Cranial ultrasound in neonates and infants in rural Africa

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Objective. To evaluate the usefulness of cranial ultrasound (CU) at a rural hospital in a developing country setting and to analyse how indications, results and therapeutic consequences differ from those in developed countries.

Methods. All CU scans performed over a 32-month period at Haydom Lutheran Hospital, Tanzania, were retrospectively analysed. The patients’ presenting signs and symptoms were categorised into nine groups: 1. birth asphyxia; 2. congenital syndromes; 3. neural tube defects/spina bifida; 4. macrocephalus; 5. post-meningitis; 6. seizures; 7. developmental/neuromuscular abnormalities; 8. head trauma; and 9. miscellaneous. The information derived from the scans was then analysed with regard to underlying pathology and possible influence on the child’s future management.

Results. 420 scans were performed in 293 patients, of whom 34 were older than 1 year. In 155 cases no abnormal result was obtained. When results of the abnormal scans were related to their impact on patient management, the pathological findings were found to have provided useful information in groups 1 (45%), 3 (100%), 4 (87%), 6 (57%), 6 (31%) and 7 (45%).

Conclusions. CU is a highly feasible technique even in resource-poor settings and provides valuable additional information in patients with neural tube defects/spina bifida, macrocephalus, post-meningitis, birth asphyxia, developmental/neuromuscular abnormalities and seizures.

In industrialised countries CU plays a significant role in the diagnostic approach to intracranial disorders in neonatology (and to a minor degree in paediatrics) and influences therapeutic decisions to quite a large degree.1,2 Major indications for CU are prematurity because of risk of intracerebral haemorrhage, birth asphyxia, suspected intracranial malformations, infections, trauma and metabolic disease.1,3 Its advantages are ease of application, availability for frequent, serial exams at the bedside with minimal disturbance of the neonate or infant, freedom from negative side-effects and radiation exposure, low cost, and its potential as a screening tool.1,2 Technically, the application of CU is mainly confined to the infant period until the fontanelle closes.1,2 The majority of examinations are therefore performed during the neonatal period and early infancy. Sometimes, depending on the quality of the ultrasound device and the transducers, it is possible to scan through the sutures at a later age.

Although no one would question the value of CU in affluent health systems, surprisingly little information is provided on its usefulness in a developing country setting. There are a few published studies from Asia and Africa, but these were usually performed at tertiary institutions.3-17 We therefore decided to retrospectively analyse our data on CU scans performed at a remote rural hospital in Tanzania on several hundred patients. We were interested in exploring its usefulness in this resource-poor setting, especially as no other cerebral imaging, such as computed tomography (CT) or magnetic resonance imaging (MRI), was available at the time of the study, and in comparing indications, results and possible therapeutic consequences with those in industrialised countries.

Methods

Setting

The study was performed at Haydom Lutheran Hospital (HLH), a rural hospital in northern Tanzania, owned by the Mbulu diocese of the Evangelical Lutheran Church in Tanzania. The hospital is located at the southern edge of Mbulu district, which is at the south-western border of the Manyara region (380 km south-west of Mount Kilimanjaro).18-22 People in the area mainly live by means of subsistence farming and livestock keeping. The hospital officially contains 400 beds and serves a population of more than 500 000 people. It has surgical, internal medicine, gynaecological/obstetric, paediatric and tuberculosis wards.18-22 Each year more than 12 000 inpatients and 70 000 outpatients are treated. Children represent about 30 - 40% of total patient numbers.18-22 Each year about 3 500 - 4 000 children are born at the hospital, but more than 12 000 are born at home without skilled attendance in the total catchment area.18-22 The prematurity rate is about 10%, but very premature infants, born before 32 weeks’ gestation, rarely survive the first day of life. At the time of the study, more than 25 000 examinations in pregnant women and more than 65 000 in children aged under 5 years were performed in 22 mobile maternal and child health (MCH) clinics, located up to 100 km away from HLH and served on a monthly basis, and one permanent MCH clinic at HLH.18-22
At the radiology department, which was led by the co-author (NN), an assistant medical officer trained in diagnostic radiology, only routine radiography, including contrast studies, was available at the time of the study. Plain skull X-rays are not suitable to detect intracranial pathology, and neither CT nor MRI was available. The closest medical facility with CT was located more than 350 km from the hospital. A small portable ultrasound device (Aloka Echo Camera SSD 500, Aloka, Tokyo, Japan) had been donated to the hospital and was used for all indications and age groups. The only probe of several we had that was to some degree appropriate for CU was a 3.5 MHz curved array transducer, without any Doppler or colour Doppler technique, which was not ideal for neonates and infants. Equipment for print or electronic documentation of results was not available. For a catchment area with a radius of at least 250 km, the hospital provided the only opportunity for CU.

All scans were performed by the two authors. Each examination lasted about 5 – 10 minutes and included at least three coronal views, one midline sagittal view, and one parasagittal view on each side. After infancy, scans were performed through sutures which were still widened in these patients to a varying degree. CK had trained NN in this technique and acted as a supervisor.

