BOston Neonatal Brain Injury Data for Hypoxic Ischemic Encephalopathy (BONBID-HIE): II. NICU and 2-Year Neurocognitive Outcome

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ABSTRACT

This paper introduces the second release of the BOston Neonatal Brain Injury Dataset for Hypoxic Ischemic Encephalopathy (BONBID-HIE), an open-source, comprehensive MRI and clinical dataset from Massachusetts General Hospital and Boston Children's Hospital. It includes data on 237 patients and focuses on developing prognostic biomarkers through detailed analyses of clinical, treatment, NICU and neurocognitive outcomes, aiming to enhance therapeutic strategies and trial efficiencies.

Background & Summary

HIE is a clinical syndrome caused by a lack of blood flow and oxygen to the brain. It affects around 0.5% of newborns globally [1, 2]. Despite advancements in Therapeutic Hypothermia (TH), the prognosis for many infants remains challenging, with 35%–50% suffering adverse neurocognitive outcomes by 2 years of age [3, 4, 5]. Therefore, 63 of the 130 ongoing HIE-related trials worldwide are testing whether new therapies [6, 7, 8, 9, 10, 11, 12] can supplement TH and further reduce adverse outcomes. However, therapeutic innovation is slow and inconclusive, because: 1) patients at high risk of developing adverse outcomes cannot be identified before therapy; 2) outcomes cannot be measured until age 2 years after therapy [13]. Both issues point to the lack of a neonatal biomarker that can predict adverse 2-year outcomes, so therapeutic trials can target high-risk patients, increase efficiency, evaluate therapeutic effects early, and expedite therapeutic innovations [14].

To facilitate the development of biomarkers in HIE studies, we present the Boston Neonatal Brain Injury Dataset for Hypoxic Ischemic Encephalopathy (BONBID-HIE), an open-source, comprehensive, and representative MRI and clinical dataset for HIE. This paper introduces the second part of the BONBID-HIE data. This release contains raw and derived diffusion parameter maps, as well as NICU outcomes and 2-year outcomes for 237 patients. Our data was obtained from Massachusetts General Hospital (MGH) and Boston Children's Hospital (BCH), and includes MRIs from different scanners (Siemens 3T and GE 1.5T), different MRI protocols, and from patients of different races/ethnicities and ages (0-14 days postnatal age). Part I of BONBID-HIE [15] focuses on lesion detection, while Part II (this paper) focuses on clinical, treatment, NICU and 2-year neurocognitive outcome data for further developing prognostic biomarkers.

Dataset Characteristics

Clinical Information

Table 1A lists the demographics and clinical characteristics of mothers and neonates. Maternal information includes demographics (age at delivery, race), birth mode (C-section or vaginal), and complications during pregnancy and delivery. Neonatal information includes demographics (age at MRI scan, gestational age at birth, birth weight, head circumference, sex), birth conditions (1/5/10-minute APGAR scores, lowest pH value in umbilical cord), treatment (hypothermia or not), and complications in the neonatal intensive care unit (NICU), including seizure (yes/no), length of stay (in days), the use of endotracheal tube (ETT, yes/no), and the administration of total parenteral nutrition (TPN, yes/no). In each row, we also listed

the number of patients who had such information available.

MRI Information

We provide ADC and Z_{ADC} for each HIE patient, such information has been verified crucial for HIE outcome predictions. Figure 1 shows the ADC map and Z_{ADC} map from MGH and BCH. For details on ADC and Z_{ADC}, please refer to our Part I paper. Since not all outcomes were collected with MRIs, we list the distribution of MRIs with NICU outcomes and 2-year

