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NIM™ 2.0 SYSTEMS:

Protocol and Troubleshooting Guide

A basic guide to nerve integrity monitoring

Medtronic

WELCOME

Medtronic ENT has developed this basic guide to nerve integrity monitoring as it applies to the NIM™ 2.0 System family to assist in simplifying setup procedures. (The NIM 2.0 System family includes the NIM-Response® 2.0 and the NIM-Neuro® 2.0.)

Each section gives procedure-specific protocols to follow and includes such information as: monitoring goals, electrode placement, impedance values, difference values, threshold and stimulation ranges, as well as samples of responses.

We hope that this booklet will be a helpful guide to follow and we appreciate your patronage.

Important: This document is not intended to replace the surgeon's medical judgment or knowledge of neural anatomy and physiology. Nerve monitoring does not prevent the surgical severance of nerves. Nerve monitoring with the NIM 2.0 System family or other monitors is only a technical aid and cannot substitute for the skill, experience and anatomical knowledge of the surgeon.

The user should refer to Medtronic ENT's Operations Manual for further instruction regarding any equipment referenced in this document. Requisite training and know-how for performing evoked EMG monitoring in surgical applications supplements the surgeon's knowledge of nerve anatomy for preservation of nerve function during surgical procedures.

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Procedures

- Cerebellopontine Angle Tumor
- Vestibular Schwannoma (acoustic neuroma)
- Microvascular Decompression
- Trigeminal Nerve Resection
- Vestibular Nerve Section

Skull base procedures may place at risk that segment of the facial nerve (Cranial Nerve VII) from the brainstem through the internal auditory canal (IAC). Tumors may be located either adjacent to the brain stem or within the IAC and are often intimately involved with the facial nerve. In order to remove the tumor, there will be considerable drilling of bone which may produce heat that may affect the nerve. Nerve dissections often involve direct manipulation, stretching or traction of the facial nerve. The facial nerve is nonmyelinated at this section, hence lesser amounts of stimulation will produce an EMG effect.

If other cranial motor nerves are at risk, additional electrodes may be placed to monitor EMG activity in the appropriate muscle. Additional cranial nerves that are commonly monitored in skull base procedures include the trigeminal nerve (Cranial Nerve V) and the vagus nerve (Cranial Nerve X).

As a general rule, when shunting current directly through bone, you will need 1.0mA of stimulus for every millimeter of bone above the nerve. Shunting through soft tissue will usually require a setting of at least 0.8mA.

Monitoring Goal

Locate, identify, and map the nerve.

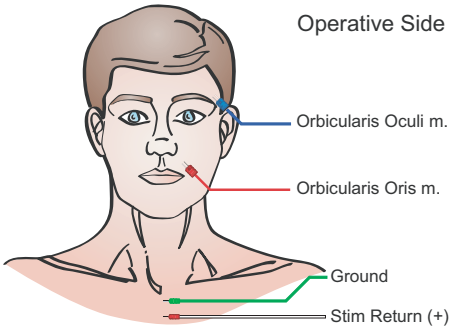
Monitor manipulation effect.

It is extremely valuable for the surgeon to verify nerve integrity prior to closing by stimulating proximal to the tumor site BEFORE and AFTER the surgery.

Procedure Specific Protocols

Suggested Electrodes	Part No.
• Paired Subdermal Electrodes	8227410
• Prass Paired Electrodes, 18mm	8227304
Suggested Stimulator Probes	**Part No.**
• Prass Standard Monopolar Probe	8225101
• Prass Bipolar Probe	8225451
Suggested Stimulus Instruments	**Part No.**
• Kartush Dissection Set (KSD)	1352400
• Neurotologic Dissection Set (NSD)	1353400

Electrode Placement: Figure 1.



Typical Electrode Readings	Channel Values	Difference Values
Subdermal needle	< 10 KΩ	< 1 KΩ
Prass paired needle	< 25 KΩ	< 5 KΩ

Event Threshold Range

Event Threshold Range is 50uV-100uV. You may wish to increase threshold in case of an EMG train response.

