

– Abstract –

Estimation of Normal BAEPs Latencies from Infancy to Early Childhood Using Meta-Analysis

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Objectives : The brainstem auditory evoked potentials (BAEPs) are an useful method to evaluate functions from the auditory nerve to the brainstem but there are many different test methods amongst different labs that make it difficult to compare the results.

Since there are many differences associated with different test method and other reference values for the evaluation of children from the period of infancy (1~12 months) to early childhood (1 year~6 years), there is a need to establish a standardized test method with normal references. We initiated this study to overcome these difficulties.

Methods : We searched through 25 sources, which had been previously published from 1974 to 1997, concerning the brainstem auditory evoked potentials in normal children from infants to early childhood. The search provided a common test method using all 25 sources and obtained a normal reference value of peak latencies and interpeak latencies through the meta-analysis technique by researching 7 sources stated normal reference values.

Results : After meta-analysis from 7 sources, we found normal peak latencies and interpeak latencies of a standard 70 dB stimulation intensity, 10 Hz stimulation frequency and monoaural mode.

The most common test method used active electrodes with a silver/silverchloride surface (70.6%) which was applied to the mastoid process (50%). The site for the reference electrode was the vertex (59%) and the site for the ground electrode was the contralateral mastoid process (38%) or upper forehead (29%). The interelectrode impedance was less than 5000 (80%), the bandpass of filter was 100 Hz (40%)~3000 Hz (55%), the stimulation frequency was 10 Hz (71%) and the stimulation intensity was 70 dB (33%).

The total stimulation number was found to be more than 1024 and the most common stimulation mode was the monoaural mode (85%). Each test was conducted more than twice on the same ear.

Conclusion : Since there are many labs that have not established a normal reference value and a stan-

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standardized method compared with labs in adults, the normal peak latencies and interpeak latencies suggested through meta-analysis and a common test method, may be used as a valuable reference for many labs.

Key Words : Meta-analysis, Normal latency, Infancy, Early childhood, Brainstem auditory evoked potentials

(Kim, 1994)¹⁵

I	V		25	가
Jewett ²		Sohmer (1970) ¹		
Lev (1972) ⁴		10 msec		
		5~7		
Buchwald (1975) ⁵	Stockard (1977) ⁶	I	1.	
		II	1974	1997
		III		
가),		IV	(25
		가),	V	4
		VI	VII	
			3,17,31,33	21
				(Table 1).
				(Pub Med)
				“brain-stem auditory evoked potentials or auditory brainstem response”
				“early children or infant”
				“normative data or normative reference”
Starr (1975) ⁸ ,	Gilroy (1977) ⁹	Stockard (1977) ¹⁰		2
		Jewett(1972) ¹¹		
가		(, latency)가		
		Lieberman (1972) ¹²		2
		가		25
		, Salamy		가
(1976) ¹³				가
				25
				(6), (10
				Hz), (70 dB) 가 7 (
				1 ¹⁷ 6 ¹⁸⁻²³) .2 ^{3,18}
				가 13~15 Hz , 3 ¹⁸⁻²⁰ 가 75~85 dB
				10 Hz, 70 dB
				7 1022
				가 가

Table 1. Demographic Characteristics of Subjects Including Studies

No. of study	Author	Year of publication	Reference number	No. of subjects	Age
1	Pierrri F.	1988	28	171(M:94, F:77)	2 day~2 y
2	Jiang ZD.	1990	29	178	1 mo~6 y
3	Michael P.	1989	26	535	3 mo~3 y
4	Michael B.	1985	21	59(M:25, F:34)	3 day~18 m
5	Salamy A.	1984	118	600	1 day~4 y
6	Jacques T.	1989	30	196	4 y~14 y
7	Robert C.	1987	15	48	4 y~13 y
8	John M.	1977	27	25	17 y~33 y
9	Jiang ZD.	1990	21	80	1 day~6 y
10	Marilyn C.	1987	25	22	1 day~26 wk
11	Barbara M.	1977	21	81	6 wk~15 y
12	Christian	1996	16	72	2y~13 y
13		1992	41	52	2 wk~6 mo
14		1987	61	243(M:122, F:121)	1 y~15 y
15		1986	49	137(M:70, F:67)	1 day~1 y
16		1983	33	60(M:27, F:23)	9 y~62 y
17	Kurt	1974	17	25	1 day~3 y
18	Salamy A.	1976	20	158	1 day~18 mo
19	Gafni M.	1980	28	26	1 day~3 mo
20	Tand OP.	1990	17	69	3 y~13 y
21	Adelma C.	1990	13	125	1 day~5 mo
22	Lucao B.	1992	15	89	1 day~52 mo

2.

