2

Quick Guide Series Book

Assessment of the Dizzy Patient with Evoked Potentials

BALANCE

For patients that complain of imbalance, we think of ENG/VNG, Calorics, Balance Platforms, Rotary Chair--but what about Evoked Potentials?

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In the assessment of the balance patient we routinely perform the standard tests contained within the ENG/VNG battery and caloric testing. We also consider platform tests, rotational chair testing as well as head impulse testing. Often we forget the tests that are offered in an evoked potential (EP) system that can prove valuable in the assessment of the dizzy patient.

EP testing can add important information to the differential diagnosis. This booklet will the various tests and a bibliography for each test will be included for reference material. The tests to be explored will be:

- Electrocochleography (ECochG)
- Vestibular Myogenic Evoked Potentials (VEMP)
- Neurologic ABR or Rate Study

For each of these tests, the section will cover a brief discussion of:

- Patient population
- Electrode montage
- Stimulus parameters
- Waveform marking
- Interpretation

Electrocochleography (ECochG)

As discussed in an early section of the series, the ECochG test is a measure of the electrical activity in the cochlea. It is a specialized ABR protocol where the electrode is placed as close to the tympanic membrane or cochlea as is realistic, depending on the type of electrode and the skill and training of the professional placing the electrode.
The ECochG waveform is comprised of three different components: the cochlear microphonic (CM) or Baseline (BL), the summating potential (SP) and the compound action potential (CAP or AP).

The ECochG test is typically performed on patients:

- Suspected of having Endolymphatic Hydrops (Meniere's Disease)
- Suspected Superior SemiCircular Canal Dehiscence (SSCD) and for monitoring during SSCD closure surgery

While not directly related to dizziness or vertigo, other uses for ECochG testing include:

- Test neural function prior to cochlear implant surgery
- Subtyping of Auditory Neuropathy Spectrum Disorder (ANSD)
- Monitor cochlear function during surgical procedures.

Electrodes

Skin surface electrodes are not sufficient to record the ECochG. The test requires that the electrode be closer to the site that actually generates the response. The three types of electrodes used are:

Earcanal
also referred to as a Tiptrode (gold foil), has a foil covered foam insert piece that is placed in the external ear canal but does not touch the eardrum.

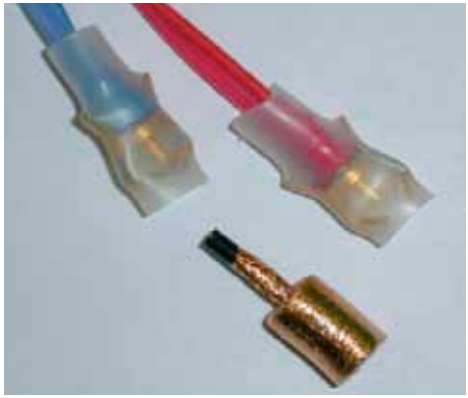
Extra-tympanic
also referred to as a TympTrode (TM Trode) or Wick, has a thin coated wire that is placed in the ear canal and rests gently on the eardrum.

Transtympanic
also referred to as a needle electrode, is placed through the tympanic membrane and rests on the oval window or promontory. A physician must place this type of electrode.

The type of electrode used will have a direct effect on the normative values to be used. See the chart at the end of the section for helpful information about normative values.

Tiptrode

The Tiptrode is an extra tympanic electrode that is more specifically called an ear canal electrode which combines the electrode with the transducer.. It is made of foam that is wrapped with a thin gold film. After the ear canal is prepared, the Tiptrode is gently squeezed and then placed in the ear canal, where it will expand and snuggly seal the canal.



- Connect the gold foil tip by squeezing the prongs together on the electrode lead cable and sliding the tip onto the cable securely.
- Connect the left and right ends of the ECochG lead to the preamp and the tubing to the Otoinserts appropriately.
- After preparing the patient, compress the Tiptrode. Use a small bit of electrode gel on the foil being cautious not to get any gel on the opening of the tip. Gently place in the ear.

TM Electrode or TM Wick Electrode

The TM electrode or TM Wick electrode is extra-tympanic; they are placed next to or on the outer side of the eardrum. Each consists of a thin wire shielded with a protective coating.