Stimulation Range

Use 0.8mA to begin, in general, unless otherwise directed by the surgeon at the start of surgery when the monopolar probe is in use with goal of mapping the nerve. Increase the stimulus setting until an EMG response has been elicited. At this stage, there will be tissue and bone through which the current must travel. Once the nerve has been located, reduce the stimulus level. There is rarely a need to use more than 1.0mA in the cerebellar pontine angle (CPA) because it is possible to place a stimulator directly on the nerve. The Kartush Bipolar Probe is good to use when the nerve is exposed because current is not shunted and low stimulus levels can be used.

Procedures

- Facial Nerve Decompression
- Mastoidectomy
- Tympanoplasty
- Cochlear Implantation
- Translabrynthine Approach to Posterior Fossa
- Labyrinthectomy

The facial nerve may be at risk during surgeries involving the temporal bone because the exact location of the nerve varies by patient. This is especially true for revision cases. These procedures, generally, are "quiet surgeries" without a lot of artifact.

Intraoperative facial nerve monitoring (IFNM) allows the surgeon to avoid the nerve. In procedures with considerable bone drilling, heating may affect the nerve. In nerve decompressions, IFNM can aid in pinpointing that portion of the nerve to be decompressed.

Monitoring Goal

Locate, identify, and map the nerve.

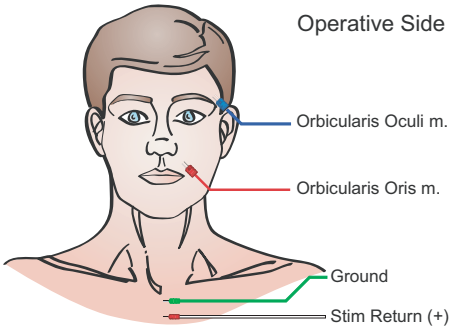
Monitor manipulation effect.

It is extremely valuable for the surgeon to verify nerve integrity prior to closing by stimulating after the surgery.

Procedure Specific Protocols

Suggested Electrodes	Part No.
• Paired Subdermal Electrodes	8227410
• Prass Paired Electrodes, 18mm	8227304
Suggested Stimulator Probes	**Part No.**
• Prass Standard Monopolar Probe	8225101
• Kartush Side-by-Side Bipolar Probe	8225401
Suggested Stimulus Instruments	**Part No.**
• Kartush Dissection Set (KSD)	1352400
• Neurotologic Dissection Set (NSD)	1353400

Electrode Placement: Figure 2.



Typical Electrode Readings	Channel Values	Difference Values
Subdermal needle	< 10 KΩ	< 1 KΩ
Prass paired needle	< 25 KΩ	< 5 KΩ

Event Threshold Range

Event Threshold Range is 50uV-100uV. May decrease to 50uV to see earliest response.

Stimulation Range

Use 0.8mA at the beginning (mapping) of the procedure or as directed by the surgeon. Hold the probe tip perpendicular to the tissue for approximately one second to elicit a response.

There is rarely a need to use more than 1.0mA in the cerebellar pontine angle (CPA) because it is possible to place a stimulator directly on the nerve. Use lower stimulus levels as directed by the surgeon and increase slowly until a response is obtained.

Procedures

- Parotidectomy
- Submandibular Gland Dissection
- Head and Neck Dissection
- Congenital Aural Atresia

Most common in this group for facial nerve monitoring is the parotidectomy. The facial nerve enters the parotid gland as one bundle, then splits into five different branches within the body of the parotid gland. To monitor a given nerve branch, electrodes must be placed in the muscle that it innervates. The nerve is myelinated now, hence more stimulus is usually necessary to evoke a response.

In general, parotidectomies are "noisy surgeries" due to potential manipulation of the nerve during blunt dissection. Also, the electrodes are in close proximity to the surgical site.

Monitoring Goal

Locate, identify, and map the nerve and branches.

Monitor manipulation effect.

It is extremely valuable for the surgeon to verify nerve integrity prior to closing by stimulating proximal to the tumor site BEFORE and AFTER the surgery.

