Value of Cranial Ultrasound Screening for the Preterms in the Neonatal ICU

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Abstract

Background: Preterms are a vulnerable group in the neonatal Intensive Care Unit (ICU), with much morbidity and mortality, hence emerge the importance of a screening method for imaging of their brain. Ultrasound is widely available and safe bedside imaging tool, playing a considerable role in the ICUs.

Objective: Is to evaluate the usefulness of cranial ultrasound screening in preterm neonates in the neonatal ICU, to detect the different intra cranial pathologies, and the asymptomatic, neurologically free, group of patients.

Patients and Methods: All fifty preterms admitted to neonatal ICU in Kasr Al-Ainy Hospital over a period of 4 months were assessed by Cranial Ultrasound (CUS), particularly studying the anatomical structure of the brain, the ventricular size, the caudothalamic grooves and the brain parenchymal echogenicity.

Results: Out of the 50 preterms abnormal CUS was found in 14 neonates (28%), 9 (64.3%) early preterm and 5 (35.7%) moderate and late preterm. The pathologies detected in the screened neonates 8 (57.2%) showing hemorrhage (5 with Germinal Matrix Hemorrhage (GMH) and 3 with Intraventricular Hemorrhage (IVH), 3 (21.4%) with Periventricular Leukomalacia (PVL) and 3 (21.4%) with congenital anomalies: 1 (Dandy Walker malformation), 1 (complete agenesis of corpus callosum), 1 (porencephalic cyst). 11 (22%) were asymptomatic, have intracranial pathology on Transcranial Ultrasonography (TCUS).

Conclusion: Study results showed that TCUS give insight of the neurological disease of the pre-terms in the neonatal ICU, especially in the clinically silent one.

Key Words: Transcranial ultrasound – Screening – Preterms – Neonatal ICUs – Original research.

Introduction

IT is well known that the number of surviving preterm infants is today steadily increasing [1].

Despite the improvements in perinatal medicine, brain injury is still a major clinical problem and remains a significant cause of perinatal morbidity and mortality [2].

The importance of preterm screening by cranial ultrasound is sustained by the observation that in this vulnerable group, babies who are found to have abnormal brain scans are usually asymptomatic. Only occasionally these patients develop symptoms (seizures or other neurological symptoms) due to a massive Intracranial Hemorrhage (ICH) [3].

Cranial ultrasound is a safe imaging modality that does not require sedation and can be performed bedside. It can be repeated as often as necessary because of the lack of ionizing radiation [4].

Institutions must make appropriate investment in personnel, machines and education to provide optimal imaging to neonates at high risk for brain abnormalities [4].

Germinall matrix hemorrhage is a frequent finding in the neonatal period. It occurs primarily, but not exclusively, in preterm (PT) neonates of very low birth weight [5].

One of the major problems in preterm neonates is damage to white matter. This damage involves multifocal necrosis resulting in cystic periventricular leukomalacia or a diffuse astrogliosis and loss of myelin-producing oligodendrocytes [6].

PVL frequently exists together with intraventricular hemorrhages, this reflecting the vulnerability of the premylinating oligodendrocytes [7].

Congenital brain anomalies are also could be seen during the cranial ultrasound screening, such
as Dandy-Walker Malformation (DWM), Chiari II malformation, agenesis of corpus callosum, Joubert syndrome, lissencephaly (smooth brain) [4].

**Patients and Methods**

All preterm neonates (50) admitted to neonatal ICU in Kasr Al-Ainy Hospital between 28 and 37 weeks of gestational age, between the third and seventh day of life, from August 1, 2015 to December 1, 2015 were included in the study. No exclusion criteria.

An informed consent was obtained from all patients’ parents—the guardians—before involving them in the study as no interventional process was done and there was no perceived risk. The steps of the study, the aims and the procedure were discussed with the parents of the study group. Confidentiality of all data was ensured. All the human studies have been approved by the Ethics Committee of the University Hospital and have therefore been performed in accordance with the ethical standards laid down in the Helsinki Declaration of 1975 and its late amendment.

Population demographic data are shown in Table (1).

The population of the study was classified into two groups according to their age:

**Group 1**: Neonates born before 32 weeks are called early preterm according to the definition of the American College of Obstetricians and Gynecologists.

**Group 2**: Neonates born between 32 and 37 weeks of pregnancy are considered moderate and late preterm.

Clinical data of the neonates were retrospectively obtained from the Neonatology and Neonatal Intensive Care Unit information system database including date of birth gestational age, mode of delivery (spontaneous or Cesarean section), birth weight, Apgar score at minutes 1, 3 and 5, need for ventilation support (continuous positive airway pressure or mechanical ventilation), presence of multiple pregnancy, maternal illness, use of drugs during gestation, history of birth insult and the presence of neurological symptoms.