**Patients**

Data on all in- and outpatients in whom CU was performed during diagnostic evaluation over a 32-month period were retrospectively collected from the records of the radiology department. Age (in months) at the time of examination, gender, indication, results and number of repeat exams, if done, were recorded.

According to history and presenting signs and symptoms, the patients were then categorised into nine groups which represented the indications for the ultrasound exams: 1. birth asphyxia; 2. congenital syndromes; 3. neural tube defects/spina bifida; 4. macrocephalus; 5. post-meningitis; 6. seizures; 7. developmental/neuromuscular abnormalities; 8. head trauma; and 9. miscellaneous (infections, septicaemia, HIV, malnutrition, rickets, shock, prematurity, etc). Within these categories, the results of the scans were listed and compared with the other categories in terms of frequency and type of pathology. The information derived from the scans was then analysed with regard to the child’s future management (no specific treatment, pharmacological, surgery, prognostic value).

**Statistics**

All data were entered manually in data collection sheets, checked for inconsistencies and then entered into SPSS v15.0 for analysis. Random checks were conducted to minimise errors from data entry. Differences in frequencies within and between the patient groups and categories were analysed using the chi-square test. The level of significance (two-sided) was defined as p<0.05.

**Ethical approval**

This work is based on the authors’ clinical work at Haydom Lutheran Hospital. Permission for publication was granted by the then medical director, the late Dr O H E Olsen.

**Results**

We performed 420 scans in 293 patients (162 males and 131 females; \( p=0.07 \)). Of these, 34 were older than 1 year, the 3 oldest being 7, 9 and 15 years old (Fig. 1). In 155 patients (166 scans performed), no abnormal results were obtained; 20 of these patients were older than 1 year. In the remaining 138 patients (14 older than 1 year) 254 scans were performed in total, all with abnormal results (Table I, Fig. 1). Patient numbers in the different categories were as follows: birth asphyxia 31; congenital syndromes 16; spina bifida 14; macrocephalus 38; post-meningitis 79; seizures

### Table I: Patient Numbers and Scans According to Results and Indication Groups

<table>
<thead>
<tr>
<th>Indication group</th>
<th>Pathological results (( N (\text{patients &gt;1 year}) ))</th>
<th>Normal results (( N (\text{patients &gt;1 year}) ))</th>
<th>Pathological findings %</th>
<th>( p)-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth asphyxia</td>
<td>14 (0)</td>
<td>17 (0)</td>
<td>45</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Congenital syndromes</td>
<td>2 (0)</td>
<td>14 (1)</td>
<td>13</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Spina bifida</td>
<td>14 (1)</td>
<td>0 (0)</td>
<td>100</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Macrocephalus</td>
<td>33 (5)</td>
<td>5 (0)</td>
<td>87</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Post meningitis</td>
<td>45 (4)</td>
<td>34 (6)</td>
<td>57</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Seizures</td>
<td>4 (1)</td>
<td>9 (1)</td>
<td>31</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Development/neuromuscular</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>abnormalities</td>
<td>20 (3)</td>
<td>24 (4)</td>
<td>45</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Head trauma</td>
<td>1 (0)</td>
<td>16 (3)</td>
<td>6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5 (0)</td>
<td>36 (5)</td>
<td>12</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>138 (14)</td>
<td>155 (20)</td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

*Chi-square test.
13; developmental/neuromuscular abnormalities 44; head trauma 17; and miscellaneous 41 (Table I). Patients older than 1 year were represented in all groups except the birth asphyxia group, although they were usually few in numbers.

Abnormal findings in the different categories were as follows: birth asphyxia 45% (abnormal/total 14/31); congenital syndromes 13% (2/16); neural tube defects/spina bifida 100% (14/14); macrocephalus 87% (33/38); post-meningitis 57% (45/79); seizures 31% (4/13); developmental/neuromuscular abnormalities 45% (20/44); head trauma 6% (1/17); and miscellaneous 12% (5/41) (Table I). Among the older patients, only in the groups with neural tube defects/spina bifida, macrocephalus, post-meningitis, seizures and developmental/neuromuscular abnormalities did some scans show important pathological findings.

When analysing the type of abnormality within the different categories (Table II), the most common finding was hydrocephalus, mainly in the macrocephalus and post-meningitis groups. All patients with spina bifida had the Arnold Chiari type II malformation (associated with hydrocephalus), and brain oedema in the asphyxia group was the third most common abnormality. All other abnormalities were much less frequent, especially intracranial haemorrhage. Very few premature infants in this setting survived the first days of life, so CU was only performed in 2 of them.

When relating the results of the scans to their possible impact on patient management, the impact on treatment was largest in the groups with neural tube defects/spina bifida, macrocephalus, post-meningitis, seizures and developmental/neuromuscular abnormalities did some scans show important pathological findings.

