# Role of grayscale transcranial ultrasound in the diagnosis of neonatal hypoxic–ischemic encephalopathy: a clinical audit study

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**Background**
Neonatal hypoxic–ischemic encephalopathy (HIE) is still accounts for a significant percentage of mortality and morbidity in the neonates. Transcranial ultrasound (US) is the investigation of choice for the initial assessment of these cases.

**Aim**
To evaluate the practice of transcranial US in the diagnosis of suspected cases of neonatal HIE in the ICU of Assiut University Hospital (AUH).

**Patients and methods**
This clinical audit study was conducted during the period from April 2017 till June 2018 (first audit cycle about 13 months and second audit cycle about 2 months) in the ICU in AUH on neonates who underwent transcranial US for the diagnosis of neonatal HIE. Six criteria were set and were measured with 40 indicators with a 100% standard set for each indicator.

**Results**
The study included 110 neonates (90 in the first audit cycle and 20 in the second audit cycle). The adherence to the audit criteria was about 17.5% in the first audit cycle and 25% in the second audit cycle, which indicates that there was just a slight improvement in the second audit cycle.

**Conclusion**
Transcranial US is the modality of choice in the initial evaluation of suspected cases of neonatal HIE. Adherence to the audit criteria of this study in the neonatal ICU of AUH fell below expected standards in both the audit cycles with a slight improvement in the second audit cycle. Further reauditing is recommended.

**Keywords:**
hypoxic–ischemic encephalopathy, neonates, transcranial ultrasound of neonatal hypoxic–ischemic encephalopathy, ultrasound

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## Introduction

Neonatal hypoxic–ischemic encephalopathy (HIE) still accounts for a significant percentage of mortality and morbidity in the neonates [1,2]. Fortunately, the use of hypothermia as a therapy for the neuroprotection of the neonates with HIE has made its prognosis better. However, the narrow window of hypothermia as a therapy necessitates quick diagnosis of those neonates who are suspected to have moderate or severe HIE [3,4].

The transcranial ultrasound (US) is of low cost, easy, and fast to perform at the bedside and can be repeated many times, allowing the evaluation of the disease process from the acute to the chronic phases. Many neonates with suspected HIE in the ICU are hemodynamically unstable, make transcranial US the investigation of choice for the initial assessment of neonatal HIE [2,5–8].

Since transcranial US depends on the skills and experience of the operator and the acoustic windows used, and also since one cannot visualize the peripheral and deeper brain structures as well as the injury of the white matter, transcranial US is not considered foolproof and brain MRI remains the most specific and sensitive imaging modality [7–10].

This study aims to evaluate the role and current practice of grayscale transcranial US in the diagnosis of neonatal HIE in neonatal ICU in Assiut University Hospital (AUH), by developing locally reliable audit criteria from the worldwide standards and evaluating

the adherence to these audit criteria in the neonatal ICU in AUH, to give recommendations and implement changes which may improve the role of transcranial US in the diagnosis of neonatal HIE in the neonatal ICU in AUH.

## Patients and methods

The study was carried out after obtaining the permission of the Ethics Committee of Scientific Research, Faculty of Medicine, Assiut University. Patients signed informed consent, with IRB number: 17101028

A clinical audit study was conducted in the neonatal ICU in AUH on neonates who underwent transcranial US for the diagnosis of neonatal HIE during 15 months from April 2017 till June 2018 (the first audit cycle about 13 months and the second audit cycle about 2 months). Neonates who had their transcranial US outside the neonatal ICU in AUH were excluded.

The process of this audit study includes the following.

### Setting criteria and standards

Six criteria were set that were measured with 40 indicators with a 100% standard set for each indicator. The sources of these selected criteria were evidence-based guidance, up-to-date literature searches, and professional consensus.

### Collection of data and observing practice

A data collection form was set and the needed data were extracted by:

(1) Retrospective and concurrent review of the medical records.
(2) Concurrently, examiners were observed who did the transcranial US:
    (a) Comparing the practice with standards.
    (b) Implementing changes.
    (c)Reauditing.