Using a microscope, the electrode is guided down the ear canal until it reaches the eardrum. When placed properly, the it rests gently on the eardrum, and the gel assists in making contact with the eardrum. For the Wick electrode, soak in a few drop of saline before use.

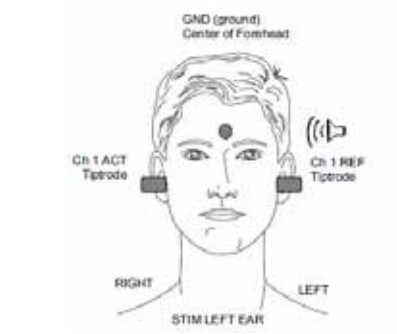
Transtympanic or needle

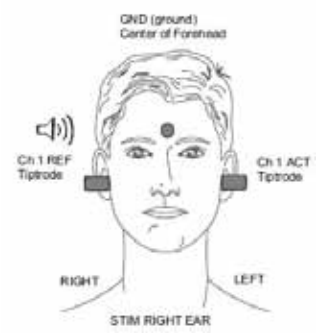
The transtympanic electrode is placed *through* the tympanic membrane and rests on the oval window or promontory. A physician must place this type of electrode.

The end result is that the electrode is closer to the generator site, resulting in a larger the response.

Use of the Tymptrode or Wick is not recommended in the presence a TM perforation

Common ECochG Electrode Montages

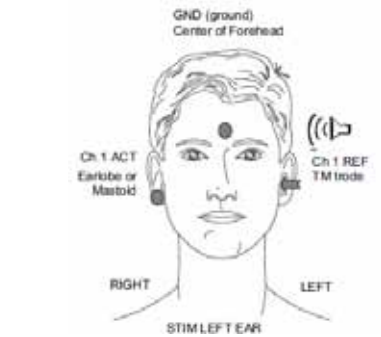


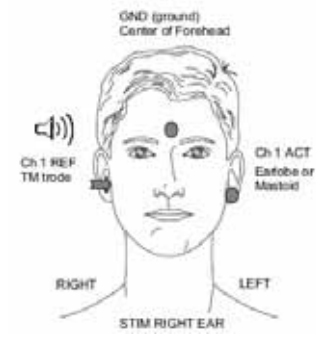


Protocol: ECochG Tip Trode

To test/stimulate the left ear connect:
- High Forehead to GND
- Left Ear to Ch 1 REF (-)
- Right Ear to Ch 1 ACT (+)

To test/stimulate the right ear connect:
- High forehead to GND
- Left Ear to Ch 1 ACT (+)
- Right Ear to Ch 1 REF (-)





Protocol: ECochG Tip Trode

To test/stimulate the left ear connect:
- High Forehead to GND
- Left Ear to Ch 1 REF (-)
- Right Ear to Ch 1 ACT (+)

To test/stimulate the right ear connect:
- High forehead to GND
- Left Ear to Ch 1 ACT (+)
- Right Ear to Ch 1 REF (-)

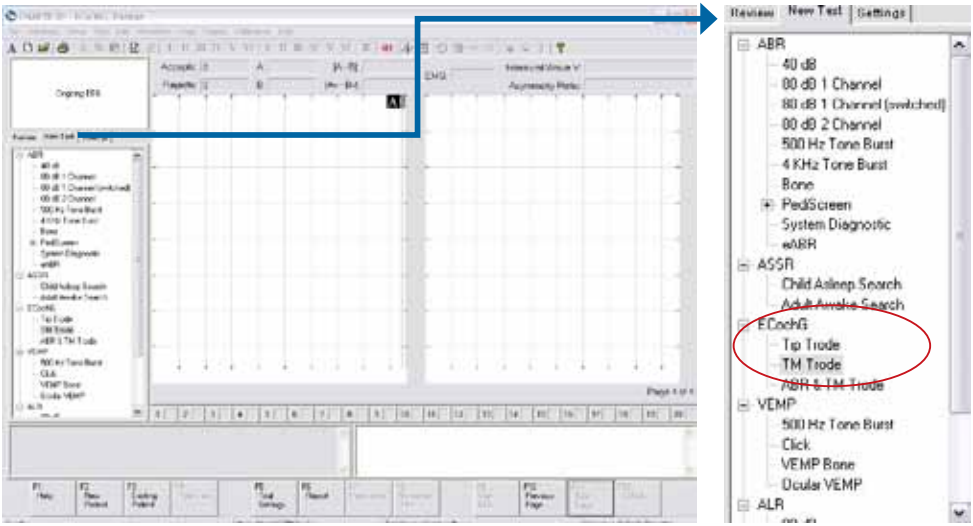
The montages listed above will result in an upward deflection of the AP