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When relating the results of the scans to their possible impact on patient management, the impact on treatment was largest in the groups with neural tube defects/spina bifida, macrocephalus and post-meningitis; 21 of these patients were operated on and received a ventriculo-peritoneal shunt for drainage, employing a simple feeding tube as the shunt device. In the birth asphyxia, seizures and developmental/neuromuscular groups, abnormalities were found in almost half of the patients but because therapeutic options were limited no specific treatment beyond standard care, such as anticonvulsant medication or physiotherapy, could be offered. In these cases the ultrasound results sometimes guided prognostic advice. In the three remaining groups the diagnostic yield was very low (Tables I and II).

### TABLE II. INDICATION GROUPS AND TYPE OF PATHOLOGY

<table>
<thead>
<tr>
<th>Type of pathology</th>
<th>Indication group</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Birth asphyxia</td>
</tr>
<tr>
<td>Arnold Chiari II</td>
<td>14/14</td>
</tr>
<tr>
<td>Hydranencephaly</td>
<td>-</td>
</tr>
<tr>
<td>Holoprosencephaly</td>
<td>-</td>
</tr>
<tr>
<td>Other malformations</td>
<td>-</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>1</td>
</tr>
<tr>
<td>Venticulitis</td>
<td>-</td>
</tr>
<tr>
<td>Abscess</td>
<td>-</td>
</tr>
<tr>
<td>Cysts</td>
<td>-</td>
</tr>
<tr>
<td>Haemorrhage</td>
<td>1</td>
</tr>
<tr>
<td>Calcifications</td>
<td>-</td>
</tr>
<tr>
<td>Oedema</td>
<td>12</td>
</tr>
<tr>
<td>Brain atrophy</td>
<td>-</td>
</tr>
<tr>
<td>Subdural effusions</td>
<td>-</td>
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</tbody>
</table>

*More than one pathological finding per patient possible.

*Associated with hydrocephalus.
postulated that this high percentage of abnormal findings in otherwise healthy neonates might be related to a high rate of congenital infections. Two other studies from Taiwan and Malaysia produced similar results. The high rate of pathological findings in neonates, developmental/neuromuscular abnormalities and seizures (Tables I and II). These indications for CU have not yet been part of a study in developing countries, except for birth asphyxia, where more than 70% abnormal findings were detected in a Malaysian study. Our results indicate that it is reasonable to perform CU in these patients, even though there may not be any treatment available other than options such as anticonvulsant therapy or physiotherapy. Its main value could then be to obtain additional information for prognosis and for counselling the patients and their families.

In the introduction, the diagnostic and hence therapeutic or prognostic yield was very low. As only a few premature infants survived the first days of life, we performed CU in only 2 weeks after meningitis in these studies, which is in line with our results in this indication group (Tables I and II). Microcephalus of non-infectious origin (congenital hydrocephalus, other malformations) was studied in other reports from Nigeria and Malawi. Similar to our results, in up to 60% of patients a diagnosis could be made by CU. In Malawi the study population included children with spina bifida, all presenting with hydrocephalus, as was seen in our patients.

All the studies affirmed the ease and value of performing CU in developing countries, especially with regard to early detection of complications in meningitis, the diagnostic approach in hydrocephalus and macrocephalus, and possible therapeutic interventions in hydrocephalus. The studies from India and Africa demonstrated that complications after meningitis constitute a significant proportion of CU findings in these resource-limited settings, which parallels our results (Tables I and II). To the best of our knowledge, this report on CU in developing countries is the first from an institution outside a university setting. Our results show that CU can be recommended as a fast, easy-to-perform, feasible, practical, cost-effective and efficient technique in resource-poor settings. It provides valuable additional diagnostic information in patients with spina bifida and macrocephalus and after meningitis (Tables I and II), in a similar range as reported in the literature. The post-meningitis group had the largest number of patients and scans, with more than 55% pathological results (Tables I and II), indicating the high risk of complications and the need for close sonographic follow-up. The high rate of pathological results in patients with spina bifida and macrocephalus also serves as a clear indication for CU, especially because in all these patients, including post-meningitis, treatment options such as ventriculo-peritoneal shunting are available. Ventriculo-peritoneal shunting in these settings carries a 10 - 20% risk of postoperative mortality and a 20 - 30% postoperative morbidity rate, but in many patients the overall prognosis can still be improved considerably. The diagnostic yield was lower for birth asphyxia in term neonates, developmental/neuromuscular abnormalities and seizures (Tables I and II). These indications for CU have not yet been part of a study in developing countries, except for birth asphyxia, where more than 70% abnormal findings were detected in a Malaysian study. Our results indicate that it is reasonable to perform CU in these patients, even though there may not be any treatment available other than options such as anticonvulsant therapy or physiotherapy. Its main value could then be to obtain additional information for prognosis and for counselling the patients and their families.

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This work is dedicated to the then medical director of Haydom Lutheran Hospital, the late Dr Ole Halgrim Evjen Olsen, who worked tirelessly for the health of the people of the Haydom area for several decades.

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**Authors’ contributions:** CK developed the idea and structure of the study. CK and NN performed the ultrasound examinations, collected, analysed and interpreted the data, and wrote the manuscript. Both authors read and approved the final manuscript.

**References**


