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Original Article

Universal Head Ultrasound Screening in Full-term Neonates: A Retrospective Analysis of 6771 Infants

Elisa Ballardini MD [a,2], Anna Tarocco MD [a,*,2], Chiara Rosignoli MD [a], Alessandro Baldan MD [a,1], Caterina Borgna-Pignatti MD [a], Giampaolo Garani MD [b]

[a] *Pediatric Unit, Department of Medical Sciences, University Hospital of Ferrara, Ferrara, Italy*
[b] *Neonatal Intensive Care Unit, Department of Reproduction and Growth, University Hospital of Ferrara, Ferrara, Italy*

ABSTRACT

BACKGROUND: Full-term neonates may have asymptomatic cranial injuries at birth and head ultrasound screening could be useful for early diagnosis. The aim of this study was to assess the prevalence and type of intracranial abnormalities and the usefulness of head ultrasound screening in these infants. **METHODS:** A head ultrasound screening was performed on all full-term neonates (gestational age between 37 and 42 weeks), born at Sant'Anna University Hospital of Ferrara, Italy, from June 1, 2008 through May 31, 2013. Ultrasound findings were categorized into three groups: normal, minor, and major anomalies. **RESULTS:** All full-term neonates (6771) born at our hospital underwent head ultrasound screening. One hundred fourteen of 6771 (1.7%) presented ultrasound abnormalities, whereas 6657 were normal or exhibited insignificant findings. In 101 of 114 (88.6%), abnormalities were minor, and only 13 infants had major abnormalities (0.19% of all full-term newborns). All neonates with major abnormalities presented with either microcephaly or abnormal neurological evaluations. Only one individual with major abnormalities was detected exclusively by ultrasound. **CONCLUSIONS:** The number of significant anomalies detected by head ultrasound screening in asymptomatic full-term neonates born during the study period was low. Therefore, there is no indication for routine general head ultrasound screening in these patients. However, even if low, in neonates who have neurological abnormalities, risk factors or suspected brain malformations, head ultrasound screening may play an important role in the early diagnosis of intracranial anomalies.

Keywords: ultrasonography, term infants, brain imaging, newborn screening

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Introduction

Ultrasonography is a noninvasive and safe technique to rapidly evaluate neonatal brains. It is especially useful to detect brain injuries in full-term infants and in premature newborns in relation to their gestational age.[1-5]

Nevertheless, head ultrasonography has limitations. For example, the quality of the images depends on the skill and experience of the technician. In addition, some areas of the brain are difficult to visualize by this technique.[6-12] Head ultrasonography is performed routinely in neonatal intensive care units (NICUs) where premature infants and sick full-term infants at high risk of intracranial lesions are admitted. Several studies reported brain abnormalities in apparently healthy, asymptomatic neonates[1,6,13-17] that often present with a mild to moderate degree of neurodevelopmental impairment. Some of these cases probably are because of subtle, clinically asymptomatic, perinatal events that can be detected by neonatal head ultrasound.[6]

Head ultrasonography is considered to be a useful tool for early diagnosis of brain injury and in some medical centers it is used as a screening test.[18] All babies born in

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* Communications should be addressed to: Dr. Tarocco; Pediatric Section; Department of Medical Sciences; University Hospital of Ferrara; Via Aldo Moro, 8; Ferrara, 44124, Italy.
E-mail address: anna.tarocco@unife.it
[1]Present address: Department of Pediatrics, Baylor College of Medicine, Houston, Texas.
[2]These authors contributed equally to the work described in this paper.

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Ferrara, Italy, over the past 20 years underwent head ultrasound screening (HUS). To analyze the usefulness of this practice in term infants, we reviewed the ultrasonographic records from the past 4.5 years.

The aim of this study was to assess the prevalence and type of intracranial abnormalities detected by HUS in asymptomatic full-term neonates.

Materials and Methods

We reviewed the data of all babies of gestational age between 37 and 42 weeks born at Sant'Anna University Hospital of Ferrara, Italy, from June 1, 2008 through May 31, 2013. The healthy newborns underwent HUS before discharge (48 to 72 hours after birth), whereas sick newborns admitted to the NICU underwent one or more ultrasounds during hospitalization.

The HUS was performed by one of the two experienced and trained neonatologists. When the neurological examination was doubtful or abnormal, it was repeated by a neonatologist specifically trained in neurological evaluation, based on the concepts of Milani Comparetti, neurobehavioral items of Brazelton, and the Prechtl's general movements.[19-23] HUS results included coronal and sagittal standard planes through the anterior fontanel[6] using the same portable ultrasound system with a 5 and 6.5 MHz transducer (Logiq 200, Pro Series, GE Medical Systems, Solingen, Germany). All infants underwent neurological examination as part of the general medical examination to evaluate posture, tone, reflexes, and behavior. Perinatal clinical details were obtained through the computerized database Neocare (available at www.neocare.it) and SAP (www.sap.com), or by retrieving the original paper records if necessary.