Parameters and Helpful Hints

The ECochG stimulus is a click or tone burst presented at a relatively slow rate (7.1/sec, 11.1/sec) at a high intensity (90dBnHL). The high intensity, slow rate combination brings out the AP component. To bring out the SP and separate it from the AP, it is recommended to use a very fast rate (90.1/sec) While this will decrease or even eliminate the AP, the SP will remain intact and make it easier for the operator to identify. The EcochG is run with alternating polarity in an effort to reduce stimulus artifact but this also eliminates the cochlear microphonic. Running a separate Rarefaction and Condensation may help in the identification of baseline.

Since the AP typically appears at approximately 1.50 msec, it is not unusual for operators to use a short sweep time or window. A 5-10 msec sweep time in the Trial Settings is not an uncommon request. The only difference between the Tip Trode and TM Trode protocols is the generally the Gain setting. Since the TM Trode is closer to the generator site, a lower gain is used—it does not require as much amplification. The typical gain for the TipTrode is 75-100K. The typical gain for a TM Trode or Wick may be as low as 50K.

The CHARTR EP200 comes with default protocols for TipTrodes and TM Trodes.



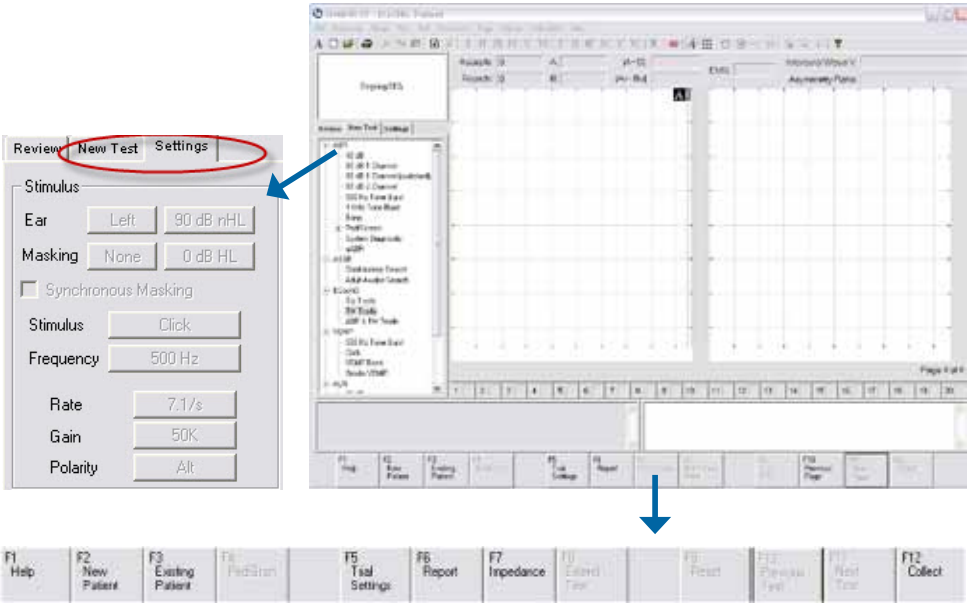
Using the CHARTR EP200 to Run the ECochG

After choosing your electrode type and protocol, prepare the patient using one of the montages listed earlier in this section. The patient should be relaxed and in a comfortable position. Refer to the EP Basic booklet for Patient Preparation hints.

Check impedance (F7) prior to the start of the test. It is not uncommon to have much -- should we say how much higher? impedance than with ABR.

