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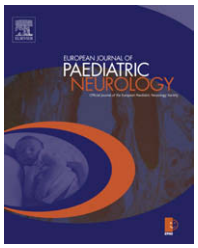

Original article

Frequently encountered cranial ultrasound features in the white matter of preterm infants: Correlation with MRI

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ABSTRACT

Background: Bilateral symmetrical echogenic and echolucent areas in the white matter are frequently seen on the cranial ultrasound scans of apparently well preterm infants without overt pathology.
Aim: To determine whether these features reflect maturational processes as seen on MRI.
Methods: Preterm and term-born infants without overt pathology on contemporaneous brain ultrasound and MRI were studied. Ultrasound scans were compared with T_2-weighted MRI to identify MR correlates for the bilateral and symmetrical echogenic and echolucent phenomena in the white matter seen on ultrasound.
Results: Forty-four sets of scans (26 preterm, 8 term-born infants) were assessed. Echogenic features were better and more frequently seen on early ultrasound as compared to nearer term age. Echogenic blushes in the white matter correlated well with high signal intensity areas and echogenic lines with low signal intensity lines on MRI. Echolucent areas correlated with the site of the internal capsule and the myelinated posterior pons. The subplate was not reliably identified.
Conclusion: Many echogenic and echolucent features in the white matter of well preterm and some term-born infants correlated well with areas of differing signal intensity on MRI. They most likely reflect normal maturational processes but the echogenic hemispheric features may represent delayed or abnormal maturation.

1. Introduction

In newborn infants, especially those born prematurely, many maturational processes take place in the brain after birth.[1–3] Preterm infants are at high risk of hypoxic, haemorrhagic and inflammatory brain lesions[4–6] and disturbed cerebral development.[7–10] They are also at risk of abnormal neurological development,[11–13] even when no overt cerebral lesions are detected.[14,15]

Abbreviations: BW, birth weight; GA, gestational age; LV, lateral ventricles; MRI, magnetic resonance imaging; PLIC, posterior limb of the internal capsule; PMA, post-menstrual age; SI, signal intensity; TEA, term equivalent age; US, ultrasound; WM, white matter.

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Cranial ultrasound (US) reliably demonstrates many forms of cerebral injury[11,15–18] and shows anatomical features and their changes with gestation. However, magnetic resonance imaging (MRI) shows maturational processes in greater detail[1–3,16–21] and it enables quantification of brain growth and maturation.[7–10]

There are several MRI and pathological studies on normal and abnormal cerebral white matter (WM) development in newborn infants,[2,5,16,21–27] but few equivalent US studies[12,16,28] or studies comparing US to MRI.[16,17] As US is the most readily available and usually the initial technique used for imaging the newborn brain,[4,11] it is desirable that its capability for assessing maturational features is understood. To do this, it is important to define appearances representing normal developmental processes as visualized on neonatal scans.

Bilateral symmetrical areas of increased echogenicity are frequently encountered on the US scans of apparently well preterm infants. These areas are mainly located periventricularly in the frontal WM and at the margins of the lateral ventricles (LV) and do not evolve into lesions. They tend to be linear or smoothly rounded. Some of these areas have correlated anatomically with areas of glial cell migration in the preterm brain before term equivalent age (TEA).[16] Areas of altered signal intensity (SI) in the periventricular WM may represent features of developing WM on MRI.[16,22–25,27] Echolucent areas are seen in more peripheral regions of the hemispheres and more centrally where defined WM tracts run; these areas have not been compared to MRI but might represent the subplate, the internal capsule and the posterior myelinated pons. We hypothesize that bilateral symmetrical echogenic or echolucent areas on US, seen in apparently normal (preterm) newborn infants and not evolving into lesions, reflect maturational rather than pathological processes in the newborn infant brain. Our aim was to determine whether such features reflect maturational processes as seen on contemporaneous brain MR imaging.

2. Materials and methods

2.1. *Patients*

During the study-period (February 2005–February 2006), all preterm and term-born infants admitted to our neonatal unit with a US and MRI examination performed on the same day were included. All infants were examined prior to scanning and their growth characteristics were recorded. Ethical approval for brain MR imaging studies was given by the Hammersmith Hospitals Research Ethics Committee and parental consent was always obtained. All US scans were done as part of routine assessment. Some MRI examinations were part of ongoing research cohort studies of apparently well newborn infants. Other infants were scanned for different clinical indications, including neonatal encephalopathy and suspected but unconfirmed metabolic and neuromuscular disorders. No infant with overt pathology on their US was included.

Exclusion criteria were major congenital anomalies or acquired injurious brain abnormalities, brain abnormalities on US scans, chromosomal disorders, metabolic disorders or neonatal meningitis.

2.2. *Neuro-imaging*

2.2.1. *Ultrasonography*

All US scans were performed by the same observer (L.M.L.), using a Siemens Antares US scanner with a multifrequency transducer (Siemens, Bracknell, UK). Scanning was done through the anterior fontanel in at least 6 coronal and 5 sagittal planes. The transducer frequency was set at 7.3 MHz. To evaluate the peripheral regions of the hemispheres where the cortical subplate and the subcortical WM can be identified on T_2-weighted MR images of very preterm infants, higher frequencies were applied. US scans were evaluated during and immediately after the procedure by the examiner and all scans were digitally stored and later analyzed by L.M.L. and F.M.C. by consensus, using the software program Escape Medical Viewer (Escape Medical Imaging, Thessaloniki, Greece).

All scans were assessed for the presence, location and appearance of the following echogenic features in the WM. These comprised:

- Frontal echogenic blush
- Echogenic lines around/below the LV
- Echogenicity running supero-laterally from the LV
- Echogenic lines running parallel to the LV
- Temporo-occipital echogenic blush

Scans were also assessed for areas of persistent echolucency in the WM that might represent:

- The cortical subplate
- The internal capsule
- WM tracts in the pons

2.2.2. *MRI*

MRI was performed according to a standard protocol for newborn infants, using a 3.0 T Philips MR system (Philips, Best, the Netherlands). If needed, infants were sedated using oral chloral hydrate (30–50 mg/kg), a regimen we have found safe and effective. They were placed supine and snuggly swaddled. Ear protection was used[5] and the head immobilized using a polystyrene bead-filled pillow from which the air was evacuated. The infant's temperature, heart rate and oxygen saturation were monitored throughout the procedure by an experienced neonatologist.

The MR sequence parameters were as follows:

T_1-weighted magnetization prepared rapid-acquisition gradient echo volumes: repetition time, 17 ms; echo time, 4.6 ms; flip angle, 30°; field of view, 210 mm; matrix, 256 × 256; number of acquisitions, 1; and voxel size, 0.8 × 0.8 × 1.6 mm;
T_2-weighted fast-spin echo pseudo volumes: repetition time, 12 000 ms; echo time, 160 ms; flip angle, 90°; field of view, 220 mm; matrix, 224 × 224; voxel size 0.86 × 0.86 × 2.0 mm.
T_1-weighted volume images were acquired in the sagittal plane and reformatted into transverse and coronal planes. T_2-weighted images were acquired in the transverse plane.