



# Correlation of Neurodevelopmental Outcome and brain MRI/EEG findings in term HIE infants

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# Disclosure Statements



Park MS, Cho HC, and Lee JH

have no relevant financial relationships to disclose or  
conflicts of interest to we solve.

# Introduction



- Perinatal brain injury: Hypoxic-ischemia (most common), Hemorrhage, Infection, Metabolic disorder,...

*Volpe JJ, Ment Retard Dev Disabil Res Rev, 2001; 7(1): 56-64*

- Hypoxic ischemic encephalopathy (HIE)
  - Incidence: 2.5 per 1,000 live births in developed countries (up to 10-folds greater in developing countries)
  - 25% or more with permanent neurologic deficits (Cerebral palsy, Mental retardation, Learning disability, Epilepsy)
  - Mortality: 15% to 20% of affected neonates during newborn period

*Cotten CM, Expert Rev Obstet Gynecol, 2010; 5(2): 227-239*

*Volpe JJ, Neurology of the Newborn 5th, Elsevier, 2008*

*Vannucci RC, Pediatrics, 1990; 85(6): 961-8*

# Introduction



- Correlation of EEG, CT, and MRI Brain with Neurological Outcome at 12 Months in Term Newborns with Hypoxic Ischemic Encephalopathy

*Jose A, J Clin Neonatol, 2013; 2(3): 125-30*

- Prediction of neurodevelopmental outcome in term neonates with hypoxic-ischemic encephalopathy.

*Polat M, Eur J Paediatr Neurol, 2013; 17(3): 288-93*

- Multimodal predictor of neurodevelopmental outcome in newborns with hypoxic-ischaemic encephalopathy .

*Temko A, Comput Biol Med 2015; 1(63):169-77*

# Aim of the study



- To estimate neurodevelopmental outcome of term infants with HIE at the age 1 year.
- To determine the usefulness of Brain MRI and EEG to predict neurodevelopmental outcome in term HIE newborns.

# Methods



- Retrospective study through medical record review
- Study population
  - 42 HIE newborn infants who were admitted in Ajou University Hospital NICU between January 2009 and June 2013

# Methods



- Inclusion criteria

- $\geq 37$  weeks of GA
- Evidences of fetal distress (needed initial resuscitation more than mask bagging)
- Modified Sarnat & Sarnat stage II~III
- Available to assess neurodevelopmental outcomes at 12 months

- Exclusion criteria

- $< 37$  weeks of GA
- Newborns with major congenital anomaly, chromosomal abnormality, inborn error of metabolism



# Methods



- Brain MRI and EEG recording
  - Performed between 7 to 14 days after birth
- Developmental outcome assessment
  - Performed at 12 to 15 months after birth
  - Denver Developmental Screening Test II & Bayley test



# Methods



- Statistics
  - IBM SPSS 22.0 software
  - Continuous variables: Student-T test
  - Categorical variables: chi-square test and Fisher`s exact test
  - Multivariate logistic regression analysis
  - $p < 0.05$ : statistically significant

# Methods



## Categorization of Brain MRI findings

MRI Findings	
Normal	No pathologies related HIE
Mild	Abnormal signal in basal ganglia or thalamus only
Moderate	Abnormal signal in cerebral cortex and parasagittal watershed area
Severe	Abnormal signal in entire cerebral cortex and basal ganglia, thalamus and brainstem

*Barkovich AJ, AJNR Am J Neuroradiol, 1998; 19(1): 143-9*  
*Polat M, Eur J Paediatr Neurol, 2013; 17(3): 288-93*

# Methods



## Categorization of EEG findings

EEG Findings	
Normal	Continuous activity with physiological EEG, appropriate synchrony for conceptional age
Mild	Isolated temporal spikes, preserved sleep state modulation, but excessive sharp wave activity
Moderate	Predominant asymmetry and asynchrony for post-conceptional age, excessive discontinuity
Severe	Inactive or permanent discontinuous activity plus theta activity, burst-suppression pattern, persistent marked voltage suppression

*Selton D, Neuropediatrics, 1997; 28(5): 276-80*

*Laroia N, Epilepsia, 1998; 39(5): 545-51*

*Holmes GL, J Clin Neurophysiol, 1993; 10(3): 323-52*



# Results



## Perinatal characteristics of HIE infants

Gestational age (weeks, Mean $\pm$ SD)		38 <sup>+3</sup> $\pm$ 1 <sup>+2</sup>
Birth weight (g, Mean $\pm$ SD)		3165 $\pm$ 472
Male infants, N (%)		24 (57.14%)
Cesarean section, N (%)		28 (66.66%)
1-min Apgar score (Mean $\pm$ SD)		5.4 $\pm$ 2.4
5-min Apgar score (Mean $\pm$ SD)		7.1 $\pm$ 2.0
ABGA	pH (Mean $\pm$ SD)	7.29 $\pm$ 0.2
	Base deficit (mmol/L, Mean $\pm$ SD)	8.8 $\pm$ 8.4
Perinatal risk factors	Meconium stained, N (%)	5 (11.90%)
	Rupture of membrane, N (%)	2 (4.76%)
	Fetal distress, N (%)	13 (30.95%)
	Placenta previa/abruption, N (%)	0 (0%)
	Abnormal presentation, N (%)	6 (14.29%)
	Prolonged labor, N (%)	4 (9.52%)
	Intrauterine infection, N (%)	1 (2.38%)
	Intrauterine growth retardation, N (%)	0 (0%)
	Multiple histories, N (%)	1 (2.38%)