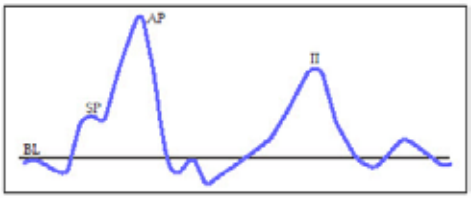
Choose Collect (F12) from the bottom of the screen to begin the test. It is recommended that you collect at least two runs from each ear. You can easily change ears by selecting the Settings Tab.

After changing ears, don't forget to change the electrode leads in the preamp. Collect the data from the other ear. You are now ready to mark the waveforms.

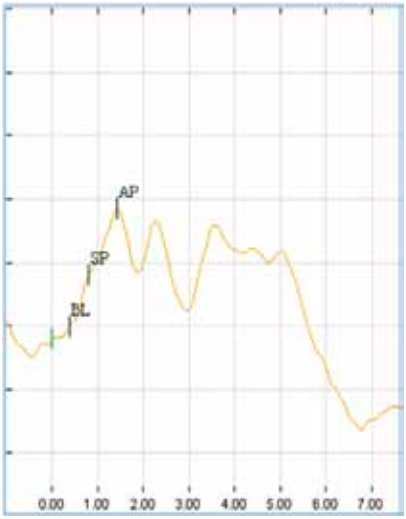


Identifying Waveforms

The CHARTR EP200 has waveform markers at the top of the page. Using your mouse, click and drag your cursor to the place to wish to mark and then select the appropriate marker. Remember, for ECochG, you are going to mark the Baseline (BL), the summating potential (SP) and the action potential (AP). Some choose to mark any standard ABR waves (III, and V) that also appear. Once the markers are placed, you can observe the latency (time between 0.0 msec and the marker) of each point marked or you can observe the amplitude (height in µv from the baseline point to SP and AP of each marked point). Most use the amplitude measure for assessing pathology.



The most frequently used measure for interpreting ECochG waveforms is the ratio of the height of SP versus AP; SP/AP x 100. This number is expressed as a percentage. The CHARTR EP200 software will automatically compute this number once you have completed labeling the waveforms. The number displays in the calculations box along with additional latency and amplitude calculations.



Approximate latencies with 90-95dB stimulus:

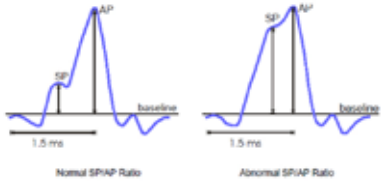
Baseline:	0.5 msec
SP:	0.8-0.9 msec
AP:	1.50 msec

Electrode Location	Approx. AP Amplitude (µV)	Normative Value Cutoff
Mastoid	0.1	N/A
Earlobe	0.4	N/A
Ear Canal	0.6	>50%
TM	1.2	30-35%
Promontory	3.5-5.0	25-30%

Normative data for ECochG differs depending on the electrode used for data collection. Commonly accepted norms use cut-off percentages of 30-35% for the tymptrode and 50% for a gold foil electrode. This means a percentage greater than ~30% is a significant finding when using a tymptrode and a percentage greater than 50% is significant when using a gold foil electrode.

As with any equipment, it is always recommended that clinic specific normative data be collected for the patient population served within that clinic.

Gold foil electrodes are placed in the outer ear canal, further away from the source of the response and are less robust. As a result, wider variations in responses are seen and a larger SP/AP ratio is necessary to classify a result abnormal. Normal ears have a larger difference between the amplitudes of SP and AP (resulting in a smaller SP/AP ratio) and diseased ears have a small amplitude difference between SP and AP (resulting in a larger SP/AP ratio). Therefore, larger ratios may indicate pathology and often can be seen in patients with Ménière's disease. A larger SP/AP Ratio is indicative of a pathological condition.



Helpful Reading

General ECochG

1. Transtympanic Versus Tympanic Membrane Electrocochleography in Examining Cochleovestibular Disorders 2000, Vol. 120, No. 545 , Pages 127-129 (doi:10.1080/000164800454189) Jorma Haapaniemi, Esa Laurikainen, Reijo Johansson, Seppo Karjalainen Ilveksenkatu 10, FI-20760 Piispanristi Finland
2. Diagnostic significance of transtympanic electrocochleography in Menière's disease. Ann Otol Rhinol Laryngol. 1983 Mar-Apr;92 (2 Pt 1):155-9.Gibson WP, Prasher DK, Kilkenny GP.

