EVALUATION OF AUDITORY EVOKED POTENTIALS 
IN WHITE NEW ZEALAND RABBITS WITH SIMULATED SUBDURAL 
HEMATOMA AND INCREASED INTRACRANIAL PRESSURE 

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EVALUATION OF AUDITORY EVOKED POTENTIALS IN WHITE NEW ZEALAND RABBITS WITH SIMULATED SUBDURAL HEMATOMA AND INCREASED INTRACRANIAL PRESSURE

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ABSTRACT
Development of a noninvasive intensive care system calls for the use of evoked potentials (EPPs) as a means of diagnosing traumatic head-injured patients. The experiment entails surgically placing two subarachnoid bolts and a subdural balloon through the skull to simulate a subdural hematoma. Using various levels of ICP and/or different sizes of balloons, auditory evoked potentials (AEPs) were recorded from a rabbit. Six positive peak latencies (P1-P6) and five negative peak latencies (N1-N5) were extracted from an averaged AEP waveform. Multiple regression analyses were performed for determining a relationship between the ICP and AEP peak latencies. The results indicate that a major correlation of changes on AEP peak latencies is due to mechanical forces of a mass (inflated balloon simulating a hematoma) in the distortion of the brain matter rather than increased ICP.

INTRODUCTION
The most frequent cause of death related in head injury is intracranial hypertension following cerebral contusion and subdural hematoma resulting in neurological dysfunction and impairment of the brain's electrical activity, as the increased pressure limits the cerebral blood flow [1]. Several major disadvantages are associated with current methods of monitoring, such as the invasive methods which pose a risk of infection to the patient, technical problems in determining reliable ICPs, requirement for surgery, and the availability of monitoring equipment at the site of injury. If a noninvasive means of measuring ICPs were developed and found to have a linear relationship with the ICP, the noninvasive method would be preferred for use on all traumatic head-injured and hydrocephalic patients [2].

The objective of this experiment is to evaluate the specifications and develop a noninvasive, quantitative, intensive care system for the traumatic head-injured patients by establishing a relationship between the ICP and parameters of the AEPs from an experimental animal group.

EXPERIMENTAL DESIGN AND METHODS
Experimental Design
The experiment was devised with twelve rabbits divided into three groups. Group 1 and 2 (two rabbits for each group) were used to establish the control for examining the effects of anesthesia and sham surgery, respectively. Group 3 (8 rabbits) was used as an experimental group to study the changes in the AEP's parameters under various experimental conditions.

An ipsilateral recording of the AEP was performed by placing an earphone in the left ear canal. The other earphone was placed in the contralateral (right) ear for white noise generation. The rabbit's auditory system was stimulated by clicks. Once the program performed data collection with 500 clicks, those AEPs were averaged, and an averaged AEP file was saved.

The experimental conditions were generated by surgically placing two subarachnoid bolts and a subdural balloon through the skull. One bolt was used to incrementally raise the ICP by continuously infusing lactated ringer's solution (LRS) into the subarachnoid space to maintain four predetermined levels of ICP (15, 20, 25, and 30 mmHg). The second bolt was attached to a pressure transducer to continuously monitor and record the ICP. A balloon was placed in the subdural space and inflated with a known volume of LRS (0.2, 0.4, and 0.6 ml) to simulate a subdural hematoma condition.

Data Processing and Analysis
After the program has stored the averaged AEP, several indices of measures were extracted from averaged AEP waveform peaks as measurements of absolute latencies in milliseconds (ms). The parameters extracted include the first six positive peak latencies (P1 through P6) and the first five negative peak latencies (N1 through N5) of the waveform. Interpeak latencies, P1-P6, P1-P5, and P5-P6 were also calculated from the waveform as a measure of central conduction time (CCT).

Multiple regression analyses were performed to determine a relationship between the ICP and regressor variables: positive/negative peak latencies. An R-square value was obtained as a measure which indicates the portion of the total variation that is attributed to the fit.

RESULTS AND DISCUSSION
The effects of anesthesia and/or sham surgery were evaluated with Group 1 and Group 2.
Two groups showed no significant changes at a 0.05 significant level on the mean differences of the AEP parameters. This infers that there is no significant adverse effect caused by anesthesia and/or surgery.

For the experimental group, fig.1 and fig.2 compare the changes on AEP parameters under combined experimental conditions. In fig.1, mean differences increase rapidly as the size of the balloon is varied while maintaining the ICP constant, but there are no definite increases in mean differences between ICP levels. On the other hand, fig.2 shows the mean differences increase gradually between different sizes of the balloons. There are no fluctuations in the mean differences between different sizes of the balloon.

![Fig.1. Changes on AEP peak latencies (P1-P6), the ICP levels are varied while holding the balloon size constant.](image)

Fig.1. Changes on AEP peak latencies (P1-P6), the ICP levels are varied while holding the balloon size constant.

Based on the best subset of variables selected for each experimental treatment, Table 1 summarizes the R² values for each experimental treatment. At a balloon inflation of 0.2 ml and 0.4 ml, AEP parameters are correlated to the various ICP levels with the R² values of 0.329 and 0.389, respectively. The experimental treatment in which the ICP is varied while maintaining the balloon size at 0.6 ml had the highest R² value of 0.608. On the other hand, varying the balloon size while maintaining the ICP level constant does not provide much variation.

**CONCLUSION**

The conclusion drawn from multiple regression analyses results are: (1) a major correlation of changes on AEP peak latencies is due to mechanical forces of a mass (inflated balloon simulating a hematoma) in the distortion of the brain matter rather than increased ICP. (2) AEP parameters have higher predictability on ICP changes with bigger size of the balloon simulating a hematoma.

![Table 1](image)

**TABLE 1**

<table>
<thead>
<tr>
<th>Experimental Treatment</th>
<th>Prob &gt; F</th>
<th>R-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation of ICP without balloon inflation</td>
<td>0.1079</td>
<td>0.225</td>
</tr>
<tr>
<td>Variation of ICP with 0.2 ml of balloon</td>
<td>0.0148</td>
<td>0.329</td>
</tr>
<tr>
<td>Variation of ICP with 0.4 ml of balloon</td>
<td>0.0038</td>
<td>0.389</td>
</tr>
<tr>
<td>Variation of ICP with 0.6 ml of balloon</td>
<td>0.0001</td>
<td>0.608</td>
</tr>
<tr>
<td>Variation of balloon size at baseline ICP</td>
<td>0.0028</td>
<td>0.440</td>
</tr>
<tr>
<td>Variation of balloon size at 15 mmHg</td>
<td>0.0235</td>
<td>0.224</td>
</tr>
<tr>
<td>Variation of balloon size at 20 mmHg</td>
<td>0.0027</td>
<td>0.336</td>
</tr>
<tr>
<td>Variation of balloon size at 25 mmHg</td>
<td>0.0255</td>
<td>0.224</td>
</tr>
<tr>
<td>Variation of balloon size at 30 mmHg</td>
<td>0.0173</td>
<td>0.244</td>
</tr>
</tbody>
</table>

**REFERENCES**


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