The collected data included the following variables: date of birth, gestational age, type of hospitalization (NICU or nursery), HUS findings, mode of delivery (spontaneous, elective caesarean section, or emergency caesarean section), birth weight and weight percentile, microcephaly (head circumference percentile ≤ 3) and macrocephaly (head circumference percentile ≥ 97) measurements, and Apgar score at one and five minutes. Furthermore, the presence or absence of neonatal jaundice, multiple pregnancy, neurological symptoms, maternal drug use, congenital infections, autoimmune diseases, antidepressant maternal therapy, and gestational or diabetes mellitus. Ultrasound findings were categorized into three groups[18]: *normal or nonsignificant* (including normal and normal variations: mild ventricular asymmetry, mild periventricular echogenicity, mild frontal or occipital horn prominence, septum pellucidum cysts, choroid plexus irregularity, mild choroid plexus echogenicity), *minor anomalies* (thalamic-striatal vessels' echogenicity, enlarged cysterna magna, choroid plexus or subependymal cysts, mild ventricular enlargement, intraplexus hemorrhage, ventricular irregularity, periventricular echogenicity, and subependymal echogenicity), and *major anomalies* as described in Table (anomalies of the corpus callosum, ventriculomegaly and hydrocephalus, ultrasonographic signs of hypoxic-ischemic injury calcifications, hemorrhages, abnormal echogenicity of parenchyma, and frontal horn prominence associated with an adjacent suspected porencephalic cyst).

Neonates with minor abnormalities were monitored after discharge, whereas neonates with major abnormalities underwent magnetic resonance imaging (MRI) or repeated ultrasounds and were followed until age 24 months.

Results

During the study period a total of 6771 full-term neonates were born at the University Hospital of Ferrara, Italy, and all underwent HUS and neurological examination. Ultrasonographic brain abnormalities were found in 114 neonates (1.7%), whereas 6657 were normal (or insignificant). One hundred one (88.6%) of the 114 abnormalities were minor. In detail, we observed 54 choroidal or subependymal cysts, two intracranial cysts, three cases of enlarged cysterna magna, 12 irregularities of the plexus, ten mild ventricular enlargements, one intraplexus hemorrhage, and one small and isolated thalamic calcification; seven patients had both ventricular enlargements and subependymal cysts. In ten infants echogenicity of the thalamic-striatal vessels and in two edema and slight periventricular echogenicity were present. Neonates with minor abnormalities underwent only a second ultrasound but no clinical follow-up.

Major abnormalities affected 13 neonates (0.19% of full-term infants), in four of them it was the consequence of hypoxia at the time of delivery. All infants with major brain injuries detected by HUS underwent neurodevelopmental follow-up and/or rehabilitation program, and these cases are described in Table. All neonates with major abnormalities presented with either microcephaly or an abnormal neurological evaluation. Three underwent prenatal diagnosis because of the early detection of cranial abnormalities during pregnancy. Only case 9 was detected exclusively by ultrasound and had a normal outcome.

Discussion

Brain abnormalities have occasionally been reported in asymptomatic neonates. Nevertheless, no recommendations exist for the use of cranial ultrasound screening in full-term infants. In this study, we reported a low rate of significant abnormal findings in full-term newborns (0.19%). As confirmed by others,[16,18] MRI has the highest sensitivity for detecting brain abnormalities in neonates. In the present study, all neonates found with HUS abnormalities underwent MRI to confirm the lesions.

Wang et al.[17] described 2309 babies in whom HUS, performed through the anterior fontanel, yielded a low incidence of abnormalities (0.25%). A higher prevalence of significant findings was reported by Gover et al.[13] in 2011 (3.8%), by Heibel et al.[14] in 1993 (9%), and by Mercuri et al.[1] in 1998 (19.7%), but the samples were small.

In our study, the rate of abnormal HUS was more similar to that of Heibel et al.[14] than to those reported by the others.[1,16,17] The different results may be because of different techniques (HUS or MRI), to the methodology used for HUS (frontal versus posterior or mastoid fontanel), to the operator's experience, or to differences in the populations examined.

We found significant brain abnormalities only in a small percentage (0.19%) of 6771 term infants. In almost all of these neonates, the presence of at least one risk factor suggested that HUS should be performed. These risk factors included abnormal neurological examination, symptoms secondary to hypoxic-ischemic encephalopathy, and abnormal head circumference. Three patients had prenatal diagnosis of brain abnormalities.