SSCD

1. Reversible electrocochleographic abnormalities in superior canal dehiscence Otol Neurotol. 2009 Jan;30(1):79-86.Arts HA, Adams ME, Telian SA, El-Kashlan H, Kileny PR.
2. Electrocochleography as a Diagnostic and intraoperative adjunct in superior semicircular canal dehiscence syndrome, Otol Neurotol. 2011 Dec;32(9):1506-12. Adams ME, Kileny PR, Telian SA, El-Kashlan HK, Heidenreich KD, Mannarelli GR, Arts HA.

Auditory Neuropathy and Cochlear Implants

1. Identification of Different SubTypes of Auditory Neuropathy Using Electrocochleography, Neuropathies of the Auditory and Vestibular Eighth Cranial Nerves, 2009, Part II, 21-36, DOI: 10.1007/978-4-431-09433-3_3. Catherine M. McMahon, Robert B. Patuzzi, William P.R. Gibson and Halit Sanli
2. Neural and receptor cochlear potentials obtained by transtympanic electrocochleography in auditory neuropathy. Rosamaria Santarelli, Arnold Starr, Henry J Michalewski, Edoardo Arslan (2008) Clinical Neurophysiology 119 (5) p. 1028-1041
3. Electrocochleogrpahy during Cochlear implantation for Hearing Preservation Otolaryngol Head Neck Surg. 2012 May;146(5):774-81. Epub 2012 Jan 30. Mandalà M, Colletti L, Tonoli G, Colletti V.
4. Auditory neuropathy: an update.William Peter Rea Gibson, Halit Sanli (2007) Ear and Hearing 28 (2 Suppl) p. 102S-106S

Vestibular Evoked Myogenic Potentials (VEMP)

The Vestibular Evoked Myogenic Potential (VEMP) has proven in recent years to be a very valuable addition to the assessment of the dizzy patient. The VEMP is a test of otolith organ function. An interesting piece to remember about this test is that although it requires sound to generate the response it is a vestibular evoked response. When the vestibular nerve is severed, the response disappears but research supports that there is no correlation between the VEMP response and sensorineural hearing loss. It is however, important to remember that a conductive hearing loss, even as small as 5dB, can abolish the VEMP response. You should always do a hearing test before VEMP testing. VEMP testing is relatively quick and easy to do. This test may be requested by an audiologist, ENT/otologist, neurologist or neuro-opthamologist.

Typically, two types of VEMPs are tested: the cervical VEMP (cVEMP) and the ocular VEMP (oVEMP). The cVEMP is recorded from the contracted sternocleidomastoid (SCM) muscle. The oVEMP is recorded from the extraocular muscles. While these two tests are both vestibular evoked myogenic potentials the similarities stop there!

	cVEMP	oVEMP
Recording Site	SCM	Extraocular Muscles
Presumed Generator Site	Saccule	Utricle
Type of Response	Inhibitory	Excitatory
Transducer	Air (bone if no response)	Air or Bone
Ipsi or Contra	Ipsilateral	Contralateral
Required Gain	5K	75K-100K

Electrodes and Monitoring

To run these tests, a 2 channel system with an additional channel for EMG monitoring is recommended. It is the most simple and efficient way to run the tests. Traditional surface electrodes can be used for this test. Otometrics offers a small differential electrode that is convenient for cVEMP EMG monitoring and for oVEMP electrode placement which is so close to the eyes.

Differential Electrode

EMG Monitor

EMG monitoring is crucial for accurate cVEMP analysis. When monitoring for cVEMP remember to first check the EMG monitor settings. Due to patient variability, it is recommended that the first VEMP run be collected with the EMG values set wide open (e.g., 0 for min and 999 for max).