**Methods**:

Screening cranial ultrasoundography was obtained by the third and not later than the seventh day of life in all newborns. Follow-up study was done for the periventricular leukomalacia after 7-10 days. In preparation for performing neonatal CUS, strict antiseptic conditions, including proper hand and transducer disinfection.

Precautions were done to maintain the neonate’s body temperature, by keeping the baby covered, shorten the study duration and rapid removal of ultrasound gel after ending the exam.

Pressure over the anterior fontanelle was avoided.

All ultrasound examinations were performed by the same single sonographer, performed with Toshiba Nemio Power vision software 6000 SSA-370A (Toshiba Corporation, Tokyo, Japan) with a 2-4MHZ sector probe and linear Array transducer (7.5MHz). Machine settings were optimized for neonatal brain imaging and special CUS presets were used. The anterior fontanel was used as the principal acoustic window. The trans-mastoid view was additionally used particularly to assess the posterior fossa structures. The routine sagittal and coronal technique was used.

The study included full assessment of the caudothalamic grooves on both sides to exclude the presence of GMH, the ventricular size recording any ventricular dilatation, hemorrhage, the cerebral parenchymal echogenicity for the possibility of PVL and the different anatomical structures of brain hemispheres to detect any congenital anomalies.

**The reports of cranial ultrasonography were classified into two groups**: (1) No significant abnormalities: With normal cranial ultrasonography or normal variations. (2) Significant abnormalities: if any intracranial pathology recorded.

**Statistical methods**:

Data were analyzed; the numerical data were expressed as a percentage and compared by Chi-square test or Fisher’s exact test when appropriate. Exact test was used instead when the expected frequency is less than 5. *p*-values less than 0.05 was considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows.

**Results**

The study population was divided into two groups according to the TCUS findings. Group 1: Normal CUS findings, in 36 neonates (36/50) (72%), Group 2: Abnormal CUS findings, in 14 neonates (14/50) (28%).
The different type of intracranial pathology detected, with the intracranial hemorrhage the most encountered pathology (8/14) (57%) (Table 2).

The distribution of the neonates with intracranial hemorrhage (8/14) according to the gestational age; 5 (5/8) (62%) neonates with ICH were early preterms and 3 (3/8) (38%) were late preterms.

Abnormal cranial ultrasound scan was found to be statistically significantly associated with early preterms and with the presence of neurological symptoms (Table 3).

**Table (1): Demographic data of the 50 cases.**

<table>
<thead>
<tr>
<th>Data</th>
<th>Cases (no=50)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gestational age:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early preterms</td>
<td>19</td>
<td>38</td>
</tr>
<tr>
<td>Late preterms</td>
<td>31</td>
<td>62</td>
</tr>
<tr>
<td><strong>Sex:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td>Female</td>
<td>28</td>
<td>56</td>
</tr>
<tr>
<td><strong>Mode of delivery:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaginal</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>CS</td>
<td>30</td>
<td>60</td>
</tr>
</tbody>
</table>

*CS: Caesarian Section.

**Table (2): Different intracranial pathologies encountered in the CUS.**

<table>
<thead>
<tr>
<th>Data</th>
<th>Cases with abnormal CUS (no=14/50)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intracranial hemorrhage</td>
<td>8/14</td>
<td>57</td>
</tr>
<tr>
<td>Congenital anomalies</td>
<td>3/14</td>
<td>21.4</td>
</tr>
<tr>
<td>PVL</td>
<td>3/14</td>
<td>21.4</td>
</tr>
<tr>
<td><strong>GMH</strong></td>
<td>5/14</td>
<td>35.6</td>
</tr>
<tr>
<td><strong>IVH</strong></td>
<td>3/14</td>
<td>21.4</td>
</tr>
<tr>
<td>Corpus callosum agenesis</td>
<td>1/14</td>
<td>0.7</td>
</tr>
<tr>
<td>Dandy walker</td>
<td>1/14</td>
<td>0.7</td>
</tr>
<tr>
<td>Porencephalic cyst</td>
<td>1/14</td>
<td>0.7</td>
</tr>
</tbody>
</table>