The same criteria, indicators, and standards set in the first audit cycle were used in the second audit cycle, with the same procedures of sample selection, information collection, and analysis.

### Statistical analysis

Data were expressed as the number of indicators that have met the standards, in each audit cycle. This was done by selecting the appropriate total number of applicable cases for an audit indicator, and the total number from within this that met the indicators and calculate what percentage this represents to decide if each indicator met the standard or not. Then we calculated the percentage of the indicators which met the standards from the total number of indicators to evaluate the adherence in each audit cycle [11–13].

## Results

The study included 110 neonates (90 in the first audit cycle and 20 in the second audit cycle). The first audit cycle included 52 men, 37 women, and one undetermined sex; the second audit cycle included nine men and 11 women, showing that male neonates were more than the women in the first audit cycle, while female neonates were more than men in the second audit cycle.

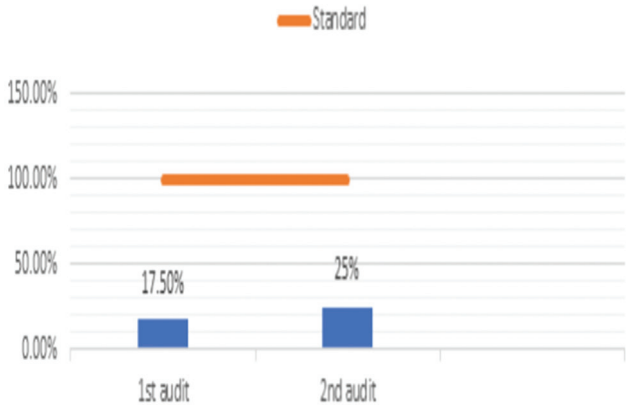
The first audit cycle included 67 preterms and 23 full terms; the second audit cycle included 17 preterms and three full terms, showing that preterm neonates were more than the full-term neonates in both the first and the second audit cycle.

In the first audit cycle, meeting the standards were achieved in seven out of the 40 indicators (Tables 1–6), with 17.5% adherence, while in the second audit cycle, the standards were met in achieved in 10 out of the 40 indicators (Tables 1–6), with 25% adherence, which was higher than the adherence in the first audit cycle (Fig. 1).

## Discussion

This audit study was conducted for 15 months (first audit cycle about 13 months and second audit cycle about 2 months) and included the neonates who underwent transcranial US for the diagnosis of neonatal HIE in the neonatal ICU in AUH.

**Figure 1**




Adherence to the standards in both the first and second audit cycles.

**Table 1 Analysis of criterion 1 in the first and second audit cycle**

| Criterion 1 | Indicators | Meeting the standards | |
|---|---|---|---|
| | | First audit cycle | Second audit cycle |
| Proper US machine and probes were used | Transportable real-time US machine was used | Yes | Yes |
| | A curved linear array probe was used | Yes | Yes |
| | A high-frequency linear array probe was used | No | No |
| | The size of the probe was fit to the examined neonatal fontanel | No | No |

US, ultrasound.

**Table 2 Analysis of criterion 2 in the first and second audit cycle**

| Criterion 2 | Indicators | Meeting the standards | |
|---|---|---|---|
| | | First audit cycle | Second audit cycle |
| Examination was done under infection control | Proper hand hygiene | Yes | Yes |
| | All the gel and residues were removed | Yes | Yes |
| | A low-level disinfectant was used | No | No |
| | A sterile gel was used | No | No |

**Table 3 Analysis of criterion 3 in the first and second audit cycle**

| Criterion 3 | Indicators | Meeting the standards | |
|---|---|---|---|
| | | First audit cycle | Second audit cycle |
| The transcranial US examination was technically well-done | The examiner was on the right side of the patient | Yes | Yes |
| | Screening was done via the AF | Yes | Yes |
| | Screening was done via other supplemental fontanels | No | No |

US, ultrasound.

