Using High Risk Factors to Predict Audiometric Profiles in Infants

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Introduction

The Joint Committee on Infant Hearing (JCIH, 2007) identified eleven risk factors associated with childhood hearing loss. Presently these risk factors are used to help identify infants who pass their initial newborn hearing screening (NBS) but are at risk for developing delayed onset hearing loss and infants or who may have a mild hearing loss (HL) that is overlooked by the initial screen.

In 2006, Lieu and Champion sought to quantify the relative importance of the known risk factors for congenital HL, look for previously unidentified risk factors for HL, and create a prognostic system that could predict the chance of an infant being diagnosed with HL. In 2013, Lieu and colleagues explored whether a prognostic model using risk factors for HL would predict the chance that infants who did not pass the NBS, would subsequently be diagnosed with HL by auditory brainstem response (ABR) testing. Both studies focused on high-risk infants who received their initial hearing screening in a neonatal intensive care unit (NICU).

The seven independent risk factors identified by Lieu and Champion (2006) as significantly associated with referral on NHS using automated ABR were: hyperbilirubinemia, maternal alcohol abuse, presence of named syndromes (or associations that have been linked with HL), neonatal hydrocephalus, bronchopulmonary dysplasia (BPD), congenital cytomegalorvirus (CMV) infections, and presence of craniofacial abnormalities. The proposed prognostic staging system with weighting values is presented in Table 1.

Data from the derivation cohort (N = 1811) and the validation cohort (N = 405) was used to construct a four-factor prognostic stratification system. The proposed prognostic factor stratification system based on the 2006 data is shown in Table 2. Results demonstrate that these combined risk factors differentiated children based on outcome (not passing the NHS ABR screen) from 11% among those with risk factors to 61% with the highest scores.

Table 1. Assignment of Weighted Score for Risk Factor Staging for Prior Prognostic Staging System by Lieu and Champion, 2006

Weighted Score	Risk Factor
0	None
1	Intraventricular hemorrhage or syndromes
2	Cytomegalorvirus, birth weight ≤ 2500 gm or NICU stay > 2 days
3	Oxygen use > 1 L/min (severe bronchopulmonary dysplasia)
4	Hydroencephalus
5	Craniofacial abnormalities

Table 2. Performance of Derivation and Validation Cohorts for Prognostic Model based on the Number of Risk Factors Present [N = 1836 and N = 437] (from Lieu & Champion, 2006)

		Derivation Cohort	Validation Cohort
Stratum	Number of Risk Factors Present (Score)	# Referred (%)	# Referred (%)
I	0	162/1439 = 11.3	29/288 = 10.1%
II	1	11/66 = 16.7 %	3/16 = 18.8 %
III	2-4	90/226 = 39.8 %	22/49 = 44.9%
IV	5-10	49/80 = 61.2 %	31/52 = 59.6%

In the 2013 follow-up study by Lieu and colleagues, used the 2006 proposed model to predict the chance that 687 infants who did not pass their initial newborn hearing screen would subsequently be diagnosed with HL by diagnostic ABR. When applying the prognostic staging system by Lieu and Champion (2006) to a this new population, the predictive ability of this system to classify infants with normal hearing (421/458 = 91.9%) was much better than infants with HL (64/229 = 27.9%). Therefore, a revised three-tier prognostic stratification system was proposed based on the number and weighting of risk factors. The Revised Prognostic Stratification System based on the Lieu et al. 2013 data is shown in Table 3. The purpose of the current project was to evaluate the three-tier revised prognostic model in an independent NICU population referred for ABR and diagnosed with HL.

Table 3. Revised Prognostic Stratification System Based on Whole Cohort and Did Not Pass Newborn Hearing Screening Cohorts Present [N=687and N = 512] (from Lieu, Ratnaraj, & Banan 2013)

		Whole Cohort	Subgroup
Stratum	Number of Risk Factors Present	# Referred (%)	# Referred for ABR Diagnosed with HL
I	0	56/383 = 15%	43/296 = 14%
II	1-2	158/290 = 54%	104/206 = 50%
III	>3	13/14 = 96%	9/10 = 90%

Method

This retrospective chart review study was approved by the Internal Review Board (IRB) at the University of Arkansas for Medical Sciences (UAMS) protocol # 202049.

