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Prospective Study

Interobserver Reliability of Cranial Ultrasound for Intraventricular Hemorrhage in Premature Infants

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Abstract

BACKGROUND

Germinal matrix intraventricular hemorrhage may contribute to significant morbidity and mortality in premature infants. Timely identification and grading of intraventricular hemorrhage affect decision-making and clinical outcomes. There is the potential for misinterpretation of the ultrasound appearances, which has not been previously researched between radiology resident and board-certified radiologist.

AIM

This study is aimed at assessing interobserver reliability between senior radiology residents performing bedside cranial ultrasounds during on-call hours and board-certified pediatric radiologists.

METHODS

From June 2018 to June 2020, neonatal cranial ultrasound examinations were evaluated in NICU patients. Ultrasound findings were recorded for the resident performing the ultrasound and the pediatric attending radiologist.

RESULTS

There were 200 neonates in the study, with a mean gestational age of 30.9 weeks. Interobserver agreement for higher grade (Grade III & IV) intraventricular hemorrhage was excellent. There was substantial agreement for lower grade (Grade I & II) intraventricular hemorrhage.

CONCLUSION

There is strong agreement between radiology residents and the board-certified pediatric radiologist, which is higher for higher grade intraventricular hemorrhages.

INTRODUCTION

Intraventricular Hemorrhage (IVH) is a major neurological complication of prematurity. In neonates weighing less than 1500 g, the incidence of IVH reaches up to 27% whereas, in extremely preterm infants weighing 500-750g, the prevalence is about 45% [1]. A substantial subgroup of premature infants with moderate to severe IVH develops neurologic sequelae including an elevated risk of post-hemorrhagic hydrocephalus, cerebral palsy, and mental retardation, while infants with mild IVH are at risk of developmental disabilities [2–4]. IVH and its neurologic and psychiatric sequelae are a major public health concern around the globe [5].

The multifaceted etiology of IVH is primarily attributed to the intrinsic fragility of the germinal matrix vasculature and the disturbance in the cerebral blood flow. The germinal matrix exhibits rapid angiogenesis in contrast to other brain regions 6 causing its high vascular density. Hemorrhages occurring in the germinal matrix often rupture through the ependyma into the lateral ventricle and are then referred to as IVH [6].

The development of IVH is attributable to a number of risk factors including vaginal delivery, low Apgar score, severe respiratory distress syndrome, pneumothorax, hypoxia, hypercapnia, seizures, patent ductus arteriosus, thrombocytopenia, infection,

and others [7–9]. 9-11. Dysregulation of cerebral blood flow by these risk factors induces IVH.

While the potential for interobserver variability exists in all imaging modalities, it is considered to be the highest in ultrasound. Interobserver variability in ultrasound may result from technical errors such as inadequate gain/depth settings, incomplete anatomic interrogation, or misinterpretation errors [10]. For a given ultrasound examination, both the image acquisition and interpretive skills improve with increasing experience.

Despite the ostensibly important role of accurate cranial ultrasound interpretation, few studies have investigated the reliability of interpretation of cranial ultrasound. Differences in the identification and grading of IVH may affect the clinical outcome like morbidity and the subsequent management options. This study is aimed at assessing interobserver reliability between senior radiology residents performing bedside cranial ultrasounds during on-call hours and board-certified pediatric radiologists.

MATERIALS AND METHODS

This prospective cross-sectional study was carried out in the Department of Radiology at Aga Khan University Hospital, Karachi, Pakistan. The study was approved by the institutional Ethical Review Committee. The study period was two years, from June 2016 to June 2018. All premature infants (less than 37 wk of gestational age) or infants with very low birth weight (birth weight equal to or less than 1500 gms) and infants in the Neonatal Intensive Care Unit for whom a cranial ultrasound was requested were included in the study. Patients were excluded if they were born at term, had prior CT Brain or MRI brain imaging, or patients with known morphologic brain disorders. Prematurity was defined as infants born alive before 37 wk of pregnancy with further subcategorization as follows.

