Noninvasive Detection of Changes in Intracranial Pressure Using DPOAEs

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INTRODUCTION

Intracranial pressure (ICP) is commonly monitored in a wide range of disorders, including head injury, encephalopathy, and brain surgery. As the skull contains brain, blood, and cerebrospinal fluid (CSF), the skull is subject to changes in the volume and contents of these tissues, which can lead to increases in ICP. When ICP increases, it can lead to the expansion of the skull, causing headaches, nausea, and vomiting, and potentially leading to brain injury or death. Therefore, accurate monitoring of ICP is crucial for the management of these disorders.

In this study, we used DPOAEs (Distortion Product Otoacoustic Emissions) to assess changes in ICP in healthy, normal-hearing subjects. DPOAEs are generated by the cochlea in response to a combination of two pure tones and can be measured non-invasively using earphones. We performed DPOAE measurements in seven normal-hearing subjects at different postural positions, ranging from 0° to 90°, in order to assess the interaction between posture and ICP.

RESULTS

All subjects had systematic low-frequency changes in DPOAE magnitudes as their position was changed from upright (0°) to 20° and 45°. In general, for f2 frequencies between 1500 and 2000 Hz, DPOAE magnitudes decreased as posture moved from 90° to 45° (Figures 3 and 4).

DPOAE MAGNITUDES AT DIFFERENT POSTURAL POSITIONS: METAPILOT RESULTS (FIGURE 5)

There was a significant position by frequency interaction (F2,14 = 3.4, p<0.0001). For frequencies lower than 1500 Hz, the predicted differences in magnitude between upright and 45° were significantly small (F2,14 = 0.5, p<0.001). At higher frequencies, there were minimal differences.

EXPERIMENTAL METHODS

DPOAEs appear to be a candidate for a method to monitor ICP changes in some patients.

DPOAE magnitudes changed systematically with posture - and presumably with ICP - for f2 ≤ 1500 Hz. DPOAE magnitudes generally decreased as posture changed from upright (0°) to 45° relative to the horizontal. The largest changes occurred at the lowest frequencies, with an average change of 7.5 dB for f2 < 750 Hz.

Multiple DPOAE measurements repeated within a minute of another showed relatively small standard deviations (often less than 1 dB). Variations over several days had standard deviations ranging from 0.3 to 7.6 dB, with 50% between 2 and 4 dB.

Future work includes (1) making DPOAE measurements on patients undergoing medically-necessary ICP monitoring, and (2) improving our tympanometric methods to include a higher static-pressure resolution.

REFERENCES


Summary

Several methods have been proposed to measure ICP, but none of them is without limitations. The work presented here is part of the honors theses of T.H.P. Tabucchi and F. Folowosele within the Eaton- Peabody Laboratory, Massachusetts Eye & Ear Infirmary, and the Department of Otolaryngology, Harvard Medical School.

DPOAEs appear to be a candidate for a method to monitor ICP changes in some patients.

DPOAE standards were measured with a DPOAE measurement system described below. All measurements were made in the right ear of each subject.

All subjects had systematic low-frequency changes in DPOAE magnitudes as their position was changed from upright (0°) to 20° and 45°. In general, for f2 frequencies between 1500 and 2000 Hz, DPOAE magnitudes decreased as posture moved from 90° to 45° (Figures 3 and 4).

DPOAE MAGNITUDES AT DIFFERENT POSTURAL POSITIONS: INDIVIDUAL DATA (FIGURES 3 AND 4)

All subjects had systematic low-frequency changes in DPOAE magnitudes as their position was changed from upright (0°) to 20° and 45°. In general, for f2 frequencies between 1500 and 2000 Hz, DPOAE magnitudes decreased as posture moved from 90° to 45° (Figures 3 and 4).

DPOAE STANDARD DEVIATIONS (FIGURE 6)

The standard deviations ranged from 0.3 to 7.6 dB (Figure 6).