

## Original Research Article

# Study of brainstem auditory evoked potentials in early (grade I) essential hypertensive patients

Sangeeta Gawali<sup>1</sup>, Garima Suryavanshi<sup>2\*</sup>, Manish Badkur<sup>3</sup>, Gaurav Suryawanshi<sup>4</sup>

<sup>1</sup>Department of Physiology, B. J. Government Medical College, Pune, Maharashtra, India

<sup>2</sup>Department of Physiology, L. N. Medical College, Bhopal, Madhya Pradesh, India

<sup>3</sup>Intensivist, Bansal Hospital, Bhopal, Madhya Pradesh, India

<sup>4</sup>Resident Physiology, All India Institute of Medical Sciences, Raipur, Chhattisgarh, India

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### \*Correspondence:

Dr. Garima Suryavanshi,

E-mail: [dr.garimasuryavanshi@gmail.com](mailto:dr.garimasuryavanshi@gmail.com)

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## ABSTRACT

**Background:** Essential hypertension is one of the most common world's health diseases. It frequently affects central nervous system (CNS) by producing micro-infarctions which results into altered evoked potentials. Previous studies have shown correlation between hypertension and brain stem auditory evoked potentials. But very scarce data is available on all the parameters of BAEP and essential hypertension especially "amplitude ratio" which distinguishes between central and peripheral impairment. This study was undertaken to evaluate the brain stem auditory evoked potentials (BAEPs) as early marker of cognitive damage in essential hypertension.

**Methods:** BAEPs were recorded in 50 hypertensive subjects and in 50 normotensive controls. Absolute peak latencies, interpeak latencies of different waves and amplitude ratio were compared in both the groups by using unpaired student's T test.

**Results:** Significant changes in absolute latencies of wave I and V, Interpeak latency I-III, III-V and I-V and amplitude ratio V/I was observed in hypertensive group as compared to control group.

**Conclusions:** Findings of the current study suggests that hypertension does affect the neuronal excitation in the auditory pathways, thereby suggesting that BAEP may provide the early evidence for the presence of CNS dysfunction in the patients of essential hypertension.

**Keywords:** Brain stem auditory evoked potentials, Essential hypertension

## INTRODUCTION

Hypertension is one of the most important lifestyle diseases, having serious impact on individuals and on society in general by affecting the quality of life of individuals and is a financial burden for both. Hypertension is a complex cardiovascular disorder characterized by the presence of a chronic elevation of systemic arterial pressure.<sup>1</sup> Hypertension is a major public health challenge worldwide due to its high prevalence. Essential hypertension accounts for 95% of all cases of

hypertension.<sup>2</sup> According to Directorate General of Health Services, Ministry of Health and Family Welfare Government of India, the overall prevalence of hypertension in India by 2020 will be 159.46/1000 population.<sup>3</sup> The rates for hypertension in percentage are projected to go up to 22.9 and 23.6 for Indian men and women, respectively by 2025.<sup>4</sup>

Hypertension is often called 'the silent killer' because it is a disease which shows no early symptoms. So, one may not be aware that it is damaging our arteries and

other organs like heart, kidney, brain, retina etc. Thus, it's the most significant risk factor for various organ diseases like myocardial infarction, left ventricular hypertrophy, congestive heart failure, aneurysm, stroke, dementia, chronic kidney disease, hypertensive retinopathy and erectile dysfunction.<sup>5</sup>

Central nervous system dysfunctions e.g. stroke, vascular cognitive impairment, dementia is common in patients of essential hypertension. This is attributed to micro-infarctions resulting from arterial and arteriolar spasm in cerebral blood vessels.<sup>6,7</sup> These micro infarcts also lead to hypo perfusion, loss of auto regulation, affect blood-brain barrier, sub cortical white matter demyelination and cognitive impairment. Sensory and motor deficits in essential hypertension along with central neuronal damage at brainstem level is due to micro vascular insufficiency.<sup>8</sup>

