# THE INVESTIGATION OF THE EFFECTS OF RADICAL NECK DISSECTIONS TO THE BRAINSTEM BY BRAINSTEM AUDITORY EVOKED POTENTIALS

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*SUMMARY*

*In 33 ears of 17 patients who have undergone unilateral or bilateral neck dissection, BAEP parameters including the absolute latencies of waves I, III, and V and also the interpeak latencies of waves I-III, I-V, III-V, are discussed in order to determine any changes of the brainstem. The recordings were made on the day before the operation, on first postoperative day and on tenth postoperative day. The results were statistically analyzed by student's "t" test. Absolute latency of wave III and interpeak latencies of waves I-III and I-V showed a significant prolongation between the recordings performed at preoperative and first postoperative days. These results were thought to reflect an early and transient brainstem ischemia that resolved in ten days after radical neck dissection.*

***Key words:*** *Radical neck dissection, brainstem auditory evoked potentials*

*ÖZET*

*Tek ya da iki taraflı boyun disseksiyonu yapılan 17 hastanın 33 kulağının beyin sapı erken işitsel uyarılmış potansiyelleri kaydedilerek operasyonun beyin sapına olası etkisi araştırılmıştır. Testte I, III ve V. dalganın latansları ve I-III, I-V ve III-V dalgaların interpik latansları ölçülmüştür. Kayıtlar preoperatif, postoperatif birinci ve onuncu günlerde olmak üzere üç kez yapılmıştır. Sonuçların istatistiksel değerlendirilmesi Student's "t" testi ile yapılmıştır.III. dalganın latansı ile I-III ve I-V dalgalar interpik latansları preoperatif ve postoperatif günlerde yapılan kayıtlarda anlamlı farklılık göstermiştir. Bu bulguların radikal boyun disseksiyonundan sonra erken dönemde ortaya çıkan ve on gün içinde kaybolan minimal iskemiyi yansıttığı düşünülmüştür.*

***Anahtar sözcükler:*** *Radikal boyun diseksiyonu, beyin sapı erken işitsel potansiyelleri*

Patients undergoing unilateral or bilateral radical neck dissection, whether simultaneous or in stages usually develop some facial oedema. It has been stated that this situation had been related to the obstruction of venous and lymphatic flow (1,2).

There is a complicated collateral system between extracranial and intracranial venous systems. Extravertebral veins, emissary veins, occipital veins, the pterygoid, pharyngeal, oesophageal and orbital plexuses are included in this system. Following internal jugular vein ligation, compensation for cerebral venous drainage takes place through those collaterals and mostly by the external vertebral plexus. This collateral compensation system takes place at different periods in each individual which reduces the raised intracranial pressure. If the collateral system does not drain sufficiently at some instances, the intracranial pressure will raise.

Until adequate venous drainage takes place, the absorption of cerebrospinal fluid in the superior sagittal sinus diminishes which leads to a raised intracranial pressure. In such cases papilloedema, headache, nausea, vomiting and sometimes the paralysis of abducens nerve may occur. These symptoms of raised intracranial

pressure could not only be related to the increase of cerebrospinal fluid pressure and might be due to the temporary oedema of the brain also.

Brainstem auditory evoked potentials (BAEP) are generated in the auditory pathways. Some authors have reported that rising of intracranial pressure, and compression or ischemia of brainstem might be observed as changes in those potentials (3,4,5). BAEP had became a routine, sensitive and objective test in brainstem impairments such as multiple sclerosis, acoustic neurinoma and brainstem tumours since its introduction to clinical practice. This study was planned to evaluate the use of BAEPs in the assessment of brainstem compression or ischemia and detect the cases of raised intracranial pressure without clinical symptoms following radical neck dissection.

## MATERIALS and METHODS

17 patients who have undergone either unilateral or bilateral neck dissections because of head and neck malignancies in the ENT and Head and Neck Surgery Clinic of Dokuz Eylül University Medical School have been included in this study. The patients were between 42 and 73 years of age with a median of 49 years, and 16 of them were male and only one was female.