Procedure Specific Protocols

Suggested Electrodes	Part No.
• Paired Subdermal Electrodes	8227410
• Prass Paired Electrodes, 18mm	8227304
Suggested Stimulator Probes	**Part No.**
• Prass Standard Monopolar Probe	8225101
• Kartush Side-by-Side Bipolar Probe	8225401

Typical Electrode Readings	Channel Values	Difference Values
Subdermal needle	< 10 KΩ	< 1 KΩ
Prass paired needle	< 25 KΩ	< 5 KΩ

Event Threshold Range

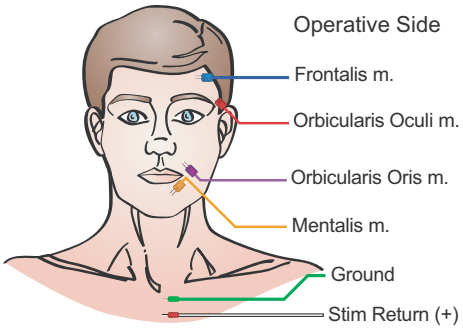
Event Threshold Range is 100uV-150uV.

Stimulation Range

Use 0.8mA at the beginning of the procedure (mapping) or as directed by the surgeon. Increase rapidly until a response is evoked. May need to increase to 3.0mA.

The best guideline for setting the stimulus intensity level is to use the lowest amount of stimulation needed to produce an EMG response large enough for monitoring. Be prepared to stimulate to as high as 3mA if necessary. Apply probe perpendicular to tissue for approximately one second to elicit a response.

Electrode Placement: Figure 3.



Procedures

- Thyroidectomy
- Parathyroidectomy
- Radical Neck Dissection
- Anterior Cervical Fusion
- Substernal Goiter
- Hemithyriodectomy

Intraoperative monitoring of the Recurrent Laryngeal Nerve – branch of the Vagus (Cranial Nerve X). This surgery may be "noisy" due to potential manipulation of the nerve during blunt dissection. Also, the EMG tube is in close proximity to the surgical site which may produce some artifact.

Tips for Monitoring during Anterior Cervical Surgery

The EMG Endotracheal Tube should be utilized as for thyroidectomy. It may not be possible to directly stimulate the Recurrent Laryngeal Nerve as it may not be exposed. However, the NIM 2.0 System family will passively monitor traction and pressure status of the nerve and is especially helpful while the Thompson Retractor is being positioned and extended.

Monitoring Goal

Map the nerve, monitor manipulation effect, and verify nerve integrity.

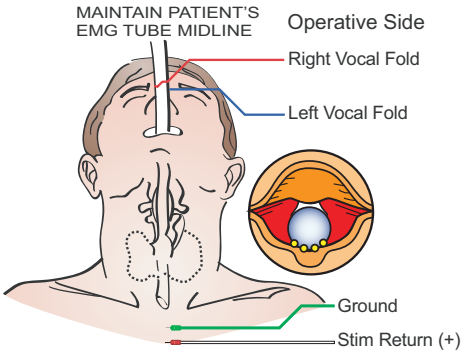
It is extremely valuable for the surgeon to verify nerve integrity prior to moving to the contralateral lobe dissection and prior to closing. Stimulate proximally and distally to the tumor site.

Procedure Specific Protocols

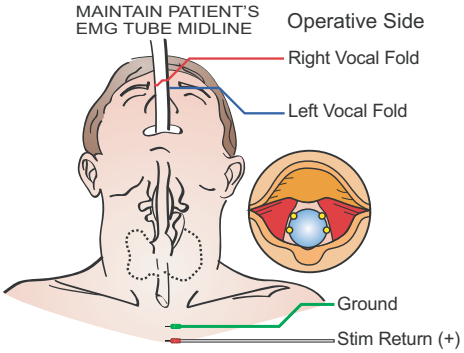
Suggested Electrodes	Part No.
NIM™ EMG Reinforced Endotracheal Tubes	8229XXX
See catalog for choice of sizes.	
• Usually use one size larger than normal.	
• Use only non anaesthetic lubricants like K-Y® Jelly.	
• Place EMG tube in the midline & with electrodes in contact with vocal cords. Secure tube to midline of mouth (not to the side). Temporarily deflate cuff for adjusting position. Complete instructions are provided in the package insert.	
• Visualize electrodes contacting true vocal cords.	