1)

2

Jacobson²⁴ 15 Hz Kim (1994)¹⁵

V 0.006 ms/Hz 7 가

I III 가

V 가

0.002 ms/Hz 0.004 ms/Hz 75~85 dB 3 1991 Jiang

25 V $\mu = \frac{n_i \cdot \bar{i}}{n_i}$

V I $\hat{\sigma}^2 = \frac{(n_i - 1)S_i^2}{(n_i - 1)}$

0.005 ms/dB III 가 V 0.001 ms/dB 0.003 ms/dB 70 dB

u_{is}, n_{is}, s_i

2)

가 3 가

(Table 3),

Delisa(1994)가 (: 15 ~51) (Fig. 1, 2).

$$\mu = \frac{1}{0.9973} \sum_i n_i \int_{u_i-3}^{u_i+3} f(x) dx$$

2.

$$\sigma^2 = \frac{1}{0.9973} \sum_i (n_i-1) \int_{u_i-3}^{u_i+3} (x-u)^2 f(x) dx$$

1)

가 22 , 5
가 11 (50%) 가 ,
가 4 , 가 1 .
13 (59%) , 가 3 .
21 가 6 가 1
가 8 (38%),

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

3)

2)

sil-
ver/silverchloride 17 12 (70.58%)
가 gold cup grass gold disc
, clip 1 .

3)

10 5000
가 8 (80%) 가 , 3000
가 2 .

1.

6y)

(1m ~

4) Filter

Low filter 50~300 Hz High fil-
ter 1500~5000 Hz .

5)

15 10 Hz(71%) , 2 15 Hz ,

Hz

± (: msec)

(Table 2).

Table 2. Estimated Means and Standard Deviations of Peak Latencies and Interpeak Latencies in Infants and Early Childhood According to the Age(unit: msec)

	I PL	III PL	V PL	I-III IPL	III-V IPL	I-V IPL
1 mo Age<2 mo	1.715±0.233	4.401±0.320	6.473±0.303	2.677±0.279	2.070±0.426	4.725±0.361
3 mo Age<6 mo	1.590±0.195	4.265±0.299	6.311±0.302	2.575±0.242	2.110±0.318	4.693±0.301
6 mo Age<9 mo	1.586±0.170	4.092±0.278	6.168±0.260	2.451±0.227	2.089±0.209	4.550±0.261
9 mo Age<1 y	1.589±0.178	4.090±0.303	5.956±0.281	2.361±0.234	2.017±0.210	4.378±0.288
1 y Age<2 y	1.566±0.147	3.861±0.133	5.839±0.252	2.282±0.170	2.008±0.192	4.283±0.233
2 y Age<3 y	1.560±0.161	3.823±0.187	5.700±0.256	2.207±0.168	1.930±0.179	4.140±0.227
3 y Age<6 y	1.620±0.171	3.724±0.215	5.636±0.244	2.042±0.092	1.862±0.163	3.913±0.180

PL: peak latency

IPL: interpeak latency

Table 3. Estimated Reference Values(Mean+2SD) of Peak Latencies and Interpeak Latencies in Normal Infants and Early Childhood According to the Age(unit: msec)

	I PL	III PL	V PL	I-III IPL	III-V IPL	I-V IPL
1 m Age<2 m	2.181	5.041	7.079	3.235	2.922	5.447
3 m Age<6 m	1.980	4.863	6.915	3.059	2.746	5.295
6 m Age<9 m	1.926	4.648	6.688	2.905	2.507	5.072
9 m Age<1 y	1.945	4.696	6.518	2.829	2.437	4.954
1 y Age<2 y	1.860	4.127	6.343	2.622	2.392	4.749
2 y Age<3 y	1.882	4.197	6.212	2.543	2.288	4.594
3 y Age<6 y	1.962	4.154	6.124	2.226	2.188	4.273

PL: peak latency
IPL: interpeak latency
m: month

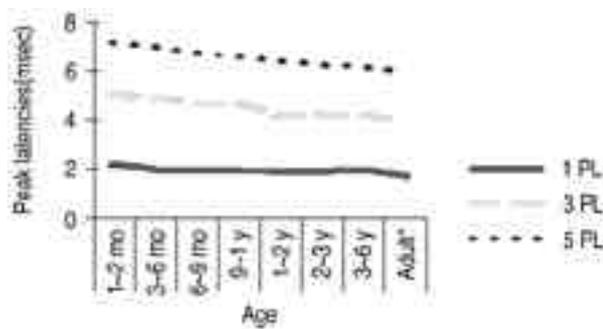


Fig. 1. Change of estimated normal reference value(Mean±2 SD) of each peak latency of brainstem auditory evoked potentials in infancy and early childhood.

* Adult value(Delisa JA: Manual of nerve conduction velocity and clinical neurophysiology, 3rd ed, Raven press, 1994:297).

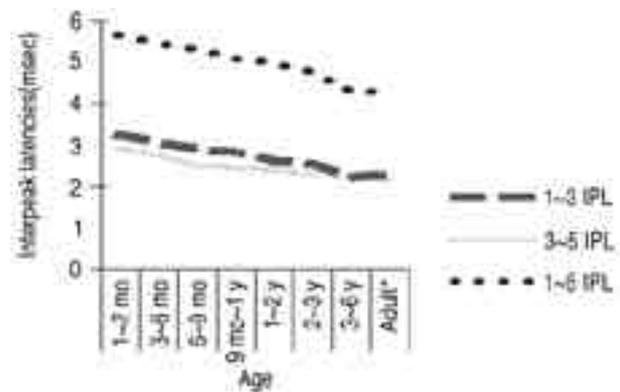


Fig. 2. Change of estimated normal reference value(Mean±2 SD) of interpeak latencies about brainstem auditory evoked potentials in infants and early childhood.