These central neuronal damage may alter electrical activity in the central nervous system and may affect various evoked potentials.<sup>9</sup> Evoked potentials are responses to stimulation of a sensory pathway in the nervous system. This comprise of stimulation of a sensory nerve in the limb (somatosensory evoked potentials-SSEPs), the visual system (visual evoked potentials-VEP) or the auditory system (brain stem auditory evoked potentials-BAEP or brain stem auditory evoked responses-BAER). These techniques have the potential for evaluating the integrity of the pathways of sensory transmission all the way from the point of peripheral activation through the cerebral cortex.<sup>10,11</sup>

Brain stem auditory evoked potential recording is an objective electrophysiological technique for assessing the auditory pathway from the auditory nerve to the brainstem.<sup>12</sup> When auditory stimulus is given to one ear, there's activation of peripheral and central auditory pathways. Brain stem auditory evoked potentials (BAEPs) are the electrical activities resulting from the activation of the eighth nerve, cochlear nucleus, tracts and nuclei of the lateral lemniscus and inferior colliculus.<sup>13</sup> So, by means of brainstem auditory evoked potential it is possible to assess integrity of neuronal brainstem generators and they are also effective in evaluation of early cognitive dysfunction due to micro vascular insufficiency.<sup>14</sup>

Previous studies have shown correlation between hypertension and brain stem auditory evoked potentials.<sup>15-17</sup> But very scarce data is available on all the parameters of BAEP and essential hypertension especially "amplitude ratio" which distinguishes between central and peripheral impairment.<sup>18</sup> With this background knowledge, current study was undertaken to compare absolute latency of waves I to V, interpeak latency I-III, III-V and I-V and amplitude ratio V/I in essential hypertensive patients and control group in both right and left ear.

## METHODS

A cross sectional comparative study of brainstem auditory evoked responses was carried out in department of Physiology, B. J. Govt. Medical College, Pune from March 2014 to August 2015. Before commencement of study, approval was taken from the institutional Ethical committee and informed written consent was taken from each subjects. 50 newly diagnosed cases of Grade I essential hypertension (SBP: 140-159 and DBP:90-99) according to JNC 7 classification of both sexes in the age group of 40-60 years and having normal auditory function test were enrolled as a study group.<sup>19</sup> For comparison, 50 apparently healthy age and sex matched controls were enrolled in a control group. Patients with conductive or sensorineural deafness, hepatic disorder, renal disorders, endocrinal disorders, alcoholics, smokers and H/O tobacco chewing, female patient not taking hormonal replacement therapy were not included in the study.

A detailed history by way of self-administered questionnaire about medical history and lifestyle was noted from selected subjects. A detailed general and clinical examination of all the system was done to exclude any other medical problems. Blood pressure was measured in supine position by both palpatory and auscultatory method. Diamond mercury sphygmomanometer was used under same clinical setting with optimum temperature. The same instrument was used throughout the study. On an average 2 readings were taken. Patients ear were first examined with otoscope. Wax was removed, if present. Tuning fork test was done and hearing threshold was determined using pure tone audiometry. Air conduction and bone conduction for each ear were noted. Audiometric tests were carried out in a sound proof room in the audiology department with a diagnostic audiometer (Orbiter 922 clinical audiometer version 2, Madsen electronics).<sup>20</sup>

The auditory evoked potentials study was carried out with prior appointment to patients. Patient was instructed to clean scalp with shampoo and not to apply oil. The skin was prepared by mild abrading and degreasing by Nu-Prep gel. Standard cup electrodes were used. The electrode was placed on their respective sites using Ten 20 conductive neurodiagnostic electrode paste as per 10-20 international system EEG of electrode placement. Test was carried out in a quiet room. AEP digital neurophysiological system software, bio-logic auditory evoked potential version 7.0, of Natus hearing diagnostic co. was used to conduct evoked potential tests.<sup>21</sup> All the techniques of recording, machine setting and instrument were maintained uniformly throughout the study. Patients were made to lie down comfortably on couch and were asked to close their eyes and relax. EEG on monitor was used as indicator for stable and relaxed brain. And then BAEPs were obtained using monoaural (one ear at a time) stimulation in the form of clicks at a rate of 11.1 per second (11.1Hz) delivered through ear inserts placed

inside the ear. The click stimulus at an intensity of 70dB SPL was given to the stimulated ear (ipsilateral) and masking sound (white noise) of 60 dB SPL to non stimulated, contra lateral ear through the ear inserts. Low and High band pass filter was set at 150Hz and 3000Hz respectively and the electrode impedance was kept below 5k $\Omega$ . The signals picked up by these electrodes were filtered, averaged, amplified and displayed on the computer monitor. Two trials of recording were done and waveforms were superimposed to check for reproducibility. BAEP waveforms from each ear were recorded. Parameter recorded and analysed were:

- Absolute latencies of waves I, II, III, IV and V in msec.
- Interpeak latencies (IPLs) of I-III, III-V, I-V in msec.