Suggested Stimulator Probes	Part No.
• Prass Standard Monopolar Probe	8225101
• Kartush Side-by-Side Bipolar Probe	8225401

NIM Contact™ Tube Electrode Placement: Figure 4.



NIM™ Standard Electrode Placement: Figure 4b.



Typical Electrode Readings	Channel Values	Difference Values
EMG tube	< 10 KΩ	< 1 KΩ

Event Threshold Range

Event Threshold Range is 100uV-150uV.

Stimulation Range

The Stimulation Range is approximately 1.0mA. The best guideline for setting the stimulus intensity level is to use the lowest amount of stimulation needed to produce an EMG response large enough for monitoring. If stimulation levels are too high, nerve fibers of adjacent branches may be stimulated. Be prepared to stimulate at a higher level if necessary. Apply probe perpendicularly to tissue for about a second to elicit a response.

If there is no response, shunt stimulus in the area just below the Adam's apple (cricothyroid), through the muscle. If there is response, the tube is probably too low through the vocal cords and will need to be repositioned.

Verifying Stimulus Delivery
The "Stimulus Tone" or "Stimulus Voice" can be heard if stimulus is flowing to the surgical site from the probe tip. Stimulus delivery can also be confirmed by comparing the Stimulus setting with the Stimulus Measure readings (mA). The stimulus measure reading will be found on the top right-hand side of the screen. The value should be approximately the same as the stimulus setting.

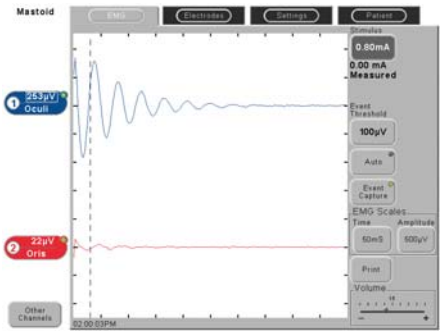
Tips for Reducing Artifact

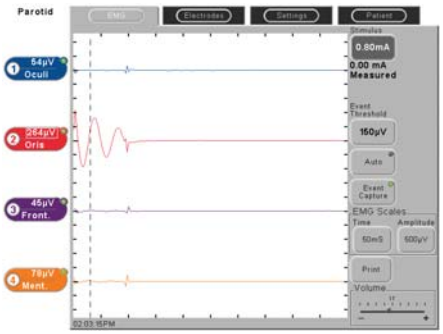
- Keep the NIM 2.0 Systems away from the electrosurgical unit and other electrical equipment.
- Ensure electrode cables are not intertwined with stim anode return or with stimulator probe cable.
- Utilize a bipolar stimulating probe as soon as the nerve is exposed to minimize artifact. Current is flowing in a very small area and stim levels can be reduced accordingly. Also, dry the surgical area before stimulating, as fluid can shunt current. Keep bipolar tips dry to prevent shunting.
- Minimize excessive stimulating current. Each patient's tissue conducts electrical energy differently. To decrease artifactual interference, it is better to establish effective levels of stimulating current as soon as possible to keep the current to a minimum. Begin stimulation with the lowest level, 0.05mA, with the Event Threshold at 100uV. Increase stimulus intensity fairly quickly until raw EMG sound is heard. This is the lowest level of stimulation which will evoke a response. Increase stimulus until an audible event tone occurs (the four-times-per-second tone we expect to hear when stimulating the nerve). Set the stimulation to at least this value.
- Note the reading next to the amplitude shown on the screen and adjust the Event Threshold slightly lower than that value. This will effectively screen out unwanted artifactual EMG activity.
- As an option in head and neck dissections, you may change the Stimulus Filter on the menu. For otology and skull base procedures, verify that the artifact delay marker is set to 3.1 milliseconds.
- If necessary, owing to frequent artifacts tones, disable the "Tone Audio". **You must now rely on raw EMG only.**

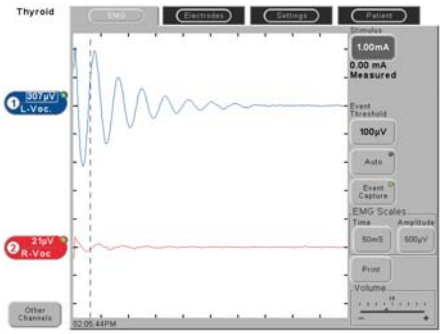
Procedure Specific Protocols

Example of EMG Responses

Interpretation of events by the surgeon is enhanced by knowing the characteristics of the waveform, peak-to-peak amplitude, strength of the audio signal, and the surgical context.