* Adult value(Delisa JA: Manual of nerve conduction velocity and clinical neurophysiology, 3rd ed, Raven press, 1994:297).

(13 Hz, 22 Hz, 33 Hz).

6) 10 (33%) 70 dB , 7
(24%) 60 dB , 5 90 dB, 4
80 dB

7) 21
1024 가 8 , 2000 가 6 , 2048 가 3 1024
2048 2 , 2400
1000 가 1

8) Stimulation polarity
Stimulation polarity 11
rarefaction click

9) (Pulse duration)
14 13 (92.85%) 100 μs , 1
60 μs

10) Stimulation mode
20 17 (85%) monoaural stim-
ulation 3 binaural stimulation

11) 21 17 (80.95%) earphone , 4
headphone

12)

Table 4. Electrode Setting Differences Among Collected Archives

No. of study	Electrode type	Site of active electrode	Site of reference electrode	Site of ground electrode	Interelectrode impedance()
1	silver chloride surface	upper forehead	mastoid	contralateral mastoid	<5000
2	silver disc surface	earlobe	midforehead	earlobe	<5000
3	silverchloride	mastoid	vertex	forehead	<3000
4	-	earlobe	vertex	nose	-
5	-	mastoid	Cz	-	-
6	surface	mastoid	vertex	forehead	-
7	surface	mastoid	vertex	earlobe	-
8	-	Cz	mastoid	FPz	-
9	silver disc	mastoid	vertex	mastoid	-
10	silver disc	earlobe	midforehead	earlobe	<5000
11	silver disc	mastoid	forehead	mastoid	<5000
12	gold cup	mastoid	vertex	mastoid	<5000
13	silver surface	mastoid	vertex	mastoid	<5000
14	-	mastoid	vertex	mastoid	-
15	surface	mastoid	Cz	Fz	-
16	surface	Cz	earlobe	forehead	-
17	-	-	-	-	<3000
18	disc	vertex	mastoid	mastoid	-
19	grass gold disc	Cz	A1	A2	-
20	disc	earlobe	vertex	earlobe	-
21	silver disc	Cz	earlobe	forehead	<5000
22	clip	earlobe	vertex	earlobe	-
23	-	mastoid	vertex	mastoid	<5000

13)

myogenic potential

chloral hydrate 12 6 (50%)
 chloral hydrate 10% (45~70 mg/kg) 4
 thazine 1 valium prome- 가

14) Masking noise

masking 8 , 가
 dB 4 40
 20 dB 2 (50%), 30 dB 가 1

Table 5. Characteristics of Filtering and Stimulation Method Among Collected Archives

No. of study	Filter(Hz)	Clicks	Click mode	Pulse(μsec)	Mono/Binaural
1	200-2000	2048	rarefaction	100	—*
2	100-2000	1024	rarefaction	100	monoaural
3	100-3000	1024	rarefaction	100	monoaural
4	320-5000	1024/2048	—	60	momoaural
5	—	2000	—	—	biaural
6	75-3000	2000	rarefaction	100	monoaural
7	100-3000	1024	rarefaction	100	monoaural
8	—	—	rarefaction	—	monoaural
9	75-3000	2000	rarefaction	100	monoaural
10	100-3000	1024	—	—	—
11	100-2000	1024	rarefaction	100	monoaural
12	150-1500	1024	rarefaction	100	—
13	100-3000	1024/2048	—	—	monoaural
14	300-3000	—	—	—	—
15	150-3000	2000	rarefaction	100	monoaural
16	—	—	—	100	—
17	100-2500	2000	—	—	monoaural
18	100-3000	2048	—	—	biaural
19	—	2000	—	100	monoaural
20	80-3000	—	—	—	monoaural
21	—	2400	—	—	biaural
22	250-5000	1024	—	—	monoaural
23	150-3000	2048	rarefaction	100	monoaural
24	200-2000	1024	—	—	monoaural
25	50-2500	1000	—	100	monoaural

*: Not presented

Table 6. The Order of Frequency in the Use of a Examination Method in Collected Archives.

Electrode					
Composition	silver/silverchloride(71%), gold cup(6%)				가
Aactive electrode	mastoid(50%), earlobe(23%), vertex(18%)		가	가	가
Reference electrode	vertex(59%), mastoid(14%), earlobe(14%)		가		
Ground electrode	mastoid(38%), earlobe(29%), forehead(29%)				
Electrode resistance	< 5000 (80%)				
Filter	100 Hz(40%) - 3000 Hz(55%)				
Stimulation frequency	10 Hz(71%), 15 Hz(9%)				
Stimulation intensity	70 dB(33%), 60 dB(24%), 90 dB(20%)				
Stimulation mode	monoaural(85%), biaural(15%)				가

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