Preoperatively all of the cases have been controlled ultrasonographically to confirm the patencies of both internal jugular veins by a radiodiagnostics specialist. Patients have been operated under general anaesthesia. Halothane, nitrous oxide and pentobarbital have been used as anaesthetic agents. In four of the patients a simultaneous functional neck dissection have been done on the opposite site also.

Pre and postoperatively, complete blood counts, glucose, urea, electrolytes and $PO_2$ levels have been calculated. Pure tone hearing threshold levels of all patients have been recorded with Interacoustics AC5 digital audiometer. BAEP recordings have been made in the night before the operation, 12-24 hours and 10 days after the surgery with simultaneous papilla examination. BAEPs were recorded with a Medelec MS92 EMG machine in a silent and normally heated room. Body temperatures were between 36.5° C and 37.2° C. All of the patients were placed in supine position with the eyes closed and the head and neck muscles relaxed. The active electrode was placed to the vertex and the reference was attached to the ipsilateral mastoid process while the ground electrode was on the forehead. Monaural 0.1 msec alternating clicks at 75 dB were presented at 10/sec stimulus repetition rate to the ipsilateral ear. No masking were used for contralateral ears. The band pass filters range was 250-1600 Hz. 2 msec/div monitor rate, 10μv/div calibration and 20 msec analysing time were set for recording. Each record was an average of 4000 stimuli, and BAEP waves were evaluated on each side separately after the second performance of the tests for confirmation of the waveform.

The peak latencies of waves I, III, and V and interpeak latencies of waves I-III, I-V, and III-V were measured for each ear.

Statistical analysis of the parameters measured on preoperative, postoperative first and tenth days were checked by Student's "t" test and the p value of less than 0.05 was considered significant.

## RESULTS

In all of the cases the internal jugular veins were found patent bilaterally by ultrasonography. The complete blood count and other biochemical parameters tested during each BAEP study were found to be within normal ranges. Sequential ophtalmologic examinations were normal as well.

The averages and standart deviations of pure tone hearing thresholds of the 33 ears of the 17 cases have been shown on Table I, while one chronically discharging ear had an average air conduction threshold of 60 dB, thus this ear was not held in this study for the standardisation of BAEP recordings. The statistical significances of the preoperative BAEP values and the values of the first postoperative day are shown on Table II. The statistical significances of the same parameters of the preoperative and postoperative tenth day, and postoperative first and tenth days are shown on Tables III and IV respectively. The differences of wave III peak latency, interpeak latencies of waves I-III and I-V between the preoperative and postoperative first day recordings were found to be statistically significant. The rest of the parameters showed no statistical differences.

**Table I:** The averages and standart deviations of the pure tone hearing threshold levels of the patients

| | Preoperative | Postoperative1$^{st}$ day | Postoperative 10$^{th}$ day |
|---|---|---|---|
| 500 Hz | 14.5 ± 5.9 dB | 15.5 ± 5.5 dB | 14.8 ± 4.9 dB |
| 1000 Hz | 15.3 ± 6.7 dB | 16.5 ± 6.1 dB | 15.7 ± 4.6 dB |
| 2000 Hz | 18.8 ± 7.0 dB | 19.2 ± 6.5 dB | 18.9 ± 6.5 dB |
| 4000 Hz | 24.0 ± 6.9 dB | 25.2 ± 5.8 dB | 24.8 ± 5.7 dB |

**Table II:** The statistical comparison of the BAEP parameters of preoperative and postoperative first day values. (IPL:Interpeak latency) (Note that the latency of wave III and interpeak latencies of waves I-III, and I-V are statistically significant.)

| Parameters | Preoperative | Postoperative 1$^{st}$ day | t | p |
|---|---|---|---|---|
| Latency of wave I | 1.83 ± 0.15 msec | 1.82 ± 0.18 msec | 0,51 | p >0.05 |
| Latency of wave III | 3.82 ± 0.19 msec | 3.91 ± 0.19 msec | 2,26 | **p < 0.05** |
| Latency of wave V | 5.77 ± 0.23 msec | 5.86 ± 0.26 msec | 2 | p > 0.05 |
| IPL of waves I-III | 1.99 ± 0.22 msec | 2.09 ± 0.12 msec | 2,6 | **p < 0.05** |
| IPL of waves I-V | 3.94 ± 0.24 msec | 4.04 ± 0.19 msec | 2,22 | **p < 0.05** |
| IPL waves III-V | 1.95 ± 0.18 msec | 1.90 ± 0.15 msec | 0,06 | p > 0.05 |

