Chulalongkorn Medical Journal

Volume 45
Issue 5 *May 2001*

Article 4

5-1-2001

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Chula Med J Vol. 45 No. 5 May 2001

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Luangpitakchumpon P, Isipradit P, Asawavichianginda S, Luangpitakchumpon P. A study of auditory brainstem response in adult with normal hearing. Chula Med J 2001 May; 45(5): 403 - 11

Objective : *To find the normal values of auditory brainstem response in Thai adult with normal hearing.*

Design : *Prospective*

Setting : *Otoneurologic Clinic, Department of Otolaryngology, Faculty of Medicine, Chulalongkorn University.*

Subjects : *165 adults with normal hearing and an age range of 15 - 50 years were recruited in the two years period (from 1998 to 1999) study at King Chulalongkorn Memorial Hospital. The hearing threshold in both ears should be less than 25 dBHL at all test frequencies.*

Methods : *The auditory brainstem response was studied in 165 adults with normal hearing. The stimuli were click signals at a level of 90 dBHL, which are presented to the ears separately via an air conduction transducer (TDH – 49 Headphone). Responses were detected by electrodes, processed by a computer to waveform measurements, and manipulated by the operator.*

Main outcome measure : *The absolute latencies of waves I, III and V, the interwave latencies of wave I-III, III-V and I-V and the interaural absolute wave V latency difference are measured.*

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Results : *The means (± SD) of the absolute latency of the waves I, III and V in male patients were 1.55 ±.19, 3.73 ±.19 and 5.65 ±.21 msec in the right ear, these were 1.55 ±.16, 3.75 ±.20 and 5.63 ±.20 msec in the left ear respectively. In females, they were 1.51 ±.15, 3.68 ±.21 and 5.53 ±.24 msec in the right ear, and 1.50 ±.12, 3.68 ±.18 and 5.52 ±.17 msec in the left ear respectively. The means (± SD) of the interwave latency of the waves I – III, III – V and I – V in male patients were 2.18 ± .21, 1.90 ± .23, and 4.10 ±.34 in the right ear; and 2.20 ± .23, 1.88 ± .22 and 4.08 ±.31 msec in the left ear msec respectively. In female, they were 2.16 ±.21, 1.86 ±.24 and 4.02 ±.31 msec in the right ear; and 2.18 ±.23, 1.84 ±.25 and 4.02 ±.29 msec in the left ear respectively. The mean of the interaural absolute wave V latency difference was 0.03 ±.23 msec in male patients and 0.04 ±.24 msec in the female. And in both sexes, the AWL of wave I,III, and V were 1.53 ± .18, 3.71 ± .20 and 5.61 ± .21 msec, the difference of wave I-III, III-V and I-V were 2.18 ±.22, 1.88 ±.23 and 4.07 ±.30 msec and the wave V ILD was 0.06 ±.27msec.*

Conclusion : *Less than 10 % of measurements in adults with normal hearing could not detect wave I and wave III, but all of them had wave V. These values for ABR will form the baseline for our clinic, and will be highly useful for the differential diagnosis of patients who show abberrart ABR results. Lower brainstem and higher brainstem lesions should be able to be observed and referred for further investigation. ABR should be recommended in cases whom difficult to test via behavioral methods (audiogram).*

Key words : *Auditory brainstem response, Audiometry, Ear, Hearing.*

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Received for publication. January 20, 2001.

ปริญญา หลวงพิทักษ์ชุมพล, เพิ่มทรัพย์ อิสีประดิฐ, เสาวรส อัศววิเชียรจินดา, พัชดา หลวงพิทักษ์ชุมพล. การศึกษาค่า auditory brainstem response ในคนปกติ. จุฬาลงกรณ์-เวชสาร 2544 พ.ค; 45(5): 403 - 11

วัตถุประสงค์ : *เพื่อศึกษาค่าปกติของการทดสอบ auditory brainstem response ในผู้ใหญ่ที่มีการได้ยินปกติ*