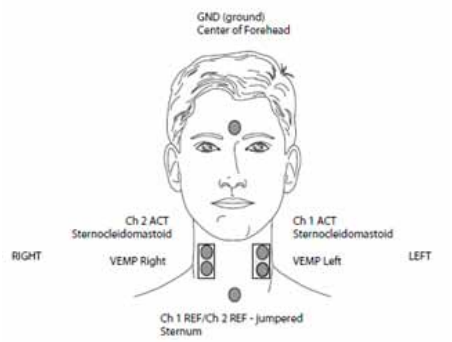
Position the patient to contract the SCM and collect one run. The average EMG will be displayed in the calculation box. Next set the min to 20 µV below the average and the max to 20 µV above the average (e.g., if average is 85 µV, then the min = 65 µV and the max = 105 µV). The min and max values should be the same when collecting data from the left and right SCM to ensure that the EMG value is similar on both sides. The response average will only include sweeps when the EMG is in between the min and max values or "Good".Since the cVEMP is an inhibitory response it also requires normalization to correct for muscle tension. The asymmetry ratio calculation is this:

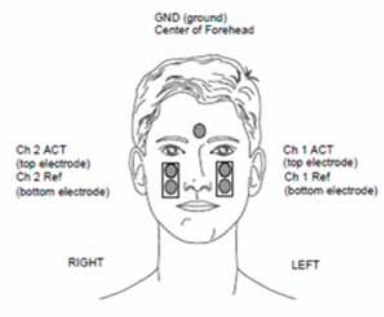
$$100 \times \frac{(\text{AmpL/Left EMG}) - (\text{AmpR/Right EMG})}{(\text{AmpL/Left EMG}) + (\text{AmpR/Right EMG})}$$

The oVEMP does not require normalization or monitoring because it is an excitatory response.

**VEMP Module is not available in the United States*

Common Electrode Montages





Protocol: cVEMP

Connect:

- High Forehead to GND
- Left SCM to Ch 1 ACT (+)
- Sternum to Ch 1 REF (-) jumpered to Ch 2 Ref
- Right SCM to Ch 2 ACT (+)

For monitoring:

- Left SCM (below ACT electrode) to L VEMP on preamp
- Right SCM (below ACT electrode) to R VEMP on preamp

Protocol: Ocular VEMP

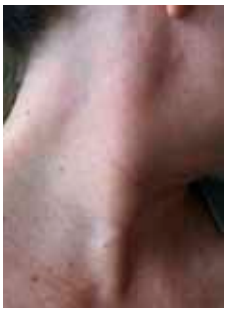
Connect:

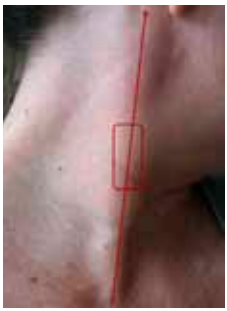
- Low forehead or Chin to GND
- Left eye top to Ch 1 ACT (+)
- Left eye bottom to Ch 1 REF (-)
- Right eye top to Ch 2 ACT (+)
- Right eye bottom to Ch 2 REF (-)

Parameters and Helpful Hints

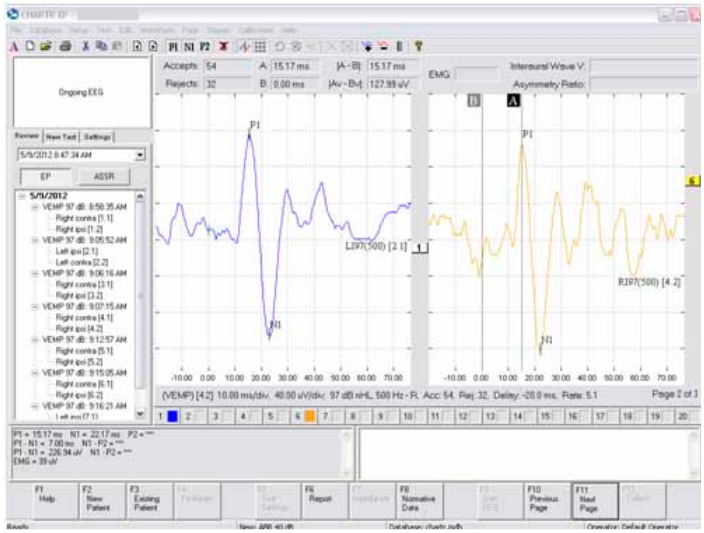
The CHARTR EP200 has default protocols for cVEMP and oVEMP. A quick guide for VEMP testing is available with detailed information for both tests including the use of a mini shaker (document 7-45-00651). A video and quick guide are also available. For cVEMP it is important to consider electrode placement and contraction of the muscle. Electrodes must be placed on the "belly" or largest part of the SCM to obtain a good measurement. If the electrodes are too high or too low you may have difficulty measuring EMG or it may result in low amplitudes. Remember to aim for the middle third of the muscle.

