is the first step when performing an intracranial evaluation in neonates, because it is a portable, low cost , available ,can assess the vascular structure without need for contrast.

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