Chart Review

A retrospective medical record chart review was conducted at Arkansas Children's Hospital (ACH).

Inclusion Criteria

- Received newborn hearing screening (NHS) while in residence in the neonatal intensive care unit (NICU)
- Received follow-up diagnostic auditory brainstem response (ABR) for the purpose of threshold estimation via natural sleep or sedation from January 1, 2007 through December 30, 2012

Exclusion Criteria

- Incomplete medical record information (NHS or ABR)

Procedure

A list of one 1036 patients who received a diagnostic ABR during the target time period was generated. Medical records were cross-checked to identify participants who had a history of NICU inpatient status and had returned for follow-up ABR.

Variables

Thirty-one risk factors, identified and detailed in the Lieu and Champion 2006 and the Lieu et al., 2013 studies were extracted from the patient charts. The JCIH 2007 risk factors along with other known risk factors for late onset hearing loss were included. The clinical variables of interest included in the study were the same used in the Lieu et al. (2013) chart review study (i.e., ontological examination results, auditory brainstem response estimated thresholds, type and degree of hearing loss.

Data Extraction

A trained graduate student researcher conducted the medical records review, entered data into a standard extraction form using definitions and codes recorded in a data dictionary. Patients' inpatient admission reports, discharge summaries, medication lists, history and physical reports, genetics reports, demographic information, lab and radiology reports, and audiology records were included in the review. Data was de-identified and maintained in a password protected database.

Analysis

Descriptive statistics included frequency counts, means and standard deviations. Variables were combined to ascertain which of the two proposed stratification systems best predicted hearing loss diagnosis as an outcome for these children.

Results

Participants

One-hundred and eighty-nine infants met the inclusion criteria for chart review. Of the 189 infants receiving diagnostic ABR testing, 45 were diagnosed with HL.

Three Stage Prognostic Model

The proportion of NICU infants diagnosed with HL (45/189 = 24%) after ABR NHS referral for ABR diagnostic testing was 24%. We used the clinical characteristics defined by Lieu et al, (2013) and applied the Three Factor Revised Prognostic Stratification System (Table 3) to this population. The factors included in this model included intracranial complication, APGAR@ 5 min ≤ 6, prematurity, and craniofacial abnormality.

Results of our analysis are shown in Table 4. For example, if the infant had more than a 7 on their APGAR at 5 minutes and none of the other three clinical characteristics, the infant was categorized as Stratum I. If the infant was premature and had a craniofacial abnormality, the infant fell into Stratum II. If the infant had three or more of the four clinical characteristics listed above, results were classified as Stratum III.

Table 4. Three Factor Revised Prognostic Stratification System Applied to Cohort of Arkansas Children's Hospital NICU Infants

Stratum	#f Risk Factors Present	Number Referred for ABR and Diagnosed with HL (%)
I	0	12/45 = 26.6%
II	1-2	29/45 = 64.4%
III	≥3	4/45 = 8.8%
Overall		33/45 = 73.3%

Clinical Implications

Almost one in four of the infants who referred following the NICU ABR screening were diagnosed with HL. This result is limited to families that followed-up and received diagnostic ABR evaluation. This important finding lends support for the use of standardized scripts when delivering results of hearing screening to families.

Almost 75% of the infants diagnosed with HL could be predicted using the Lieu et al., 2013 Three Factor Revised Prognostic Stratification System. These results suggest that over 50% of NICU hearing loss can be predicted if a child has one or more of the four independent clinical characteristics identified by Lieu and colleagues. More research is needed to identify clinical characteristics of clinic patients who received a diagnostic ABR, but were not diagnosed with HL to determine if this prognostic model can differentiate between the two conditions.

References

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