**Table (3): Relation between different variables and the CUS findings.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal CUS</th>
<th>Abnormal CUS</th>
<th><em>p</em>-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gestational age:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early preterms</td>
<td>10/19 (52.6%)</td>
<td>9/19 (47.4%)</td>
<td>Less than 0.05</td>
</tr>
<tr>
<td>Late preterms</td>
<td>26/31 (83.9%)</td>
<td>5/31 (16.1%)</td>
<td></td>
</tr>
<tr>
<td><strong>Sex:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>16/22 (72.8%)</td>
<td>6/22 (27.2%)</td>
<td>More than 0.05</td>
</tr>
<tr>
<td>Female</td>
<td>20/28 (71.4%)</td>
<td>8/28 (28.6%)</td>
<td></td>
</tr>
<tr>
<td><strong>Mode of delivery:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaginal delivery</td>
<td>14/20 (70%)</td>
<td>6/20 (30%)</td>
<td>More than 0.05</td>
</tr>
<tr>
<td>CS</td>
<td>22/30 (73.3%)</td>
<td>8/30 (26.7%)</td>
<td></td>
</tr>
<tr>
<td><strong>Presence of symptoms:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptomatic</td>
<td>0/3 (0%)</td>
<td>3/3 (100%)</td>
<td>Less than 0.05</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>36/47 (76.6%)</td>
<td>11/47 (23.4%)</td>
<td></td>
</tr>
</tbody>
</table>

*CS: Caesarian Section.

Fig. (1A,B): 31 weeks female preterm, delivered by CS, with history of RH incompatibility, with cranioesthesia examined by CUS in day 7 after delivery; limited sagittal (A) and coronal views (B) showing an oval echoclear cystic lesion perpendicular on the right lateral ventricular wall with surrounding hyperechoic rim, representing a porencephalic cyst surrounding gliosis.
Fig. (2A-D): 34 weeks female preterm, delivered by CS, presented with weak suckling and poor crying, examined by CUS in day 7 after delivery showing complete agenesis of corpus callosum. (A) Coronal image showing frontal horns of the lateral ventricles giving Viking helmet appearance. (B) Coronal image showing wide inter-hemispheric fissure and wide separation of the bodies of the lateral ventricles. (C,D) Mid sagittal plane by low and high frequency probes showing absent corpus callosum, callosal sulcus and the normal course of cingulate sulcus.

Fig. (3): 31 weeks male preterm, delivered by NVD, presented with respiratory distress, neurology free, examined by CUS in day 7 after delivery showing supra and infratentorial marked hydrocephalic changes, enlarged posterior fossa, cerebellar vermian hypoplasia with splayed and thinned out cerebellar hemispheres.
Fig. (4): 30 weeks male preterm, delivered by NVD, presented with respiratory distress, no neurological symptoms, examined by CUS (coronal and sagittal) in day 4 after delivery, showing exaggerated periventricular white matter echogenicity. Early cystic changes, tiny periventricular cysts in the frontal and parietal regions (PVL grade II).

Fig. (5): 31 weeks female preterms, one of twin, delivered by CS, presented with respiratory distress, no neurological symptoms, examined by CUS (coronal and sagittal) in day 7 after delivery, showing exaggerated periventricular white matter echogenicity. No cystic changes are seen. (PVL grade I). On follow-up after 1 week and 10 days, persistence of periventricular white matter increased echogenicity.
Fig. (6): 30 weeks female preterm, delivered by NVD, presented with convulsions, poor suckling and weak crying, examined by CUS (coronal and sagittal) in day 7 after delivery, showing bilateral periventricular hyperechoic patches, with obliterated lateral ventricles, (parenchymal extension of IVH (grade IV IVH)/bilateral periventricular hemorrhagic infarctions). On follow-up of the patient after 2 days, the clinical condition of the patient worsened and died.

Fig. (7): 28 weeks male preterm, one of twin, delivered by normal vaginal delivery, with no history of maternal illness or birth insult, presented with respiratory distress, no neurological symptoms, examined by CUS (coronal) in day 3 after delivery showing asymmetrical dilatation of both lateral ventricles more on the left side, with echogenic blood clot seen extending into the occipital horn of the left lateral ventricle. Effacement of cortical sulci is also noted (grade III IVH). On follow-up of the patient after 2 days, the clinical condition of the patient worsened and died.
Fig. (8): 31 weeks male preterm, delivered by CS, with history of placenta previa and endotracheal intubation after delivery, no neurological symptoms, examined by CUS in day 6 after delivery, showing hypoechoic nodule with echogenic margin seen in the region of caudothalamic groove on the left side compressing the ipsilateral frontal horn of the lateral ventricle and elevating its floor, with no intraventricular extension of the hemorrhage. (Aging left GMH grade I).