Adherence to the audit criteria in the first audit cycle was 17.5%. Analysis of the results revealed many possible reasons for that low adherence in the first audit cycle, including the high target level that was chosen (100%), structure, and process defects. The defect of the structures included lack of a curved array probe of suitable size, lack of a high-frequency linear probe, and the lack of sterile gel. The few numbers of trained examiners and lack of good agreed-upon process of documentation of transcranial US reports and follow-up, besides many limitations for further evaluation with MRI when indicated. All of these may explain the underperformance. Sampling bias may also account for the underperformance.

After the first audit cycle, many changes were recommended to be implanted as the following:

(1) Providing the neonatal ICU with a convex probe and a high-frequency linear probe that are small enough to fit the size of the examined fontanelle.
(2) Organizing regular lectures and practical training for the transcranial US examination.
(3) Providing the neonatal ICU with an adequate amount of sterile gel regularly.
(4) Recording adequate images of both abnormal and normal findings of transcranial US examination.
(5) Recording the date of the next transcranial US follow-up or the indication for further imaging in the US report and fixing a little paper note of this on the neonatal incubator.

Then, the second audit cycle revealed slight improvement of the performance; however, this was still far from the set standards, with adherence is only about 25%. Honestly the very short period of the second audit cycle and the lack of enough time to implement the recommended changes mentioned above make the results of reauditing are not sufficient to judge if there is an actual improvement.

## Conclusion

Transcranial US is the modality of choice in the initial evaluation of suspected cases of neonatal HIE. Measurable audit criteria and standards were developed to assess the role of grayscale transcranial US in the diagnosis of neonatal HIE in neonatal ICU in the AUH. Adherence to the audit criteria fell below the expected standards in both the two audit cycles with a slight improvement in the second audit cycle. Further reauditing after a considerable period of enough time to implement changes is recommended.

**Table 4 Analysis of criterion 4 in the first and second audit cycle**

| Criterion 4 | Indicators | | Meeting the standards | |
|---|---|---|---|---|
| | | | First audit cycle | Second audit cycle |
| Proper documentation of transcranial US examination | The images were recorded in at least five coronal and five sagittal images | | No | No |
| | Images of abnormal findings were recorded | | No | No |
| | The images were labeled with | Patient name | No | No |
| | | Date of examination | Yes | Yes |
| | | Side (right or left) of the anatomic site imaged | No | No |
| | The US report included | Neonatal name | No | No |
| | | Neonatal age and status of maturity | No | No |
| | | Date of US examination | No | Yes |
| | | Indication of US examination | No | No |
| | | Normal anatomical variants if present | No | No |
| | | Measurement of cerebral structure or ventricle if needed | No | No |
| | | A scoring system for GMH-IVH | No | Yes |
| | | A scoring system for PVL if present | No | No |
| | | Determination of the side of the lesion | No | No |
| | | No abbreviations | No | No |
| | | Comparison with prior transcranial US if available | No | No |
| | | Specific diagnosis and differential diagnosis | No | No |
| | | A recommendation for follow-up transcranial US if needed | No | No |
| | | A recommendation for further evaluation with indicated MRI/CT imaging | No | No |
| | | Limitations | No | No |
| | | The name and status of the sonographer | No | No |
| | The US reports were kept within the medical records | | No | No |
| | The recorded images were kept within the medical records | | No | Yes |

US, ultrasound.

**Table 5 Analysis of criterion 5 in the first and second audit cycle**

| Criterion 5 | Indicators | Meeting the standards | |
|---|---|---|---|
| | | First audit cycle | Second audit cycle |
| The time of examination and follow up | Transcranial US had been done on 1st day of birth or admission | No | No |
| | Transcranial US had been done at the recommended time for follow-up | No | No |

US, ultrasound.

**Table 6 Analysis of criterion 6 in the first and second audit cycle**

| Criterion 6 | Indicators | Meeting the standards | |
|---|---|---|---|
| | | First audit cycle | Second audit cycle |
| Further evaluation with the indicated MRI/CT imaging was done in the proper time | MRI had been done when indicated | No | No |
| | CT was indicated in cases that had done CT | No | No |
| | MRI had been done at the recommended time | No | No |
| | The time elapsed between the US and CT/MRI was <48 h | No | No |

CT, computed tomography; US, ultrasound.

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**Conflicts of interest**

There are no conflicts of interest.

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