รูปแบบการวิจัย : *ศึกษาไปข้างหน้า*

สถานที่ : *คลินิกโสตประสาทวิทยา ภาควิชาโสต นาสิก ลาริงซ์วิทยา คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย*

ผู้เข้าร่วมศึกษา : *ทำการศึกษาในผู้ใหญ่จำนวน 165 คน ที่มีการได้ยินปกติทั้ง 2 ข้าง อายุระหว่าง 15 - 50 ปี โดยมีระดับการได้ยินน้อยกว่า 25 dB ในทุกความถี่ที่ทำการทดสอบ และใช้เวลาในการทดสอบ และเก็บข้อมูล 2 ปี (พ.ศ. 2541 ถึง 2542)*

วิธีการ : *ทดสอบหาค่า auditory brainstem response โดยกระตุ้นด้วยเสียง click ที่ระดับความดัง 90 dBnHL ในหูทั้ง 2 ข้าง บันทึกผลและพิมพ์ผลออกมาด้วยเครื่องคอมพิวเตอร์เป็นลักษณะคลื่น และค่าระยะเวลาของการเกิดคลื่นจริง*

การวัดผล : *วัดค่า latency ของ wave I ถึง V วัดค่า latency ระหว่าง wave I กับ III,III กับ V และ I กับ V รวมทั้งวัดค่าแตกต่างของระยะเวลาการเกิดคลื่นจริงของ wave V ระหว่างหู ทั้ง 2 ข้าง*

ผลของการศึกษา : *จากการศึกษาค่าระยะเวลาของการเกิด wave I, wave III และ wave V ในหูข้างขวาของผู้ชายคือ 1.55±.19, 3.73±.19, 5.65±.21 msec และในหูข้างซ้ายคือ 1.55 ±.16, 3.75±.20, 5.63±.20 msec สำหรับผู้หญิงในหูข้างขวามีค่าดังนี้ 1.51±.15,3.68 ±.21, 5.53±.24 msec และในหูข้างซ้ายมีค่า 1.50±.12, 3.68±.18, 5.52±.17 msec ตามลำดับ ผลการศึกษาค่าระยะเวลาระหว่าง wave I-III, wave III-V และ wave I-V ในหูข้างขวาของผู้ชายพบระยะห่างเป็นดังนี้ 2.18±.21, 1.90±.23, 4.10±.34 msec ในหูข้างซ้ายพบระยะห่างเป็นดังนี้ 2.20±.23, 1.88±.22, 4.08±.31 msec ในผู้หญิงหูข้างขวาพบระยะห่างเป็นดังนี้ 2.16±.21, 1.86±.24, 4.02±.31 msec ในหูข้างซ้ายพบว่าระยะห่างดังนี้ 2.18±.23, 1.84±.25, 4.02±.29 msec และการศึกษาความต่างกันของระยะเวลาการเกิด wave V ระหว่างในหูข้างขวาและหูข้างซ้ายพบว่า ในหูผู้ชายมี*

ความต่างกัน ของ wave V คือ 0.03 ± 0.23 msec และในผู้หญิงมีความต่างกันของ wave V คือ 0.04 ± 0.24 msec ผลการศึกษาโดยรวมทั้งสองเพศพบว่าค่าระยะเวลาการเกิด wave I, wave III และ wave V คือ 1.53 ± .18, 3.71±.20 และ 5.61 ±.21 msec ค่าระยะห่างของ wave I -III wave III-V และ wave I-V คือ 2.18 ±.22, 1.88 ± .23 และ 4.07 ± .30 msec ค่าระยะเวลาความแตกต่างของ wave V ระหว่างหูซ้ายและขวา คือ 0.06 ± .27 msec