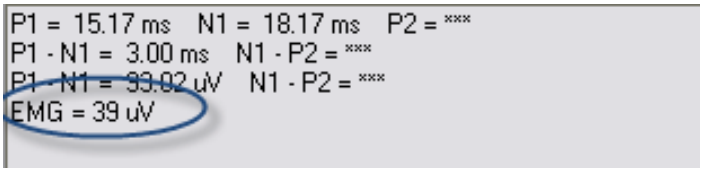
The same holds true for oVEMP; electrode placement is very important. The electrodes should be placed very close to the eyes. If they are too low the amplitudes will be inaccurately small. Neither cVEMP or oVEMP requires many sweeps. 75-150 sweeps may be sufficient. For oVEMP the patient can sit or lay supine. Instruct the patient to look 25 to 30 degrees in an upward direction. Simple dots positioned on the ceiling or wall may help the patient go from one position to the next and will help with consistency.





**VEMP Module is not available in the United States*





**VEMP Module is not available in the United States*

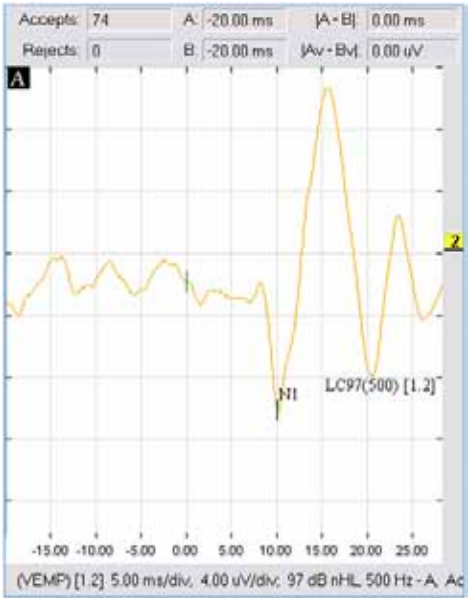
Marking the Waveform
Marking waveforms on the CHARTR EP200 is simple. Highlight the waveform you wish to mark. Click and drag the cursor to the desired position and choose the desired marker from the toolbar.

For cVEMP typically the marked points are P1 and N1. P2 may also be marked. P1 and N1 may also be called P13 and N23 which communicates their approximate latency post stimulus. This means a peak should be seen at or around 13 msec followed by a negative trough around 23 msec.

For oVEMP, the operator is typically looking for the prominent N1 (also called N10) or negative trough at approximately 10 msec.

After collecting both sides and marking the P1 and N1 for the cVEMP, the asymmetry ratio can be calculated. On the CHARTR EP 200 you simply highlight a left and right waveform then choose an asymmetry ratio calculation from the toolbar. The ratio will appear in the asymmetry ratio box.

Example of air conducted cVEMP



Example of air conducted oVEMP

**VEMP Module is not available in the United States*

Helpful reading

1. Vestibular-Evoked Myogenic Potential Testing: Normative Threshold Response Curves and Effects of Age. Janky KL, Shepard N. (2009) Journal of the American Academy of Audiology (20)8:514-522

2. Clinical assessment of otolith function. Akin, F. W., & Murnane, O. D. (2009, Feb. 10) The ASHA Leader, 14(2), 14-17

3. Characteristics and clinical applications of vestibular-evoked myogenic potentials. Miriam S Welgampola, James G Colebatch (2005) Neurology 64 (10) p. 1682-1688

4. Clinical Assessment of Otolith Function. Faith W Akin, Owen D Murnane (2009) Perspectives on Hearing and Hearing Disorders Research and Diagnostics 13 (2) p. 29-39