Fig. (9): 30 weeks female preterm, delivered by CS, presented with respiratory distress, no neurological symptoms, examined by CUS (coronal, sagittal) in day 3 after delivery showing bilateral hyperechoic nodules seen in the region of caudothalamic grooves on both sides elevating the floor of the lateral ventricles, with no intraventricular extension of the hemorrhage. (Bilateral acute GMH grade I). On follow-up of the patient after 5 days, the clinical condition of the patient worsened and died.
Discussion

Cranial ultrasound is relatively inexpensive, does not require sedation or radiation, and offers the important benefit of being portable. Sequential CUS is the standard imaging modality in the preterm neonates. It can reliably detect germinal matrix, intraventricular hemorrhage, cystic periventricular leukomalacia, ventricular dilatation, and post-haemorrhagic hydrocephalus [8].

Our study’s aim was to evaluate the importance of universal cranial ultrasound screening in all preterm neonates in the neonatal ICU with gestational age between 28 and 37 weeks of gestational age even if clinically silent.

The American Academy of Neurology and the Practice Committee of Child Neurology recommend routine cranial ultrasonography screening on all newborns born before 30 weeks of gestational age [9]. The Canadian Pediatric Society suggests the need for cranial ultrasonography before 32 weeks of gestational age [9]. There are few published studies examining the need for cranial ultrasonography in late and moderately preterm newborns. According to Meijler, cranial ultrasonography should be performed in all neonates admitted to a neonatal unit [10].

In our study, the first head ultrasound was performed between postnatal day 3 and 7.

In our study, neonates less than 32 weeks of gestational age (early preterm) present an abnormal cranial ultrasonography 4.7 times more often than those born at 32-37 weeks similar to Ballardini et al., [11].

However, ten percent of the studied population had positive cranial ultrasonography although being above 32 weeks of gestational age that would have been missed if screening was limited to early preterm neonates less than 32 weeks of gestational age.

In our study, only 21% of the preterm with abnormal CUS were symptomatic and there is a significant statistical association between the presence of symptoms (e.g. convulsions, poor suckling, poor crying) and the presence of CUS abnormalities, in agreement with Ballardini et al., [11].

In our screening of 50 preterms, 14 (28%) showed abnormal CUS, 8 of them diagnosed with GMH, classified on the Papile 4 degrees scale, according to their location and severity [12]. In the study group, grade I subependymal hemorrhages represented around 60% of the ICH. All of subependymal hemorrhage cases were incidental findings, with no suggestive neurological symptoms. 5 out of 19 (26%) of the early preterms were diagnosed with GMH, leaving them, to be the most vulnerable group, while less than 10% of late preterms (3 out of 31) presented with GMH, this is may be due to the fact that the germinal matrix disappears during the intrauterine life, the Germinal Matrix (GM) is no longer well visualized by 34 weeks Gestational Age (GA) [13].

Subjects with subependymal hemorrhages generally demonstrated a good prognosis, according to most reported data, both grades I and II GMH tend to have low/moderate long-term impact on the cognitive and neuromotor development of the baby. On the contrary, the more severe grade III and IV hemorrhages are associated with a poor developmental prognosis [14].

PVL represents the most frequent complication of perinatal hypoxia in preterm [15]. PVL incidence in preterms admitted in the intensive care units varies between 4-26%, and postmortem examination demonstrates a much higher incidence of around 75% [16].

In our study, three of the screened preterm neonates were diagnosed as PVL, according to de Vries and Cowan Grading system, [17] two of them were scaled as grade one PVL with just transient periventricular hyperechogenicity without any cystic changes and the third one showed tiny periventricular early cystic changes in frontal and parietal regions. All of them were discovered accidentally with no neurological symptoms. Follow-up revealed no evidence of brain atrophy which give very useful prognostic information [17].

Although there is a very wide spectrum of congenital brain anomalies described, the number of anomalies routinely encountered is limited and it is important for the radiologist to be aware of them. Our screening picked two relatively common congenital brain anomalies which are complete agenesis of the corpus callosum and Dandy Walker malformation. We also found a case of congenital porencephalic cyst in a neonate with craniostenosis.

There are several limitations of our study, the most important were: Relative small number of cases, short study period and shortage of the follow-up of the neonates discharged from the NICU.

Conclusion:

TCUS give insight of the neurological disease of the preterms in the neonatal ICU, especially in the clinically silent one. So global cranial US
screening for all preterm neonates in the NICUs is recommended.

References