วิจารณ์และสรุป : จากการศึกษาพบว่าในจำนวนผู้ทดสอบทั้งหมดมีจำนวนน้อยกว่า 10 % ที่ตรวจแล้วไม่พบว่ามีการเกิด wave I และ wave III แต่พบว่าเกิด wave V ทุกรายทั้งเพศชายและหญิง ค่าต่าง ๆ เป็นค่าปกติเฉพาะของเครื่องตรวจ ABR เครื่องนี้ของคลินิก และจะเป็นค่าอ้างอิง สามารถนำไปเปรียบเทียบกับผู้ป่วยที่มารับการตรวจจากคลินิก ซึ่งจะพบได้ทั้งเหมือนและแตกต่างไปจากค่าปกติที่ตรวจได้ในครั้งนี้ หากพบว่าค่า ABR ที่ตรวจได้ในผู้ป่วยรายใดมีความแตกต่างไปจากนี้ ควรตั้งข้อสังเกตว่าน่าจะมีความผิดปกติของ lower brainstem หรือ higher brainstem ควรจะมีการตรวจวินิจฉัยด้วยเครื่องมือชนิดอื่นอีกต่อไป และค่าปกติที่ได้จากการศึกษาในครั้งนี้สามารถนำไปเปรียบเทียบเพื่อการประเมินหาระดับการได้ยินในผู้ป่วยที่ไม่ร่วมมือในการตรวจแบบ subjective test ได้

The brainstem evoked response (BSER) or auditory brainstem response (ABR) is an electro-encephalogram based test technique. It may be defined as any procedure which derives an average electrical response to auditory stimuli. The auditory signal, characterized by a fast response time, is time-locked to an averaging computer. The result is a brainwave characterized by seven waves (or peaks),[1] which are believed to originate from various brainstem locations. The first wave, wave I, is believed to be a remote recording of the whole - nerve action potential from the closest portion of auditory nerve. Wave II is believed to be the response of the more distant portion of the auditory nerve. One millisecond later the electrical activity has traveled to the next center in the brainstem, the cochlear nucleus (pons), and produces the response recorded as wave II. Wave III represents the activity of the superior olivary complex (pons). Wave IV represent the response of the lateral lemniscus (pons). Wave V is believed to be the response of inferior colliculus (midbrain). Wave VI and wave VII represents the response of the later brainstem structures, the median geniculate (thalamus) and auditory radiations (thalamo-cortical) pathway. ABR is thus a far field recording of neuroelectric activity of CN VIII and the brainstem auditory pathway.[2-3] Occuring within 1.4-8.00 msec after stimulus.[4-5] The time and amplitude of these waveforms supply information on peripheral hearing status and the intregrity of the brainstem pathway.

ABR has two primary clinical applications, I) an objective evaluation of hearing in patients who are unable to provide an accurate response by behavioral testing and II) a powerful measure of neural activity in the auditory brainstem. ABR testing has an important role in audiological assessment especially for those who cannot successfully be tested using the conventional methods. The ABR supplies a valuable information on the hearing status and the auditory pathway. However reference ABR values in Thai people are limited available, the purpose of this study is to established the normal ABR values for adult Thai people with normal hearing.

Methodology

Subjects were tested in a sound proof room, in which ambient noise is less than 40 dB, and was electrically shielded to prevent electrical artifacts, which may interfere with clear recording. Electrodes were placed on the skin which is properly cleansed and bathed with conductive electrode paste. Four electrodes are located on the vertex, over both mastoid area and at the forehead as a ground electrode. The electrodes are securely fixed with paste or tape and the electrode impedance is measured to determine the impedance between any two electrode sites. Low and/or equal impedance between electrodes is required and should be less than 4,000 ohms for all electrodes. A headphone (TDH – 49) applied the test ear. The patients are lying quietly and were asked to be relaxed to avoid muscle interference during recording. They were placed in a comfortable supine position, and were a sleep during testing. Sedation, such as chloral hydrate, was critical with subjects who had difficulty sleeping. Click stimuli (27.7 sec) at a level of 90 dBnHL is used to stimulate the hearing pathway. The computer recorded neural activity in a series of successive time units after the occurrence of the stimulus. It collects the incoming electrical responses, and processes the data to form the

averaged brainstem waveform presenting in the monitor. The operator has to identify and label the waves from I to VII. The readings were transferred to disc for storage and could be printed for future analysis. Absolute wave latency (AWL), interwave latency (IWL) and interaural latency difference (ILD) were studied . AWL is the time interval from the onset of the stimulus to the peak of the waveform. In this study, we collected the AWL of wave I, III and V. IWL is the latency between the two wave ie.: wave I - III, wave III -V and wave I - V. ILD is the different between AWL of wave V on right and left ear in each subject.