Table 1. Cohort characteristics (N=237) in MGH and BCH

A. Demographics and Clinical Characteristics		
Maternal Information		
Maternal age at delivery (years)	30.30 ± 6.04	N=236
Race	White (117), Black or African American (13), Hispanic or Latino (18), Multi Race (5), Unknown (69), Other (15)	N=237
Delivery	C-section (143), Vaginal (94)	N=237
Antepartum hemorrhage	Yes (43), No (194)	N=237
Thyroid dysfunction	Yes (12), No (225)	N=237
Pre-eclampsia	Yes (10), No (227)	N=237
Fetal decels	Yes (153), No (84)	N=237
Shoulder dystocia	Yes (11), No (226)	N=237
Chorioamnionitis	Yes (26), No (206)	N=232
Emergency c-section	Yes (127), No (104)	N=231
Neonatal Information		
Age at scan (days)	3.47 ± 2.40	N=232
Gestational age at birth (weeks)	39.08 ± 1.94	N=237
Birth weight (g)	3294.06 ± 603.91	N=144
Infant head circumference (cm)	34.28 ± 1.70	N=165
Sex	Male (137), Female (100)	N=237
1-minute APGAR scores	1.89 ± 1.80	N=237
5-minute APGAR scores	3.98 ± 2.35	N=235
10-minute APGAR scores	5.03 ± 2.36	N=207
Lowest pH value in umbilical cord	6.99 ± 0.22	N=225
Therapeutic hypothermia before MRI?	Yes (171), No (66)	N=237
Endotracheal tube (ETT) in NICU	Yes (168), No (59)	N=227
Total parenteral nutrition (TPN) in NICU	Yes (209), No (27)	N=236
Seizures NICU	Yes (115), No (122)	N=237
Length of stay in NICU (days)	11.68 ± 9.86	N=237
B. NICU Outcome	Deceased (33), Survived (204)	N=237
C. 2-year Neurocognitive Outcome	Adverse (103), Normal (104)	N=207
Developmental Delay	Yes (61), No (173)	N=173
Cerebraipalsy	Yes (26), No (147)	N=173
Visual impairment	Yes (12), No (159)	N=171
Hear impairment	Yes (14), No (157)	N=171
D. BSID-III Scores		
age at test (months)	21.41 ± 2.79	N=64
Raw score - cognition	56.90 ± 7.28	N=21
Composite score - cognition	95.51 ± 17.47	N=61
Percentile - cognition	45.00 ± 26.09	N=60
Scaled score - cognition	8.68 ± 2.15	N=19
Raw score - language total	n/a	
Raw score - language (receptive communication)	21.71 ± 4.24	N=21
Raw score - language (expressive communication)	23.71 ± 5.24	N=21
Composite score - language	93.20 ± 13.14	N=46
Percentile - language	38.06 ± 26.94	N=47
Raw score - motor total	n/a	
Raw score - motor (fine motor)	35.76 ± 3.18	N=21
Raw score - motor (gross motor)	50.20 ± 4.52	N=20
Scaled score - motor (fine motor)	10.04 ± 2.96	N=27
Scaled score - motor (gross motor)	8.53 ± 1.73	N=19
Composite score (motor)	94.14 ± 15.04	N=50
Percentile - motor	41.44 ± 22.56	N=50