5. Influence of cochlear implantation on sacculus function. Eike Krause, Juliane Wechtenbruch, Tobias Rader, Robert Gürkov (2009) Otolaryngology Head and Neck Surgery Official Journal of American Academy of Otolaryngology Head and Neck Surgery 140 (1) p. 108-113

6. The influence of voluntary tonic EMG level on the vestibular-evoked myogenic potential. Faith W Akin, Owen D Murnane, Peter C Panus, Stacy K Caruthers, Amy E Wilkinson, Tina M Proffitt (2004) Journal Of Rehabilitation Research And Development 41 (3B) p. 473-480

7. A review of the scientific basis and practical application of a new test of utricular function--ocular vestibular-evoked myogenic potentials to bone-conducted vibration. I S Curthoys, L Manzari, Y E Smulders, A M Burgess (2009) Acta otorhinolaryngologica Italica organo ufficiale della Societa italiana di otorinolaringologia e chirurgia cervicofacciale 29 (4) p. 179-186

8. The ocular vestibular-evoked myogenic potential to air-conducted sound; probable superior vestibular nerve origin. Ian S Curthoys, Ann M Burgess, Shinichi Iwasaki, Yasuhiro Chihara, Munetaka Ushio, Leigh A McGarvie (2011) Clin Neurophysiol. 2011 Mar;122(3):611-6. Epub 2010 Aug 14

9. Patterns of Abnormality in cVEMP, oVEMP, and Caloric Tests May Provide Topological Information about Vestibular Impairment. Gary P Jacobson, Devin L McCaslin, Erin G Piker, Jill Gruenwald, Sarah L Grantham, Lauren Tegel (2011) Journal of the American Academy of Audiology 22 (9) p. 601-11

Rate Study/Neurodiagnostic ABR

The ABR is best known for its use in the assessment of hearing thresholds in populations that cannot or will not respond to more traditional audiometric testing. The ABR can also be used to rule out retrocochlear pathologies such as Acoustic Neuroma or even Multiple Sclerosis. While it is not the primary diagnostic test it can provide important information. With the CHARTR EP200 it is simple to run this test.

While the ABR is more sensitive to larger CPA tumors it is not as sensitive to smaller tumors. Using a 1996 study by Bauch et al, the sensitivity and specificity of ABR to tumor detection is 92% and 88% respectively. While research varies, Interaural Latency Difference of Wave V (ILD V or ITV) of greater the 0.2 - 0.4 msec or an Interpeak I-V Latency of greater than 6 msec could be indicative of retrocochlear pathology. The operator must remember to account for sensorineural hearing loss; for every 10dB above 50dB at 4kHz, 0.1 msec is allowed/added.

The Neurodiagnostic ABR can be run a few different ways. Unilaterally, some will run a slower rate (ie 21.1 followed by a faster rate (ie 77.1 or 90.1) at a high intensity (80-90dBnHL). Run the test on the other side. Similar changes should be seen. The faster rate stresses the system however, the system should react similarly on both sides and an ABR should be attainable for the normal ear. The ITV is calculated after running the selected rate for each ear. Mark the wave V for the right and left. Next highlight each waveform and select the ITV calculation icon from the toolbar. Remember, interaural differences of 0.2 to 0.4 msec can be considered significant.

Helpful reading

1. ABR indices: sensitivity, specificity and tumor size. Bauch, C.D., Olson, W.O. , Pool, A.F. (1996) American Journal of Audiology, 5, 97-104

2. Auditory brain stem response results from 255 patients with suspected retrocochlear involvement.C D Bauch, D E Rose, S G Harner (1982) Ear and Hearing 3 (2) p. 83-86

3. Diagnostic implications of stimulus polarity effects on the auditory brainstem response. Cynthia G Fowler, Christopher D Bauch, Wayne O Olsen (2002) Journal of the American Academy of Audiology 13 (2) p. 72-82

Notes

Notes

Auditory Evoked Potential testing can be an extremely comprehensive evaluation of the auditory system. From the pre-neural responses within cochlea to the responses of the auditory cortex, EP testing provides objective, quantifiable measures of the auditory pathway. Otometrics provides comprehensive, efficient and user friendly EP solutions in modular packages.

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