Populations

The subjects in this study were selected by otolaryngologist from the ENT out patient department, KCMH. No ear abnormality was detected in each subject and the determination of hearing sensitivity from the pure tone audiogram was not more than 25 dBHL at all test frequencies (250, 500, 1000, 2000, 4000 and 8000 Hz). 165 adult patients with normal hearing documented by behavioral testing (audiogram) on both ears were recruited. There were 88 men and 77 women with the age ranged between 15 to 50 years (the means of 36.95 $\pm$ 9.03 and 32.22 $\pm$7.83 for men and women respectively).

Results

In the ABR tracing, wave I and III are not consistency found even in the normal hearing ears. Only 93.3 % presenting of wave I and 93.9 % of wave III can be obtained in our series. However wave V is absolutely obtainable, and it is the first wave to look for in ABR threshold testing. (Table 1)

The mean values of AWL of wave I, III and V, IWL of wave I – III, III – V, and I – V and wave V ILD were shown in table 2.

Discussion

We present the results of a study of ABR in adult normal hearing. A total of 330 ears were studied from 88 males and 77 females. Their age range was between 15 - 50 years old. The results are shown in Table 1 to Table 3. Each clinic should obtain normative data for ABR results, because the values from each clinic will differ with each instrument and environment. [6]

In previous years many investigators had studied the normative data of the ABR results in their clinics. These data are showen in the table below. (Table 3)

In our study, three parameters of ABR were studied, I) absolute latency II) interwave latency and

Table 1. The presence of waves I,III and V in 165 Thai normal hearing adults.

Wave	Men (88)		Women (77)		Total
	Rt ear (88)	Lt ear (88)	Rt ear (77)	Lt ear (77)	(330 ears)
I	78 (88.7 %)	88 (100 %)	70 (90.9 %)	72 (93.5 %)	308 (93.3 %)
III	80 (90.9 %)	88 (100 %)	70 (90.9 %)	72 (93.5 %)	310 (93.9 %)
V	88 (100 %)	88 (100 %)	77 (100 %)	77 (100 %)	330 (100 %)

Table 2. The mean of AWL, IWL and wave V ILD in Thai men and women.

Latency (msec)		Men (N = 88) Rt ear	Men (N = 88) Lt ear	Women (N = 77) Rt ear	Women (N = 77) Lt ear	Total (N = 165)
AWL	I	1.55 ± 0.19	1.55 ± 0.16	1.51 ± 0.15	1.50 ± 0.12	1.53 ± 0.18
	III	3.73 ± 0.19	3.75 ± 0.20	3.68 ± 0.21	3.68 ± 0.18	3.71 ± 0.20
	V	5.65 ± 0.21	5.63 ± 0.20	5.53 ± 0.24	5.52 ± 0.17	5.61 ± 0.21
IWL	I – III	2.18 ± 0.21	2.20 ± 0.23	2.16 ± 0.21	2.18 ± 0.23	2.18 ± 0.22
	III – V	1.90 ± 0.23	1.88 ± 0.22	1.86 ± 0.24	1.84 ± 0.25	1.88 ± 0.23
	I – V	4.10 ± 0.34	4.08 ± 0.31	4.02 ± 0.31	4.02 ± 0.29	4.07 ± 0.30
Wave V ILD		0.03 ± 0.23		0.04 ± 0.24		0.06 ± 0.27

Table 3. Normative data in each clinic. [6,7]