Only four of the 13 infants (0.06% of entire sample) with abnormal findings in HUS (Patients 4, 5, 9, and 10) had no identifiable risk factors. Brain MRI of Patients 4 and 5 confirmed the ultrasound findings. Those patients required neurological and rehabilitation follow-up. Patients 9 and 10 only required clinical and ultrasound follow-ups; these patients developed normally. The other four infants, who had abnormalities in HUS, were diagnosed prenatally with partial or complete agenesis of the corpus callosum, or had

TABLE.
Major Abnormalities Detected by HUS

Diagnosis by HUS	Gender	NICU or Nursery	SGA	HC < Third Percentile	Mode of Delivery	Apgar Score 1′-5′	Neurologic Evaluation	Follow-up	MRI	Prenatal Diagnosis
1. Partial agenesis of corpus callosum	Female	Nursery	No	Yes	Spontaneous	9-10	Normal	Hypotonia	PACC confirmed, cerebellar vermis hypoplasia	No
2. Agenesis of corpus callosum	Female	Nursery	No	No	ElC	8-9	Normal	Normal, febrile status epilepticus at age 1 + 5/12 year	ACC	Yes
3. Agenesis of corpus callosum	Female	Nursery	Yes	Yes	Spontaneous	8-9	Abnormal general movements: poor repertoire	Normal	ACC	Yes
4. Periventricular calcifications	Female	Nursery	Yes	Yes	ElC	8-9	Normal	Normal with rehabilitation program	Frontal bilateral pachygyria, white matter abnormalities, multiple calcifications	No
5. Ischemic stroke of left frontal lobe	Male	Nursery	No	Yes	Spontaneous	10-10	Normal	Normal	Ischemic stroke	No
6. Ischemic stroke of left temporal, parietal, occipital lobes	Male	Nursery	No	No	EmC	9-10	Seizures	Right-side hemiplegia with rehabilitation program	Ischemic stroke	No
7. Hypoxic-ischemic encephalopathy	Male	NICU	No	No	ElC	2-5	Seizures	Normal with rehabilitation program	Hypoxic-ischemic encephalopathy with stroke	
8. Hydrocephalus	Female	NICU	No	No	ElC	7-8	Seizures, hypotonia	Ventricular peritoneal shunt	Hydrocephalus, lissencephaly	Yes
9. Ventriculomegaly	Male	Nursery	No	No	Spontaneous	10-10	Normal	Normal	No	No
10. Porencephalic cyst	Female	Nursery	No	No	Spontaneous	9-9	Slight hypotonia	Normal	No	No
11. Hypoxic-ischemic encephalopathy	Male	NICU	No	Yes	Spontaneous	2-6	Sarnat I-II	Normal	Normal	No
12. Hypoxic-ischemic encephalopathy	Female	NICU	No	Yes	EmC	2-7	Sarnat II	Normal with rehabilitation program	Normal	No
13. Hypoxic-ischemic encephalopathy	Male	NICU	No	No	Spontaneous	0-4	Sarnat III	Rehabilitation program: cerebral palsy	Hypoxic-ischemic encephalopathy	No

Abbreviations:
ACC = Agenesis of corpus callosum
ElC = Elective caesarean
EmC = Emergency caesarean
HC = Head circumference
HUS = Head ultrasound screening
MRI = Magnetic resonance imaging
NICU = Neonatal intensive care unit
PACC = Partial agenesis of corpus callosum
SGA = Small for gestational age

hypotonia or seizures. The remaining five patients were hospitalized in NICU because of neonatal asphyxia or prenatal diagnosis of hydrocephalus. They underwent cerebral MRI, and neurological and rehabilitation follow-up. Patient 9 underwent brain surgery.

All neonates (1.7%) with minor abnormalities had normal neurological examinations and subsequently underwent one or more HUS.

Our study has some limitations. First, it is retrospective. Second, we performed ultrasound screening only through the anterior fontanel. No posterior fossa views were obtained through the mastoid approach. An inherent limitation of all studies using ultrasound is operator dependency. To minimize this problem, the second neonatologist repeated the examination whenever there was a doubtful finding. Major anomalies were checked and revised by both neonatologists and confirmed by cerebral MRI. Moreover, infants who had minor abnormalities underwent at least a second ultrasound for confirmation. These methods helped to eliminate the risk of false positives. No case presented to our pediatric neurology clinic with conditions that could have been recognized by HUS at birth as major anomalies. Nevertheless, we cannot exclude that a few minor abnormalities escaped recognition, but this does not represent a clinical problem.

The major strengths of this study are its large sample size and that HUS was performed in all the neonates born at the University Hospital of Ferrara. In addition, the infants who had some anomalies were followed up clinically or with additional HUS.

Conclusions

Our data suggest that there is no indication for routine HUS in asymptomatic full-term infants, and we no longer perform HUS on all neonates. At least in our health care system, pregnant women can be examined by obstetric ultrasound before delivery, so that most major anomalies can be detected early.

In this study, the prevalence of significant anomalies detected by HUS in term infants was low. However, even if low, in neonates who have neurological abnormalities, risk factors, or suspected brain malformations, HUS may play an important role in the early diagnosis of intracranial anomalies.

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