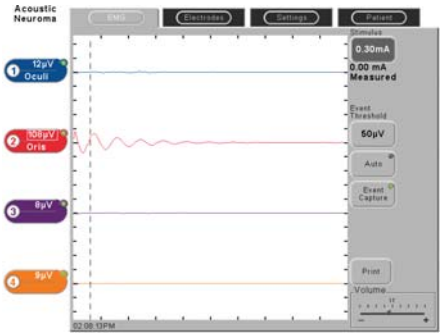


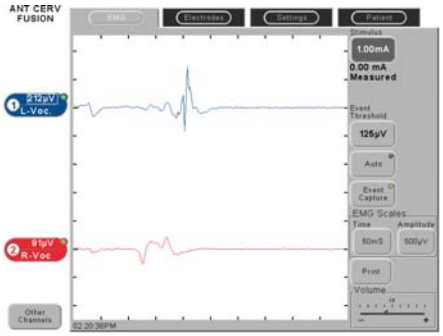


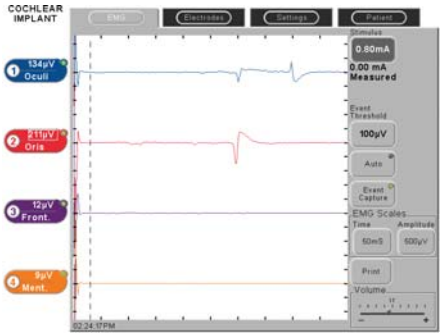
Stimulated EMG Response

Cause: Electrical stimulation

Sound: Precisely timed clicks, "machine gun", four times per second



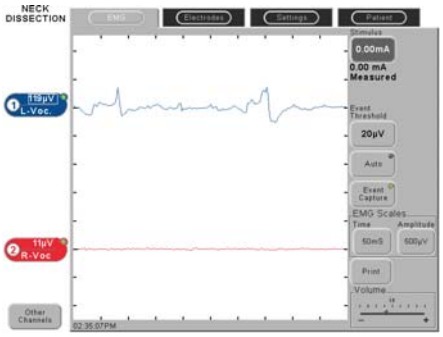


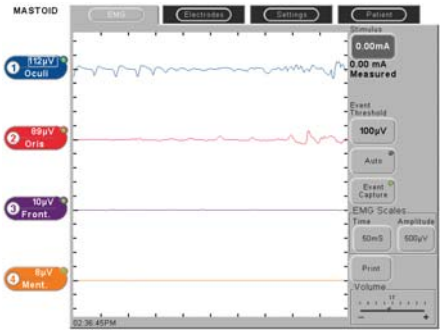


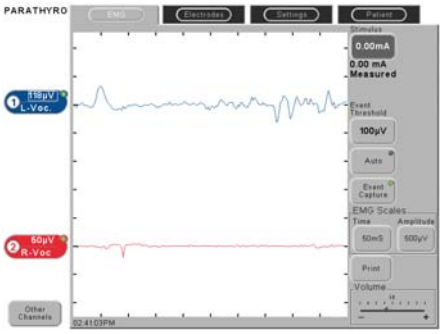
Mechanically-Evoked EMG Response

Cause: Direct surgical manipulation

Sound: Few clicks synchronous with manipulation



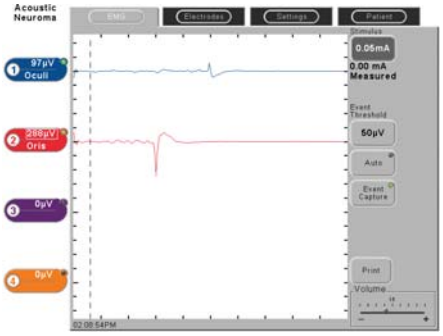




Train Response

Cause: Traction, Pressure, Irrigation, Caloric (hot or cold)

Sound: Repetitive asynchronous clicks, "popping corn"



Static Metal-to-Metal Artifact

Cause: Metal-to-metal ("banging of instruments")

Sound: "Pop"

References

This selection of reference clinical articles is provided for additional background material related to the monitoring procedures herein. The health care professional should seek and review all other clinical reference materials as dictated by an individual patient's clinical condition.