Extremely preterm (less than 28 wk)

Very preterm (28 to 32 wk)

Moderate to late preterm (32 to 37 wk)

The gestational age of all infants was determined from chart review of the mother. The weight of all infants included in the study was measured with a digital weighing scale.

Cranial ultrasound in all cases was performed through the anterior fontanelle in both coronal and sagittal planes using the Mindray M7 Diagnostic Ultrasound System with a 5- to 10-MHz transducer. All ultrasound examinations were performed by a senior resident (Year III and year IV) and reviewed by an attending board certified radiologist with at least five years' experience in pediatric imaging. The findings of both the resident and the radiologist were compared regards to presence and absence of intraventricular hemorrhage and its grading were recorded on a structured proforma by a year III resident, blinded to additional clinical information. In addition to IVH, all scans were recorded for presence or absence of hydrocephalus, Periventricular leukomalacia (PVL), brain malformations. If hydrocephalus was noted to be present, it was graded into mild, moderate or severe based on the measurement of transverse atrial width.

The Volpe grading system was used for sonographic grading of IVH [11].

Grade I: Bleed confined to the periventricular area (germinal matrix)

Grade II: Intraventricular bleeding (10-50% of the ventricular area on sagittal view)

Grade III: Intraventricular bleeding (>50% of the ventricular area or distends ventricle

Grade IV: Severe intraventricular hemorrhage with periventricular echogenicity.

Interobserver agreement was calculated using Kappa statistics (Table 1). Data was entered and analyzed by using Statistical Package for Social Sciences (SPSS) version 20 software.

RESULTS

A total of 200 neonates were included in the study. The mean gestational age of patients included in the study was 30.9 wk with a standard deviation of 3.8 wk. The age range was from 20 wk to 37 wk. Figure 1 shows the distribution of study subjects according to age.

There were 120 (60%) male and 80 (40%) female neonates, out of which 78 (39%) were delivered through spontaneous vaginal delivery while 122 (61%) were delivered through lower segment cesarean section.

The mean weight was 1.2 kg, ranging from 0.5 kg to 1.5 kg with a standard deviation of 0.3 as shown in Figure 2. 83 (41%) of the neonates had sepsis, 5 (2.5%) had pneumothorax while 60 (30%) had respiratory distress syndrome. The duration of hospital stays varied from 1 day to 46 days with an average of 9 days. The radiology resident reported 136 (68%) cases as normal and 64 (32%) as abnormal. The pediatric radiologist reported 148 (74%) as normal and 52 (26%) as abnormal.

There was IVH on the right side in 24 cases, 13 of the patients had IVH on the left side and 27 had bilateral IVH according to resident interpretations. There was IVH on the right side in 14 cases, 11 of the patients had IVH on the left side and 27 had bilateral IVH according to the pediatric radiologist. The grades of IVH seen by the resident and attendings along with the Kappa values are shown in Table 2.

Interobserver agreement on additional findings encountered was not measured in this study. Ventricular abnormality was seen in 12 (6%) cases, 1 (0.5%) on the left side and 11 (5.5%) on both sides. 11 (5.5%) had mild hydrocephalus while 1 (0.5%) had severe hydrocephalus. Choroid plexus abnormality was seen in 4 (2%) cases, 1 (0.5%) on the right side and 3 (1.5%) bilaterally. Abnormal echogenicity was seen in 6 (3%) patients, 3 (1.5%) on the right and 3 (1.5%) bilaterally.

DISCUSSION

On making the diagnosis of rheumatic fever by auscultation, Alvan Feinstein wrote in his book Clinical Judgment “The main problems of observer variability were neither in the eyes nor the ears of the observers. We all saw and heard essentially the same things, but each observer used different ingredients in his criteria for description and interpretation of the observations” [12]. The same can be said about medical imaging in which interobserver variability remains a critical issue [13].

The first reported use of ultrasound to detect intracranial abnormality dates back to 1979 [14]. In the following decades, ultrasound became the neuroimaging modality of choice in infants As it is safe in the pediatric population due to its lack of ionizing radiation, low cost, and wide availability [15,16]. Common indications for cranial ultrasound are prematurity, term infants with seizures, dysmorphic features, congenital infections, and macrocephaly [17].

