Graphic Angle Measurement (GAM) Technique in Electrocochleography: A Novel Reliable Tool

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Citation

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Abstract

Electrocochleography (ECochG) is a method of recording the stimulus related potentials of the cochlea and auditory nerve. The response that is measured in ECochG occurs within the first two or three milliseconds after an abrupt stimulus, and it includes the following components: the cochlear microphonic (CM), the summating potential (SP), and the whole nerve or compound action potential (AP). The amplitude ratio between the SP and the AP looked to be a more consistent within-subject feature of the overall response. Normal SP/AP ratios generally ranged from 0.1 to 0.4 across subjects with a mean value of 0.25. It is this particular measurement that appeared most sensitive to, or dependant on, the presence of endolymphatic hydrops. However, we were in need for a new measurement technique that integrates amplitude, latency and slope of the recorded waves. This technique was referred to as the Graphic Angle Measurement (GAM) Technique. It relies on the measurement of the angle between 2 intersecting lines: One connecting the peaks of the SP and the AP and the other one is dropped vertically from the peak of the SP. The normal values of our lab ranged from 102° to 158°.

INTRODUCTION

Electrocochleography (ECochG) is a method of recording the stimulus related potentials of the cochlea and auditory nerve. The response that is measured in ECochG occurs within the first two or three milliseconds after an abrupt stimulus, and it includes the following components: the cochlear microphonic (CM), the summating potential (SP), and the whole nerve or compound action potential (AP). Analysis of the components of and variations within an electrocochleographic waveform has been used extensively in the diagnosis of Meniere's disease.[1,2]

The cochlear microphonic is an alternating current electrical potential generated at the hair cell level in the cochlea.[2]The summating potential is a direct current response to an alternating current stimulus which arises from the Organ of Corti hair cells in response to acoustic stimuli.[1,2] The SP generally appears on the electrocochleograhpic waveform as a “ledge or hump on the beginning slope of the action potential wave”, but it can also appear as a separate peak preceding the action potential.[2] The SP is by definition a distortion component which reflects the asymmetry of basilar membrane vibration. In the case of endolymphatic hydrops, in which there is increased pressure in the scala media, the normal asymmetric vibration of the basilar membrane is altered, thus resulting in the large summating potential.[1] The normal SP has a duration of between 0.30 and 0.45 milliseconds, and the absolute amplitude of the SP can range from as small as 0.1 millivolts to 1.0 millivolts or even perhaps larger.[1]

The action potential is an alternating current response which is generated by the cochlear end of the VIIIth Cranial Nerve, and it represents the summed response of the synchronous firing of thousands of auditory nerve fibers.[1,2] The synchronous activity essential for producing the action potential is most often seen at the onset of a tone burst or in response to clicks. The size of the AP reflects the number of nerve fibers which are firing simultaneously. Furthermore, in the absence of any adverse pathology, the AP has a latency of 1.5 milliseconds, but it can range from 1.3 milliseconds to 1.7 milliseconds. Its duration is normally between 0.80 milliseconds and 1.25 milliseconds, and the absolute amplitude of the AP can vary greatly, ranging from 0.6 millivolts to 3.0 millivolts. Action potential latency, duration, and amplitude have been studied considerably in the analysis of electrocochleographic waveforms, and variations from normal have been associated with endolymphatic hydrops.[1]

Since the absolute amplitude of the summating potential and the action potential, when studied individually, displayed

sizable variation across and within normal subjects, the amplitude ratio between the SP and the AP seems to be a more consistent within-subject feature of the overall response. Normal SP/AP ratios generally range from 0.1 to 0.4 across subjects with a mean value of 0.25. It is this particular measurement that seems most sensitive to, or dependant on, the presence of endolymphatic hydrops.[1]

Although the SP/AP ratio was approved as a reliable method for the detection of the presence or absence of endolymphatic hydrops, it lacked the integration of the dimensions of slope of the waves and the wave latency difference into this measurement. Therefore, the Graphic Angle Measurement (GAM) Technique was developed to express the variability in amplitude, latency as well as slope of ECochG waves within an angle. The objective of this study is to describe this technique and to establish the normative values.

SUBJECTS AND METHODS

A total of 506 Egyptian subjects, aged 16-41 years, were included in our study. Basic audiological evaluation including: meticulous history taking, pure-tone audiometry and speech audiometry, was fulfilled. They were done using two-channel audiometer Orbiter, model 922 in a sound treated booth IAC, model 1602.

ELECTROCOCHLEOGRAPHY (ECOCHG)

Noninvasive extratympanic ECochG was performed to both the carrier and the control groups. The active electrode was the TIP trode by Nicolet Spirit Instrument. This electrode consisted of a compressible foam ear tip covered by an extremely thin and pliable layer of gold foil. The electrode was coupled to an insert phone by flexible silicon tubing. The sound delivery tube ran through the centre of the earplug. The TIP trode provides both the sound delivery and a recording electrode in one unit. Two silver disc electrodes were placed over the contralateral mastoid and the forehead to serve as a reference and ground electrodes respectively.