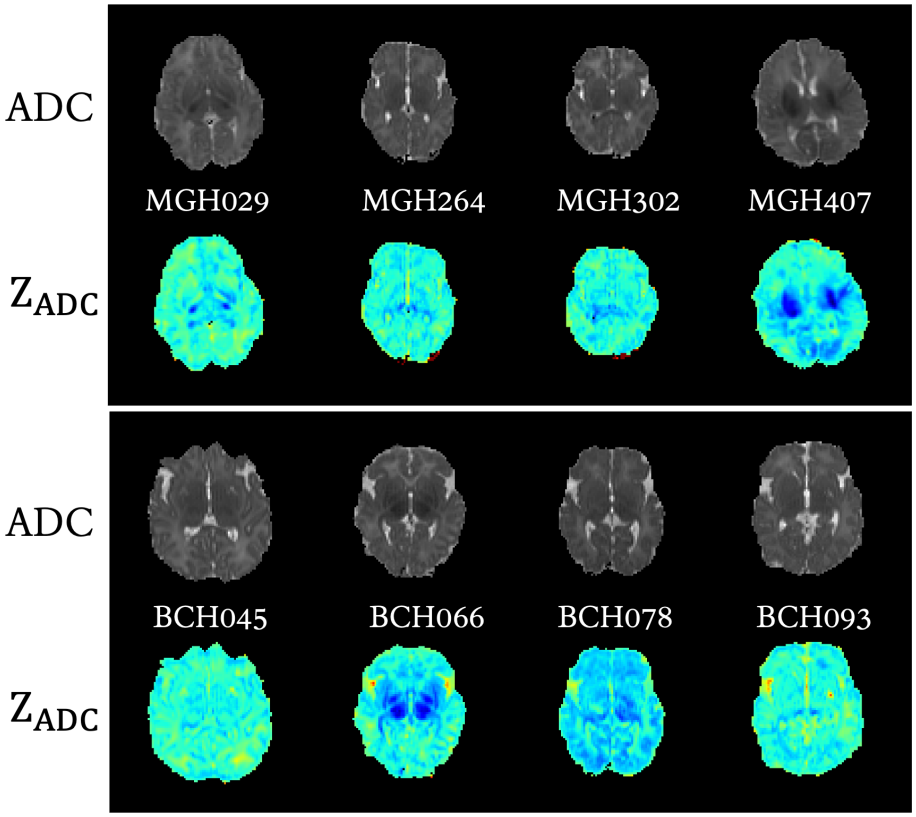

Figure 1. We show representative images for 4 HIE patients for MGH and BCH. For each patient, in the upper panel: apparent diffusion coefficient (ADC) maps; in the bottom panel: Z_{ADC} maps.

Table 2. Statistics for Site Data and HIE Outcome with MRIs

NICU Outcome with MRIs				2-year Outcome with MRIs			
Site	Total	Survived	Deceased	Site	Total	Normal	Adverse
BCH	72	65	7	BCH	72	30	42
MGH	107	94	13	MGH	84	53	31

outcomes in Table 2.

NICU Outcome

Table 1B lists the NICU outcome which represents the patient status at NICU discharge.

2-year Neurocognitive Outcome

Table 1C lists characteristics of 2-year neurocognitive outcomes. Outcome is defined as normal versus adverse, according to clinical criteria and NRN recommendations [6, 7]. An adverse outcome is defined if the Bayley (version III) cognitive score<85 in any of the Bayley-III domains, GMFCS level between 2 to 5, or blindness/hearing impairment. Otherwise, the patient had normal outcomes. Table 1C lists characteristics of Bayle version III scores (BSID-III scores).

Data structure and file formats

The data is organized in the format shown in Figure 2. BONBID-HIE II provides, per patient: (i) 1ADC_ss: skull stripped ADC map; (ii) 2Z_ADC: Z_{ADC} map; (iii) 3LABEL: expert lesion annotations; and (iv) clinical data: clinical variables as written in Table 1A. (v) NICU outcome: status when discharged at NICU. (vi): 2-year outcome: The 2-year neurocognitive outcome. Note that patients who were deceased before the 2-year appointment are marked as having an adverse outcome.

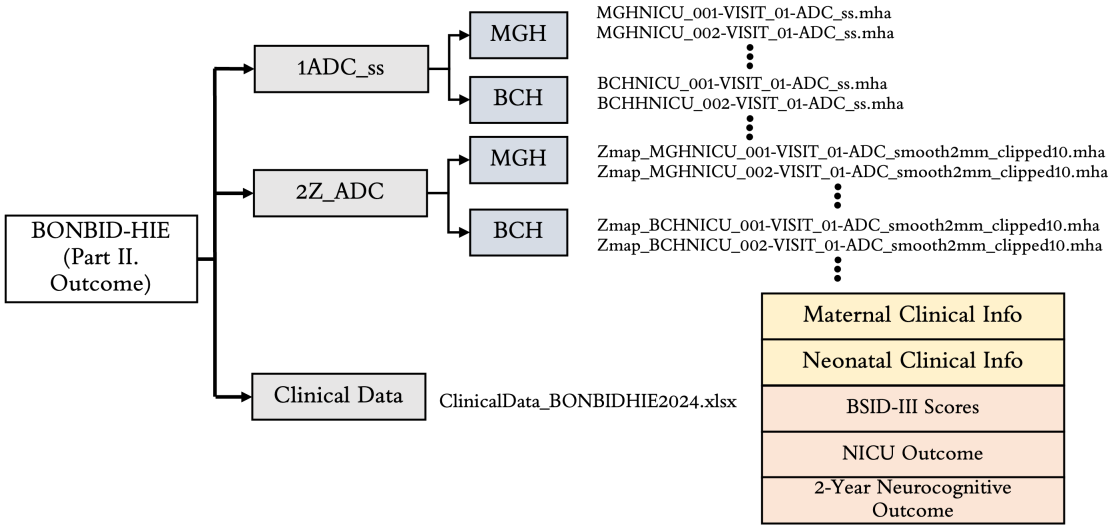

Figure 2. Folder structure of the BONBID-HIE dataset (Part II. NICU outcome and 2-year outcome).

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Competing interests

None.

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