In premature infants, a well-timed and accurate diagnosis of IVH is critical in order to minimize the rate of neurological sequelae. Bedside cranial ultrasound is the neuroimaging standard of care for the detection of IVH [18]. In contrast with cross-sectional imaging, cranial sonography is cost-effective, does not require sedation, and allows for bedside evaluation of critical patients owing to its portability. According to a study by Maalouf *et al*, ultrasound has a predictive probability of 0.85 (0.76-0.94) for the presence of Intraventricular Hemorrhage (IVH) on MRI [19].

Interobserver agreement on the interpretation of neonatal head ultrasound ranges from poor to excellent [20]. The potential for intra-observer agreement also exists, however, this is quite low. While numerous studies have explored interobserver variability in neonatal cranial ultrasonography, ours is the first to study the differences in interpretation between senior residents and board-certified radiologists. For intracranial hemorrhage, the overall concordance between the senior resident and the radiologist was excellent. For grade I and grade II IVH, substantial agreement was noted whereas agreement on grade III and grade IV intraventricular hemorrhage was almost perfect.

Although we could not find any prior study on interobserver variability between senior residents and radiologists, our results compare favorably to prior studies in that there is excellent agreement on major abnormalities such as grades III and IV IVH. In a study by Hangman *et al*, which involved radiologists, experienced neonatologists, and less experienced neonatologists, the interobserver agreement in the interpretation of cranial ultrasound ranged from poor to good [21]. Hintz *et al* reported excellent interobserver agreement for severe intraventricular hemorrhage however found poor agreement on periventricular leukomalacia between experienced board-certified radiologists with

special expertise in cranial ultrasound [22]. Pinto *et al* found an excellent interobserver agreement for major findings such as parenchymal hemorrhage between certified radiologists, pediatric neurologists, and neonatologists with experience in neonatal ultrasound, but much worse for less severe pathologies such as germinal matrix hemorrhage [23]. Corbett *et al* reported excellent agreement on high-grade hemorrhage, but poor agreement on the interpretation of ventricular size [20].

Our study results are limited by the retrospective nature of the study. Additionally, we did not compare agreement on the interpretation of periventricular leukomalacia, incidental findings, and degree of ventriculomegaly if it was present. This may be explored in a future study.

CONCLUSION

Interobserver agreement for detection of intraventricular hemorrhage is high for low-grade hemorrhage and almost perfect for high-grade hemorrhage between radiology residents and board-certified pediatric radiologist.

ARTICLE HIGHLIGHTS

Research background

Neonatal cranial ultrasound examinations were evaluated in NICU patients. Ultrasound findings were recorded for the resident performing the ultrasound and the pediatric attending radiologist.

Research motivation

Despite the ostensibly important role of accurate cranial ultrasound interpretation, few studies have investigated the reliability of interpretation of cranial ultrasound. Differences in the identification and grading of IVH may affect the clinical outcome like morbidity and the subsequent management options. This is the reason the study was undertaken.

Research objectives

To assess interobserver reliability between senior radiology residents performing bedside cranial ultrasounds during on-call hours and board-certified pediatric radiologists.

Research methods

Total of 200 neonatal cranial ultrasound examinations were evaluated in NICU patients. Ultrasound findings were recorded for both the resident performing the ultrasound and the pediatric attending radiologist. Interobserver agreement was calculated.

Research results

The mean gestational age was 30.9 weeks. Interobserver agreement for higher grade (Grade III & IV) intraventricular hemorrhage was excellent. There was substantial agreement for lower grade (Grade I & II) intraventricular hemorrhage.

Research conclusions

Interobserver agreement for detection of intraventricular hemorrhage is high for low-grade hemorrhage and almost perfect for high-grade hemorrhage between radiology residents and board certified pediatricians.

Research perspectives

Our study results are limited by the retrospective nature of the study. Additionally, we did not compare agreement on the interpretation of periventricular leukomalacia, incidental findings, and degree of ventriculomegaly if it was present. This may be explored in a future study.

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