- Amplitude ratio of waves V and I.

The data obtained was tabulated in Microsoft excel sheet. Mean and standard deviation was calculated. And then statistical analysis was done using Graph pad prism software version 6.

## RESULTS

In this study, Table 1 shows that hypertensive patients and control group are comparable with respect to age, BMI (22.23), pulse rate and pure tone audiometry, while BP parameters (SBP, DBP, MBP) are significantly higher in hypertensive patients as compared to control group.<sup>22,23</sup>

**Table 1: Demographic profile of control and hypertensive patients.**

Parameters	Control (mean $\pm$ SD)	Hypertensive (mean $\pm$ SD)	P value	S/NS
Age	50.28 $\pm$ 0.6048	48.86 $\pm$ 0.6737	0.1200	Ns
Weight	61.44 $\pm$ 0.7115	62.18 $\pm$ 0.6482	0.4438	Ns
Height	157.9 $\pm$ 0.7196	158.4 $\pm$ 0.6451	0.6351	Ns
BMI	24.62 $\pm$ 0.1808	24.78 $\pm$ 0.1660	0.5219	Ns
Pulse rate	74.78 $\pm$ 0.2623	74.58 $\pm$ 0.2323	0.5694	Ns
SBP	114.6 $\pm$ 0.3894	143.4 $\pm$ 0.3184	< 0.0001	****
DBP	77.16 $\pm$ 0.5271	89.76 $\pm$ 0.2186	< 0.0001	****
MBP	89.65 $\pm$ 0.3811	107.7 $\pm$ 0.1727	< 0.0001	****
PTA	16.80 $\pm$ 0.9342	16.10 $\pm$ 0.9068	0.5920	Ns

Non-significant (NS) at p>0.05, Significant (S) at p<0.05, Highly Significant at p<0.0001\*\*\*\*

**Table 2: Brain stem auditory evoked potentials (BAEP) right & left ear latency, interpeak latency and amplitude ratio of control and hypertensive patient.**

BERA parameters	BERA wave	Control (Mean $\pm$ SD)	Hypertensive (mean $\pm$ SD)	P value	S/NS
<b>Right Ear</b>					
Latency (ms)	Wave I	1.580 $\pm$ 0.01085	1.728 $\pm$ 0.008676	< 0.0001	****
	Wave II	2.715 $\pm$ 0.01234	2.737 $\pm$ 0.009552	0.1695	NS
	Wave III	3.687 $\pm$ 0.04276	3.701 $\pm$ 0.01219	0.7672	NS
	Wave IV	4.836 $\pm$ 0.006317	4.852 $\pm$ 0.006450	0.0758	NS
	Wave V	5.593 $\pm$ 0.01106	5.844 $\pm$ 0.009471	< 0.0001	****
Interpeak latency (ms)	I-III	2.108 $\pm$ 0.04368	1.973 $\pm$ 0.006644	0.0029	S
	III-V	1.905 $\pm$ 0.04196	2.143 $\pm$ 0.006617	< 0.0001	****
	I-V	4.013 $\pm$ 0.0117	4.116 $\pm$ 0.002666	< 0.0001	****
Amplitude ratio.	V/I	3.547 $\pm$ 0.02150	3.385 $\pm$ 0.01181	< 0.0001	****
<b>Left ear</b>					
Latency (ms)	Wave I	1.591 $\pm$ 0.01071	1.735 $\pm$ 0.009072	< 0.0001	****
	Wave II	2.723 $\pm$ 0.01218	2.748 $\pm$ 0.009374	0.1015	NS
	Wave III	3.683 $\pm$ 0.01469	3.710 $\pm$ 0.01189	0.1503	NS
	Wave IV	4.839 $\pm$ 0.006322	4.852 $\pm$ 0.006365	0.1568	NS
	Wave V	5.600 $\pm$ 0.01064	5.849 $\pm$ 0.009356	< 0.0001	****
Interpeak latency (ms)	I-III	2.092 $\pm$ 0.01496	1.975 $\pm$ 0.007029	< 0.0001	****
	III-V	1.917 $\pm$ 0.01163	2.139 $\pm$ 0.006554	< 0.0001	****
	I-V	4.009 $\pm$ 0.01201	4.114 $\pm$ 0.002828	< 0.0001	****
Amplitude ratio	V/I	3.527 $\pm$ 0.02126	3.374 $\pm$ 0.01261	< 0.0001	****