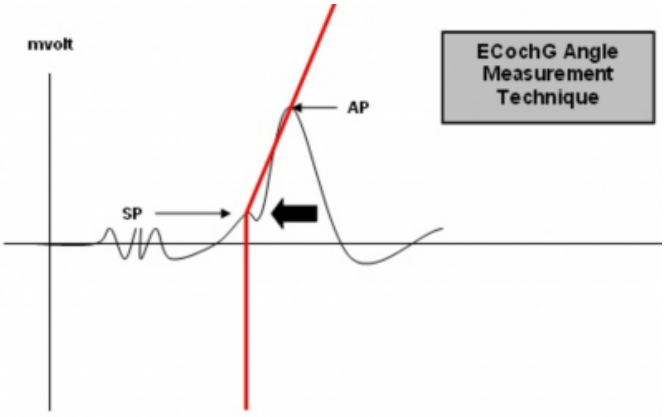
Before placement of the TIP trode, the meatal skin was irrigated with 10cc isopropyl alcohol 70% to lower skin resistance. The subject was lying comfortably with the head fully supported, and was instructed to relax. The impedance of the positive electrode as well as the ear canal electrode was always less than 3 K Ohm.

Stimuli consisted of 100 msec clicks, generated at a rate of 8.3/sec at 90 dBnHL. Alternating polarities were used to cancel the cochlear microphonic and the stimulus artifacts. A system bandpass filter of 5 Hz to 3 KHz was utilized. An artifact rejection routine in the averaging program prevented spurious high voltage samples from contaminating the averaged response. The time window was 10 msec. Responses to 1000 stimuli were included in each trace and a duplication of each average was performed to assess reproducibility. All testing were performed in a double-walled sound treated booth IAC, model 1602.

The analysis of the waveforms was carried out in the following manner: a) The amplitude of the SP was measured from the prestimulus baseline to the shoulder preceding the AP. b) The amplitude of the AP was measured from the prestimulus baseline to the maximum peak of the N1 c) The SP/AP amplitude ratio was calculated d) The graphic angle measurement (GAM) technique: I have applied this technique for 2 years in our audiological laboratory in Sohag University Hospitals. This measurement integrates amplitude, latency and slope of the recorded waves. It relies on the measurement of the angle between 2 intersecting lines: One connecting the peaks of the SP and the AP and the other one is dropped vertically from the peak of the SP (Fig. 1).

Figure 1

Figure 1: A diagram that shows the graphic angle measurement (GAM) technique as a tool of assessment of the relation between the SP and AP of the ECochG. Two intersecting lines are drawn: One oblique line passes through the two peaks of the SP and the AP and another vertical line that is dropped from the peak of the SP. The angle (arrow) in between the two lines is measured. Here it is 156 Â°.



RESULTS

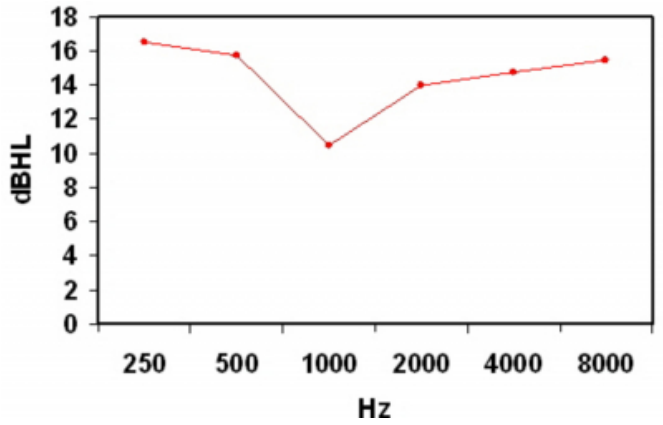
SUBJECTS' DEMOGRAPHICS AND AUDIOLOGICAL EVALUATION

The age of the study group ranged from 16 to 41 years. All participants had within normal hearing at the frequency range 250-8000 Hz (thresholds are all better than 25 dB HL;

fig. 2 & table 1).

Figure 2

Figure 2: Audiometric thresholds of the study group.



ELECTROCOCHLEOGRAPHY

A comparison between the amplitudes of the SP and the AP between both groups was made. The control group had higher amplitudes than the carriers group. However, there was a significant difference only for the SP amplitude in both groups (table 1). When the values of both the SP/AP ratios and the GAM were examined, there was a significant difference between both groups (table 1).

Figure 3

Table 1: shows the mean, SD, minimum and maximum results of age, SP amp., AP amp., HTL, SP/AP, GAM.

		Control	Group	
	Mean	SD	Min.	Max.
Age	31.2	9.6	16	41
SP amp.	0.157	0.086	0.035	0.465
AP amp.	0.558	0.268	0.190	1.19
$HTL_{250-8000}$	14.5	2.27	9.5	20.75
SP/AP ratio	0.235	0.032	0.125	0.290
GAM	136	9.5	112.5	155

-**SD**= Standard Deviation, **Min.** = Minimum, **Max.** = Maximum, **amp.** = amplitude, $HTL_{250-8000}$ = Hearing Threshold Level in dB HL at the frequencies 250- 8000Hz.

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