

# Neonatal cranial ultrasound interpretation: a clinical audit

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## Abstract

**Objective**—To assess the abilities of doctors to interpret neonatal cranial ultrasound scans.

**Design and setting**—High resolution scanned images of six important neonatal cranial ultrasound abnormalities were posted as a questionnaire to the 59 neonatal units in the North and South Thames regions.

**Results**—Forty two questionnaires were returned (71%). Currently 56% of those interpreting cranial ultrasound scans are neonatal registrars, 27% are consultant paediatricians or neonatologists, and 17% are radiologists. The response rate from registrars was excellent (97%), but it was poor from consultant paediatric (38%) and radiological (40%) staff. The mean accurate identification of cerebral abnormalities was only 59% (range 45–71%). Only 44% of the neonatal registrars, compared with nearly all the consultant staff, have had any formal training in cranial ultrasonography.

**Conclusions**—The data highlight the current accuracy of neonatal cranial ultrasound scan reporting in the Greater London region and have important implications for clinical services and research studies. Doctors who are responsible for interpreting neonatal cranial ultrasound scans should have formal training and supervision, and more formal reporting would improve and maintain standards. The findings raise significant doubts about the accuracy of local interpretation of cranial ultrasound scans in multicentre research studies.

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Keywords: neonatal; cranial; ultrasound scans; interpretation; reporting

Cranial ultrasound (US) remains the mainstay of neonatal brain imaging. It is safe and can be performed at the cot side without sedation and with very little disturbance even to very sick infants. Both normal and abnormal US scans have been very useful in predicting neurodevelopmental outcome.<sup>1-7</sup>

Initially cranial US was used to detect haemorrhage and ventricular dilatation<sup>8</sup> in preterm infants, but now the emphasis has moved to defining white matter injury, which is more difficult. Studies have shown that the recognition of white matter pathology with US is often poor.<sup>9-10</sup> There are concerns that infants with normal scans do not always have normal

neurodevelopmental outcomes.<sup>11</sup> These difficulties are assumed to be due to the limitations of the technique itself. Little mention is made of the quality of the scanning (instrumentation, correct frequency, adequate coverage, correct views, optimal timing, etc) and scan interpretation as being possible components of the problem.<sup>12</sup>

Cranial US was introduced in the late 1970s and was largely performed by paediatricians specialising in neonatology. At least in the United Kingdom, cranial US has remained a tool used by paediatricians rather than radiologists in many centres. Over the years it has become a routine technique, no longer just in the hands of a few research doctors but now performed by consultant and middle grade paediatric staff on most infants admitted to neonatal units, and on any with neurological abnormality. These staff are expected to be familiar with the US appearances of normal variations, developmental anomalies, and many types of pathology, as well as their prognostic significance in both preterm and term infants.<sup>13</sup> Most radiologists have little involvement in neonatal cranial US.

There are no compulsory training requirements in the United Kingdom for neonatologists in cranial US, and courses are few and oversubscribed. To obtain information on the adequacy of existing skills, we aimed to assess the interpretative abilities of personnel performing cranial US on neonatal units in two regions of the United Kingdom.

## Design

All neonatal and special care baby units where cranial US is performed in the North and South Thames (London) regions were included in the study (n = 59). Questionnaires were sent to the person who usually performed cranial US on the neonatal unit, as ascertained by prior telephone call. Non-responders were contacted again by post, with new questionnaires sent.

The questionnaire consisted of questions about six cranial US images of important abnormalities encountered in neonatal practice taken with an Ultramark System 4 scanner with a Sony printer. A stamped addressed envelope was included for return. The images plus the questions and correct answers can be found on the journal's website, [www.archdischild.com](http://www.archdischild.com). All images were reviewed for suitability by an experienced consultant neonatal neurologist (F C), and were reproduced using a high resolution scanner and printer (Hewlett-Packard Deskscan 2). For each image, the practitioner was asked to describe the abnormality in full,

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propose management, and suggest a prognosis that would be given to the parents, being as explicit and detailed as they felt able. Additional comments were welcomed. Each responder was asked to describe their job position and how they had learned their cranial US skills.