Non significant (NS) at p>0.05 Significant (S) at p<0.05, Highly Significant at p<0.0001\*\*\*\*

Table 2 shows significant changes in absolute latencies of wave I and wave V, interpeak latency (IPL) time I-III, III-V and I-V and amplitude ratio V/I in hypertensive group as compared to control group in both ears.

## DISCUSSION

As wave I is believed to be due to reflex activity in auditory nerve, so increase in absolute peak latency of wave I in hypertensive patients may be due to i) Stretching-compression of the cochlear nerve and brainstem caused by the intracranial hypertension; and Primary edema due to the benign intracranial hypertension syndrome.<sup>24,25</sup> Our results are comparable with results of Nigam J et al who showed that raised BP affect BAEP waveform.<sup>26</sup>

Wave V is believed to be due to activity in inferior colliculi of midbrain.<sup>24</sup> So increase in absolute peak latency of wave V in hypertensive patients may be because of interaction of central vasomotor control system with generator of wave V of the Auditory Brainstem evoked Responses in the midbrain region and thereby causing delay in the absolute peak latency of this wave in primary hypertension.<sup>27</sup> This results are in accordance with studies of Handa Y et al who found that an increase in intracranial pressure frequently affects the electrical activity in the brainstem, especially wave V of BAEP.<sup>15</sup>

I to III interpeak latency (IPL) reflects conduction between auditory nerve and the pons.<sup>24</sup> Increase in I-III interpeak latency is due to any diffuse processes like tumor, inflammation, disorders affecting proximal portion of eighth nerve, pontomedullary junction or lower pons etc. affecting generation of this wave.<sup>18</sup> Therefore, decrease in interpeak latency in our hypertensive patients suggests there was no underlying pathology. Four cases in study by Yabumoto M et al, showed an improvement of I-III interpeak latency time thereby suggesting the decompressive effect on caudal aspect of pons.<sup>28</sup>

III to V interpeak latency reflects conduction between pontine and midbrain components of the brainstem auditory pathways while interpeak latency I-V reflects neuronal conduction from acoustic nerve-pontomedullary, pontine-midbrain auditory pathways.<sup>24</sup> So prolongation of interpeak latency III-V and I-V in hypertensive patients may be due to brainstem compression in hypertensive patients due to intracranial hypertension and primary edema.<sup>25</sup> This results are in accordance with study of Karamitsos DG et al, who noted abnormalities in measured absolute latencies of waves I through V and interpeak latencies I-III, III-V, and I-V of BAEP in patients of ischemic heart disease.<sup>29</sup>

The reduced amplitude ratio V/I in our hypertensive patients as compared to control group in both ears indicate central impairment like compression of the

cochlear nerve and brainstem. Very high amplitude ratio V/I suggest peripheral hearing impairment especially of high frequency or sensorineural type.<sup>18</sup>

Large sample size is needed and follow up of all patients will keep track of CNS dysfunction was the limitation of study.

## CONCLUSION

Thus, this study concludes that there are changes in the BAEP in patients with essential hypertension. But the statistical significance was found for absolute wave latencies of wave I and V, Interpeak latency I-III, III-V and I-V, amplitude ratio V/I in essential hypertensive patients as compared to control group. Thus, findings of the current study, suggests that hypertension does affect the neuronal excitation/conduction in the auditory pathways, thereby suggesting that brainstem auditory evoked responses may provide the early evidence for the presence of central nervous system dysfunction in the patients of essential hypertension.

## Recommendations

Authors recommend evaluation of BAEP in chronic hypertensive patients as a routine test to get an insight about CNS dysfunction.

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