**Table III:** The statistical comparison of the BAEP parameters of preoperative and postoperative tenth day values

| Parameters | Preoperative | Postoperative 10th day | t | p |
|---|---|---|---|---|
| Latency of wave I | 1.83± 0.15 msec | 1.83± 0.13 msec | 0.25 | p> 0.05 |
| Latency of wave III | 3.82± 0.19 msec | 3.87± 0.19 msec | 1.42 | p> 0.05 |
| Latency of wave V | 5.77± 0.23 msec | 5.81± 0.20 msec | 0.99 | p> 0.05 |
| Interpeak latency of waves I-III | 1.99± 0.22 msec | 2.05± 0.17 msec | 1.31 | p> 0.05 |
| Interpeak latency of waves I-V | 3.94± 0.24 msec | 3.98± 0.16 msec | 1.08 | p> 0.05 |
| Interpeak latency of waves III-V | 1.95± 0.18 msec | 1.94± 0.20 msec | 0.28 | p> 0.05 |

**Table IV:** The statistical comparison of the BAEP parameters of postoperative first day and tenth day values

| Parameters | Postoperative 1th day | Postoperative 10th day | t | p |
|---|---|---|---|---|
| Latency of wave I | 1.82± 0.18 msec | 1.83± 0.13 msec | 0.33 | p> 0.05 |
| Latency of wave III | 3.91± 0.19 msec | 3.87± 0.19 msec | 1.48 | p> 0.05 |
| Latency of wave V | 5.86± 0.26 msec | 5.81± 0.20 msec | 1.62 | p> 0.05 |
| Interpeak latency of waves I-III | 2.09± 0.12 msec | 2.05± 0.17 msec | 1.89 | p> 0.05 |
| Interpeak latency of waves I-V | 4.04± 0.19 msec | 3.98± 0.16 msec | 1.88 | p> 0.05 |
| Interpeak latency of waves III-V | 1.90± 0.15 msec | 1.94± 0.20 msec | 0.39 | p> 0.05 |

## DISCUSSION

The venous drainage of the brain is highly rich and in case of obstruction or resection of the internal jugular veins the circulation of the brain will be over those rich collateral venous systems. It has been thought that the increased intracranial pressure was the result of inadequate collateral circulation through the alternate major pathways of blood return from the brain (1), and was stated that if an anomaly of intracranial venous sinuses or jugular vein on the opposite side exists, signs of intracranial hypertension may occur even in patients who have undergone an unilateral neck dissection (2). Cerebrospinal fluid pressure (CSF) is directly related to the intracranial venous pressure. Changes in venous pressure is similar to changes in CSF, thus a rise in intracranial venous pressure will raise intracranial CSF pressure. This phenomenon has been demonstrated in patients with obstruction of intracranial venous sinuses by thrombosis, thrombophlebitis or by tumours (4). The increase in CSF pressure resulting from occlusion of one or both jugular veins in radical neck dissections are known. It has been observed that there had been rises of CSF pressures in patients undergoing unilateral or staged bilateral neck dissections at early postoperative days and had lasted approximately twelve days or more (1). Simultaneous bilateral neck dissection has been thought to the possible aetiology of visual impairment (6). It has been reported that although the ocular findings were rarely normal, in most of the patients there were headache and ocular symptoms (decrease of visual acquity, visual field disturbances or diplopia) as the first manifestations of intracranial pressure rises thus implying rises in CSF pressure (4,7).

In patients that we studied no ocular symptoms developed during postoperative period. The facial oedema which developed peroperatively and postoperatively faded out in a month. In bilateral simultaneous operations according to the stage of the neck, one of the jugular veins was saved thus no ocular symptoms were seen and facial oedema disappeared early. Nine of the patients had clinically serious headache but their clinical status have not implied any intracranial pressure increase.