### Results

Of the personnel performing cranial US on the 59 neonatal units in the Thames regions, 33 (56%) were neonatal registrars, 16 (27%) paediatric or neonatal consultants, and 10 (17%) radiologists.

Forty two (71%) questionnaires were returned (32 from registrars, six from consultant paediatricians, and four from radiologists). Of the neonatal registrars, 44% had attended a neonatal ultrasonography course or had received some other formal teaching. The remaining registrars were "self taught". Nearly all of the consultant paediatricians/neonatologists or radiologists said they had received formal training, but details of the training were not requested.

Question 1: 71% correctly identified the bilateral posterior periventricular flares. Of these correct answers, 80% would give a guarded prognosis to the parents. The remaining 20% would give a "good" prognosis. Only one responder made the point that prognosis relates to flare resolution, although most wished to carry out further serial scans. Other responses included unilateral flare, periventricular and intraventricular bleeds, periventricular leucomalacia (PVL), and normal reports, with prognosis and information to parents based on the diagnosis.

Question 2: 45% described a subependymal pseudocyst or multicystic appearance. Only 17% correctly identified the need to investigate for congenital infection (particularly cytomegalovirus), and no one suggested a metabolic cause. Most described it as a resolving intraventricular haemorrhage (IVH; grades 1–3), with a range of prognoses from good to poor, and three responders (two registrars, one consultant paediatrician) did not know what the lesion was. The prognosis given by those who correctly answered this question was equally divided between a good and guarded outcome.

Question 3: 52% correctly described the bilateral ventricular dilatation and right sided pencephalic cyst, although a further 19% reported bilateral ventricular dilatation only, and 17% described a right pencephalic cyst only. Only 14% described the enlarged third ventricle in the coronal view, and only one reported the midline shift. There were no comments on the irregular ventricular margins. No one commented on the poor tissue definition posteriorly on the parasagittal view, and we had hoped that someone might suggest scanning through the posterior fontanelle to overcome this.<sup>12</sup> Of those who gave the correct answers, 82% would give a "poor" prognosis to the parents, whereas 18% would give a guarded prognosis.

Question 4: 50% correctly described the bilateral ventricular enlargement with right sided periventricular cystic change consistent with PVL. A further 36% identified only right sided PVL, and two registrars interpreted this as choroid plexus cysts. No one commented on the irregular ventricular margins. Only 76% of the correct responders gave a guarded prognosis.

Question 5: 64% correctly described the right ventricular dilatation and right parenchymal haemorrhage/infarct with right germinal layer haemorrhage (right intraventricular haemorrhage). Only 14% described this as a unilateral flare or as a grade 4 IVH. Some 59% of the correct responders gave a guarded prognosis, and the remainder gave a poor prognosis.

Question 6: only 24% described the bilateral thalamic echodensities, which are far more important in our opinion than the cerebral oedema recognised by 69%. Some 17% thought these scans were normal (six registrars, one consultant), and other suggestions included subdural haemorrhage, right middle cerebral artery thrombosis, flares, calcification, and IVH. Most (79%) would give a guarded prognosis to the parents, and 14% a poor prognosis.

Nearly half (48%) of responders did not know that a 5 MHz probe setting permits better interpretation of the deeper structures including the thalami in term infants.

The mean correct interpretation for all six questions was 59% (range 45–71%).

### Discussion

Our study aimed to review the current status of cranial US analysis on the neonatal unit. This study could not assess the ability to acquire images.

It was our opinion when designing this study that neonatologists tend to view cranial US from the point of view of haemorrhagic and established ischaemic lesions. We acknowledge that image interpretation should be based on a complete set of images and that sequential information is important. We do not wish to encourage interpretation solely from a single scan. However, all of the abnormalities presented have important potential management or neurodevelopmental implications and should therefore be recognised.

More than a quarter (29%) of the questionnaires were not returned, which could conceivably have introduced either negative or positive bias. There was an excellent response rate from the neonatal registrars (97%) compared with the poor rates from consultant paediatricians (38%) and radiologists (40%). Despite checking that contact details were correct, and writing by name to non-responders again, we are disappointed by the response from the latter groups. We do not know whether senior staff felt they did not have the time, or felt it unnecessary, to partake in a survey of a very important aspect of neonatal care.