Investigators	AWL			IWL		
	I	III	V	I – III	III – V	I – V
Jewett & Williston (1971)	1.5	3.5	5.1	2.0	1.6	3.6
Lev & Sohmer (1972)	1.5	3.5	5.0	2.0	1.5	3.5
Picton et al (1974)	1.5	3.8	5.8	2.3	2.0	4.3
Starr & Achor (1975)	1.6	3.8	5.5	2.2	1.7	3.9
Salany (1976)	1.57	3.64	5.55	2.07	1.99	3.98
Gilroy & Lynn (1978)	1.55	3.60	5.40	2.05	1.90	3.83
Beagley & Sheldrake (1978)	2.1	4.3	6.1	2.2	1.8	4.0
Chiappa et al (1979)	1.7	3.9	5.7	2.1	1.9	4.0
Hodd & Berlin (1986)	1.6	3.7	5.6	2.0	1.8	3.8
This study	1.53 ± .18	3.71 ± .20	5.61 ± .21	2.18 ± .22	1.88 ± .23	4.07 ± .30

III) interaural wave V latency difference. 176 ears were studied in males. We found that in 10 ears (5.68 %) we could not obtain absolute wave I latency and in 8 ears (4.54 %) we could not obtain wave III latency. Wave V was able to be assessed all of them. 154 ears were studied in female. We found that in 15 ears (9.74 %) we could not obtain either absolute wave I and wave III latency, but wave V was also assessable in all of them.

In this study, absolute latency values (wave I, wave III & wave V) were close to the normative data from published investigations. (Table 3). We compared the absolute latency results between the right and the left ears in males and found the results to be similar. (Table 2) These values were also very close to the absolute latency in females (Table 2). When we compared the mean absolute wave V latency in males (5.64 msec, Table 2) to females (5.53 msec,Table 2),

this value was greater, by 0.11 msec. This degree of difference is the same as that found by Jerger and Hall (1980).[8] They reported that generally absolute latency in females is shorter than in males, and they recommended that a gender effect be considered in reporting ABR results.

Normal absolute wave V latencies have been observed in patients with Meniere's disease and hearing losses at 60 dB HL.[9] The prolongation of all waves, with interwave latency differences remaining within normal limits, have been found in cases of conductive hearing loss.[10-12] And the prolongation of wave III or wave V should be found in case of lesions along the VIII nerve pathway. [13,14]

The interwave latency difference is the time period between waves or peaks of the ABR waveform. Hood & Berlin (1986)[6] and Beagley & Sheldrake (1978)[15] stated that the difference values for wave I-III and wave III-V should be approximate 2.0 msec, and wave I-V, about 4.0 msec. Stockard & Rossister (1977)[16] and Chiappa et al (1979)[17] indicated that in normal subjects the wave I-III difference may be slightly longer that than between wave III-V. The interwave latency difference values in our study are shown in Table 2 and Table 3. When these are compared to the other published studies, the difference values in males (Table 2) and in females (Table 2) are close to those of other investigators. (Table 3).

Arnold & Bender (1983),[18] Chiappa et al, [17] Stockard & Ro ssister (1977)[16] and Stockard, Stockard & Sharbrough (1980)[19] have found that prolongation of wave I-III, is suggestive of a lower brainstem lesion and prolongation of wave III-V is associated with higher brainstem lesions.

.Thus for interwave latency differences, wave I-III and wave III-V are abnormal if the latency exceeds 2.4 msec, and whereas wave I-V should not be considered abnormal unless it exceeds 4.4 msec.[6]

With interaural latency difference studies, The difference of absolute wave V latency is measured between the right and left ear. Clemis & Mitchell (1977),[20] and Selters & Brackman (1977)[21] have stated that a difference in wave V latency between both ears of from 0.2 - 0.4 msec is considered to exeed the limits of normal. Selters & Brackman (1977).[21] and Pratt & Sohmer (1976)[22] suggested that when value of latency difference of wave between ears is greater than 0.2 - 0.4 msec, VIII nerve tumors may been present. In our study we found the interaural wave V latency difference in male was 0.03 ± 0.23 msec, and in females was 0.04 ± 0.24 msec; these values are within normal limits.

In conclusion, the study of ABR in normal subjects is very important for each clinic. These values will be the baseline for comparing to other patients who may show different values. At the same time, each clinic must establish its own criteria for the diagnosis of cases of normal, cochlear lesions and retrocochlear lesions results.

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