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ORIGINAL ARTICLE

Transfontanellar contrast enhanced ultrasound in infants: Initial experience

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KEYWORDS
Transfontanellar ultrasound;
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Summary
Background and purpose: Transfontanellar contrast enhanced ultrasound (TCEUS) in infants with neurological diseases has not been previously reported. Thus, the objective of our study was to describe the imaging findings of transfontanellar contrast enhanced ultrasound (TCEUS) performed in various neurological conditions in infants and to compare the findings with non-enhanced transfontanellar ultrasound (TFUS) and MRI.
Methods: Local institutional review board approval was obtained and, because of the need to catheterize children for contrast media administration, written informed consent of parents was obtained prior to all performed TCEUS. Twelve infants who underwent 12 TCEUS were included in this study from June 2009 to June 2012. Second generation contrast material was used (Bracco). TCEUS imaging findings were compared with those of conventional transfontanellar ultrasound in each case and with MRI.
Results: In 10 out of the 12 performed examinations, TCEUS showed abnormalities which were not depicted on non-enhanced TFUS. Accurate diagnosis of TCEUS compared with MRI was found in 10 out of 12 initial TCEUS. No adverse events during or immediately after contrast media injection occurred.
Conclusion: TCEUS appears to be a potential bedside accessible non-ionizing alternative imaging modality in the assessment of neonatal brain injury. It provides additional information when compared to non-enhanced transfontanellar US, especially in the field of brain perfusion assessment. Moreover, the information provided seems to be accurate when compared with those of MRI.

Abbreviations: CT, Computed tomodensitometry; MRI, Magnetic resonance imaging; TCEUS, Transcranial enhanced ultrasound; TFUS, Transfontanellar ultrasound; US, Ultrasound.

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Introduction

Cranial ultrasonography is the preferred modality to image the neonatal brain, specially in the emergency setting, as it can be performed at the bedside, it is relatively safe, and it can be repeated whenever needed [1,2]. However, MRI is to date the best imaging modality in the early depiction of multiple types of neuropathologic lesions in infants and has been widely used over the past decades [2—6]. It offers excellent soft-tissue contrast and good spatial resolution and it is a non-invasive and non-ionizing technique [7—11]. Literature findings comparing the usefulness of US and MR examinations of the neonatal brain suggest that US is not as effective as MR [12—14] and that despite recent advances in US equipment, US might underestimate the degree of injury [15]. US remains better than MR regarding access and availability as it is a real-time bedside imaging modality [1,15,16]. Enhanced ultrasound is widely performed in adults in various indications and is becoming increasingly accepted and utilized in the clinical setting and has proven to improve US sensitivity and diagnosis accuracy especially concerning tissular lesion characterization [17]. However, because contrast material is to date used off label only in children both in Europe and the USA, transfontanellar contrast enhanced ultrasound (TCEUS) in infants with neurological diseases has not been previously reported. Thus, the primary objective of our study was to describe imaging findings of TCEUS performed in various neurological conditions in a consecutive series of 12 infants. The secondary objective was to compare the findings with non-enhanced transfontanellar sonography and MRI data.

Methods

Sixteen infants who underwent a total of 20 consecutive TCEUS were scanned between June 2009 and June 2012. All infants who underwent both transfontanellar contrast enhanced ultrasound and MRI were included in our study. Therefore, a total of 12 infants were included for assessment. Decision to perform TCEUS was based on multiple factors, including: infant's clinical state (transportability), access and availability to MRI and availability of experienced operator. Local institutional review board approval was obtained and, because of the need to catheterize children for contrast media administration, written informed consent of parents was obtained prior to all performed TCEUS. Medical records of patients were reviewed by the authors and the following data were collected and evaluated: date of birth, gestational age, APGAR Score, indication of TCEUS, age at TCEUS, Imaging Data (TCEUS, TFUS, MRI). Because the supposed added value of contrast media concerned brain perfusion abnormalities, description of TCEUS findings focused on parenchymal brain enhancement. Therefore, classification of TCEUS findings as either normal or abnormal was based on parenchymal brain enhancement assessment on arterial, venous and delayed phases to detect possible brain perfusion abnormalities. Normal or abnormal findings of TCEUS were based on the existence of brain enhancement abnormalities, as follows: hypovascular lesions were defined as asymmetric vascularization seen as a delayed enhancement compared with contralateral normal brain, avascular lesions were defined as the absence of brain enhancement, enhancing lesions were defined as lesions enhancing more than normal brain parenchyma. Homogeneous brain enhancement on TCEUS was defined as normal.

Qualitative comparison with non-enhanced US was performed and was based on the ability to suspect a diagnosis with TCEUS which could not have been suspected on TFUS findings alone. Diagnostic accuracy of TCEUS was compared to MRI scan results when available and correlation between TCEUS and MRI was attributed using the following scores: grade 0 (no correlation) was attributed in case of discordant findings; grade 1 (good correlation) was attributed in case of accurate diagnostic correlation with however underestimated extent of lesions by TCEUS, grade 2 (excellent correlation) was attributed in case of accurate diagnosis and satisfactory lesion extent correlation. TCEUS findings were considered accurate in case of good or excellent correlations (grades 1 and 2).

Eight of the 12 (69%) TCEUS were performed in the 10 days following birth. Nine of these TCEUS were performed in preterm infants who presented abnormalities (see Table 2) on initial routine transfontanellar US examinations.

TCEUS was performed in average 23 days (ranging from 1 to 120 days) after date of birth. Neurological conditions for each infant and indications for TCEUS are summarized in Table 1. TCEUS was performed prior to MRI in 8 of 12 cases. In three cases, MRI was performed the same day as TCEUS. TCEUS was performed one day after MRI in only one case.

Transfontanellar contrast enhanced ultrasound

All TCEUS were performed by a senior radiologist (P.M) using an Acuson™ Sequoia® US system (Siemens, Erlangen, Germany) equipped with 2, 5 and 7.5 MHz linear array transducers. All initial TCEUS were performed under close neonatologist supervision and vital signs (blood pressure, heart rate and respiratory rate) were monitored.

An initial non-enhanced transfontanellar ultrasound was performed using the anterior fontanel as the acoustic window and the whole brain was analyzed from frontal to occipital lobes and from left to right.

Contrast material (Sonovue® Bracco Imaging, Milano, Italy) was injected through either peripheral or central IV catheters. Three separate injections of contrast material were systematically performed in all infants with both coronal and sagittal plane analysis. The time interval between the injections was at least 5 minutes. The quantity of injected contrast material varied from 0.5 mL to 1 mL. The brain was systematically scanned in arterial (recording started immediately after IV injection), venous (60 seconds after IV injection) and delayed phases (3 minutes after IV injection) in both planes. All examinations were digitally recorded (8 frames/sec, 20 seconds of recording) and stored on the Picture Archiving and Communication System (PACS). Evaluation of recorded data was performed offline on day of TCEUS. Therefore, initial TCEUS findings and operator's conclusions on the day of TCEUS were compared with those of MRI findings. The average total examination time was 25—35 minutes.