Some authors claimed that although venous obstruction of the cochlea could lead to a severe drop in cochlear blood flow and cochlear microphonics, no change in the hearing thresholds were observed after unilateral or bilateral jugular vein ligation. They also stated that the venous obstruction may not be distal enough to cause any reduction in cochlear blood flow so that deafness is rarely reported after radical neck dissection (8,9). None of the patients reported in this study had postoperative hearing loss.

Following internal jugular vein ligation, apart from papilla oedema, headache, vomiting and sometimes a sixth nerve palsy may be found, but the latter symptoms cannot be explained by raised cerebrospinal fluid pressure alone and it has been implied that this might be due to temporary oedema of the brain tissue (2,9). The most evident BAEP parameters for ischemia or compression of the brainstem are wave I, III, V latencies. But it was also claimed that I-III, I-V, III-V interpeak latencies should be included to the interpretation because various stimuli and factors influence the absolute latencies of the previous three waves(3,8,10). All six parameters have been taken into account in this study.

In our study wave I latencies recorded at preoperative, postoperative first and tenth days showed no statistical significance. Since the patients had pure tone hearing levels within normal range preoperatively and postoperatively (Table I), this was considered as a normal finding.

It has been shown that intracranial pressure increase caused significant prolongation of wave III latencies in the rabbits (3). 24 patients with unilateral brainstem lesions demonstrated by MRI, were studied and it has been found that wave III latencies were normal in mesencephalic lesions, controversially in caudal pons lesions wave III was abolished (11). It has been reported that wave III was lost with midline trapezoid body lesion and was attenuated by lesions of either the superior olivary nucleus or lateral lemniscus (12). In our report wave III latencies recorded at preoperatively and postoperative first day showed a statistical difference ($p<0.05$). The average of the same value at tenth postoperative day was between the preoperative and postoperative first day values but did not show any statistical difference. These results implied an electrophysiological brainstem disturbance on postoperative first day without any clinical features.

In patients with acute severe closed head injuries it has been noted that, especially wave V abnormalities were always associated with obvious clinical signs of brain stem involvement

(13). It has been found that patients with unilateral acoustic neuroma had wave V abnormalities in common (14). In this study wave V latencies showed no significant differences.

It has been reported that in guinea pigs after unilateral internal jugular vein ligation, I-III interpeak latencies have showed significant changes (9). In this study I-III interpeak latencies obtained on the postoperative first day were statistically longer than the preoperative values ($p<0.05$). The measurements on the postoperative tenth day, although, showed no significant difference from the preoperative values, they were numerically between the preoperative and postoperative first day values. These findings were considered to be the result of a transient slight effect in caudal brainstem.

It has been considered that I-V interpeak latency have reflected the conduction time of stimuli from the cochlear nerve to the midbrain, thus focal lesions as demyelination, ischemia, and tumors or broad degenerations reduce the conduction (15). It has been believed that especially mesencephalic lesions demonstrated I-V interpeak latency abnormalities also (11). In our study the preoperative and postoperative first day values of this parameter showed a significant prolongation ($p<0.05$). This could be due to a slight brainstem disturbance because of an early rise in intracranial pressure. Postoperative tenth day measurements have showed no statistical differences from either preoperative or postoperative first day values. The decrease in the tenth postoperative day recordings when compared to the fist day recordings, were discussed as a remission of electrophysiologic functions according to developing collateral venous drainage.

Some authors have also thought that III-V interpeak interval showed the conduction from caudal pons to midbrain (15). The reliability of this parameter increases especially when it is associated with prolonged I-V interpeak interval. In patients with acute severe closed head injuries significant increases in I-V and III-V interpeak latencies have been shown (13). Prolongations in III-V interpeak intervals of patients with mesencephalic brainstem lesions have been reported (11). Statistically significant increases in this parameter after bilateral jugular vein ligation in guinea pigs have been demonstrated (9). In this report no statistical significances have been found in this parameter among the three recording dates. This could be explained as a result of prolongations of wave III and V absolute latencies together at postoperative first day because of slight brainstem compression.

As a result, the significant statistical changes seen in BAEP parameters are considered as reflections of a minimal brainstem ischemia developed at first 12-24 postoperative hours after the ligation of either bilateral or unilateral jugular veins. This process diminishes gradually if no collateral system abnormally is present. BAEP recording is a noninvasive method to help detection of such an event when doubted.

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