# Results



## Neurodevelopmental outcomes vs. Perinatal factors

	Favorable (n=24, 57.1%)	Unfavorable (n=18, 42.9%)	p-value
Gestational age (weeks, Mean $\pm$ SD)	39 <sup>+2</sup> $\pm$ 2 <sup>+2</sup>	39 <sup>+3</sup> $\pm$ 1 <sup>+2</sup>	0.461
Birth weight (g, Mean $\pm$ SD)	3192 $\pm$ 483	3129 $\pm$ 467	0.675
Male infants, N (%)	15 (62.5%)	9 (50%)	0.533
Cesarean section, N (%)	16 (66.7%)	12 (66.7%)	1.000
<b>1-min Apgar score (Mean <math>\pm</math> SD)</b>	6.1 $\pm$ 2.2	4.5 $\pm$ 2.4	<b>0.029 *</b>
<b>5-min Apgar score (Mean <math>\pm</math> SD)</b>	7.8 $\pm$ 1.5	6.2 $\pm$ 2.2	<b>0.010 *</b>
Initial ABGA			
pH (Mean $\pm$ SD)	7.32 $\pm$ 0.17	7.24 $\pm$ 0.22	0.171
<b>Base deficit (mmol/L, Mean <math>\pm</math> SD)</b>	6.4 $\pm$ 6.8	12.1 $\pm$ 8.4	<b>0.029 *</b>
pH < 7.27, N (%)	7 (29.2%)	9 (29.2%)	0.210
Base deficit $\geq$ 10 mmol/L, N (%)	5 (20.8%)	9 (50.0%)	0.096
Perinatal risk factors			
Meconium stained, N (%)	2 (8.3%)	3 (7.1%)	0.636
Fetal distress, N (%)	8 (33.3%)	5 (27.8%)	0.748
Abnormal presentation, N (%)	5 (11.9%)	1 (2.4%)	0.214
Neonatal seizure, N (%)	21 (87.5%)	16 (43.2%)	1.000

# Results



## Neurodevelopmental outcomes vs. MRI/EEG findings

		Favorable (n=24)	Unfavorable (n=18)	p-value
<b>MRI findings (n=42)</b>	Normal, N (%)	11 (45.8%)	2 (11.1%)	< 0.001 **
	Mild, N (%)	6 (25.0%)	0 (0%)	
	Moderate, N (%)	7 (29.2%)	6 (33.3%)	
	Severe, N (%)	0 (0%)	10 (55.6%)	

		Favorable (n=24)	Unfavorable (n=18)	p-value
<b>EEG Findings (n=42)</b>	Normal, N (%)	5 (20.8%)	2 (11.1%)	< 0.002 **
	Mild, N (%)	15 (62.5%)	2 (11.1%)	
	Moderate, N (%)	3 (12.5%)	5 (27.8%)	
	Severe, N (%)	1 (4.2%)	9 (50%)	

# Results



## Multivariate logistic regression analysis

	Adjusted Odds ratio	p-value	95% confidence interval
1-min Apgar score	1.97	0.154	0.78 - 4.99
5-min Apgar score	0.36	0.102	0.10- 1.23
Base deficit	0.98	0.755	0.84 - 1.14
<b>MRI findings</b>	<b>9.17</b>	<b>0.042 *</b>	<b>1.08 - 77.55</b>
EEG Findings	7.01	0.075	0.82 - 59.99



# Results



## Neurodevelopmental outcomes vs. Grouped MR findings

	Favorable (n=24)	Unfavorable (n=18)	p-value
Normal to Mild findings of MRI, N (%)	17 (70.8%)	2 (11.1%)	<0.001 **
Moderate to Severe findings of MRI, N (%)	7 (29.2%)	16 (88.9%)	

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
MRI	88.89	70.83	69.57	89.47	78.57

# Results



## Neurodevelopmental outcomes vs. Grouped EEG findings

	Favorable (n=24)	Unfavorable (n=18)	p-value
Normal to Mild findings of EEG, N (%)	20 (83.3%)	4 (22.2%)	<0.001 **
Moderate to Severe findings of EEG, N (%)	4 (16.7%)	14 (77.8%)	

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
EEG	77.77	83.33	77.77	83.33	80.95

# Results



## Neurodevelopmental outcomes vs. Grouped MRI/EEG findings

	Favorable (n=21)	Unfavorable (n=14)	p-value
Normal to Mild in both MRI & EEG, N (%)	17 (81.0%)	1 (7.1%)	<0.001 **
Mod. to Severe in both MRI & EEG, N (%)	4 (19.0%)	13 (92.9%)	

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
MRI + EEG	92.86	80.96	76.47	94.44	85.71

# Summary



- Out of 42 HIE infants, 16(38.1%) infants showed significant delay at 12-15 months after birth, and 2(4.8%) died in newborn periods.
- Utilizing the grading method of initial brain MRI and EEG finding appears to have significant relationships with neurodevelopmental outcomes of HIE infant at 12-15 months of age.
- According to the multivariate analysis, initial brain MRI finding was the only significant risk factors(OR, 11.24%; 95% CI, 1.36- 92.89;  $p=0.025$ ).
- The sensitivity and specificity for MRI and EEG were 88.9/70.8 and 77.8/83.3 respectively whereas combining both methods showed 92.9/81.0.

# Speculation



- Initial brain MRI combined with EEG in NICU is expected to predict neurodevelopmental outcome at 12-15 months of age in HIE.
- Limitation
  - Retrospective study
  - Relatively short follow-up period



**Thank you**



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