The images in this questionnaire consisted of important abnormalities encountered on the neonatal unit. Bilateral periventricular flares are a common occurrence. Subependymal

pseudocysts are also common, but importantly may be seen with congenital infection and, albeit rarely, are also associated with Zellweger's syndrome and some other metabolic disorders. Ventriculomegaly and porencephalic cysts, PVL, IVH, and associated periventricular haemorrhage are not uncommon, nor are thalamic echodensities with cerebral oedema associated with birth asphyxia. All require clinical management and planned follow up, and have prognostic implications for the child that need to be carefully explained to the parents. The mean correct interpretation rate was only 59%. Some answers were worryingly inaccurate.

The scans we presented were of good quality and limited in number as we felt that too many would result in limited returns. We did not include subtle pathologies, such as mild ventricular dilatation, discrete basal ganglia abnormalities, extracerebral haemorrhage, focal hemispheric lesions in term infants, or developmental abnormalities, etc, interpretation of which may be more difficult. It is likely that, in daily clinical practice, image quality will be variable, making interpretation more difficult.

Owing to the poor response rates from the consultant staff and the small overall numbers, we are not able to comment on any differences in accuracy of interpretation between consultant paediatricians, radiologists, and middle grade staff. All the groups produced answers that were partially or totally incorrect, and this study contains no evidence that any one of these groups is better at cranial US interpretation.

Only 44% of the neonatal registrars in this study had any formal training. Nearly all of the consultant staff stated that they had received formal training in cranial US interpretation. No one raised any concerns about the level of training.

A correct interpretation rate of only 59% (45–71%) is unsatisfactory for the very definite abnormalities presented in this study. Such inaccuracy would not be acceptable in other imaging domains, and we believe that we have highlighted a significant problem that has widespread implications. Our study suggests that important errors may be occurring in routine clinical practice. In addition, in many multicentre studies, US scans are not sent to a panel of experts for interpretation and it is assumed that all centres are able to perform and interpret their own scans equally well. Our findings raise significant doubts about this assumption. We note that the current multicentre United Kingdom Oscillation Trial (UKOS) has recently started to collect small random samples of cranial scans reported as normal for secondary expert review.

Courses on neonatal cranial US interpretation are offered in London, although places are very limited. There is currently no requirement to attend a course before performing cerebral US on a neonatal unit. In the main, it appears to be a skill hastily acquired once the newly appointed specialist registrar starts his/her neonatal placement.

#### RECOMMENDATIONS FOR PRACTICE

Considering the importance of accurate cranial US interpretation, we recommend that formal training should be available to all those who acquire and interpret cranial US scans, particularly neonatal registrars who perform most of the scans in the units we have surveyed. In addition, there are some excellent reference texts (Govaert and de Vries,<sup>14</sup> Rennie,<sup>15</sup> Levene<sup>16</sup>), at least one of which should be available on the neonatal unit.

We wish to emphasise the importance of serial imaging, especially where lesions are unusual or evolving, and early on this should be at least daily. When the diagnosis is in doubt, hasty prognostication is best avoided, and repeated US and clinical examination, in conjunction with other imaging modalities, such as magnetic resonance imaging, and other tests may provide more detailed information.

We believe in the value of consensus, and we have a weekly review of US scans on our neonatal unit between the neonatal neurologist and the attending neonatal consultant and team. However, while most cranial US scans continue to be acquired by paediatric specialist registrars in district hospitals, one approach to raising standards may be to initiate formal reporting sessions between neonatal paediatricians and radiologists.

There is an argument for all neonatal cranial US to be performed only by paediatric radiologists. Unfortunately such people are few, and many radiologists have very little experience of cranial US. They are most unlikely to provide a seven day 24 hour service, when urgent scans need to be carried out. Establishing normal intracranial anatomy and/or the existence of significant pathology at birth should be part of the admission procedure for all preterm and sick full term infants, as such information may well influence the immediate management. For the foreseeable future it will be necessary for middle grade and consultant neonatal staff to be able to perform scans and be aware of normal anatomical and common pathological features and keep abreast of current thinking on their significance.

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