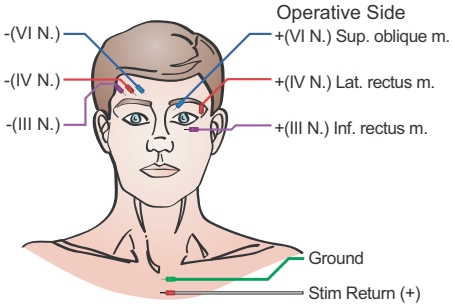
1. *Neuromonitoring in Otology and Head and Neck Surgery*, Jack Kartush, MD and Kenneth R. Bouchard, Ph.D., Raven Press, New York, 1992
2. *Handbook of Intraoperative Monitoring*, Douglas L. Beck, M.A., Singular Publishing Group, Inc., 1994
3. *Intraoperative Neurophysiologic Monitoring*. Aage R. Miller, Harwood Academic Publishers, 1995

Procedure Specific Protocols

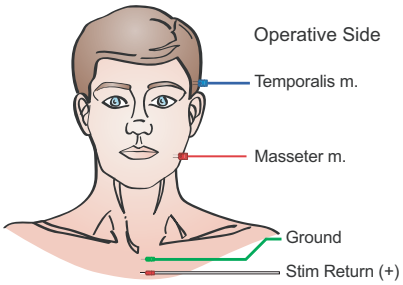
Electrode Placement

The surgeon will insert electrodes into the appropriate muscle location innervated by the monitored nerve. Additionally, a ground electrode (green) and a stim return (white) are needed to complete the electrode setup.

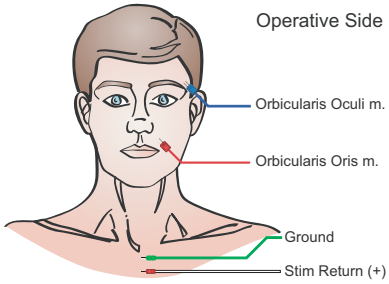
Extraocular Cranial Nerve III, IV, VI



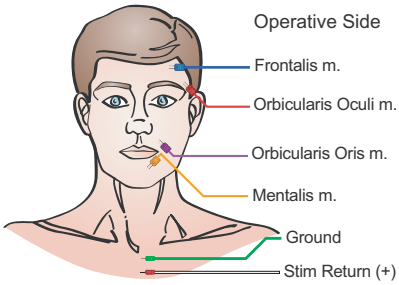
Trigeminal Cranial Nerve V



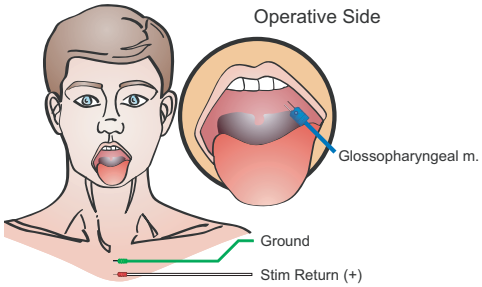
Facial Cranial Nerve VII – 2 Ch.



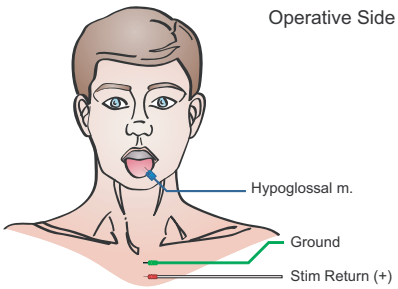
Facial Cranial Nerve VII – 4 Ch.



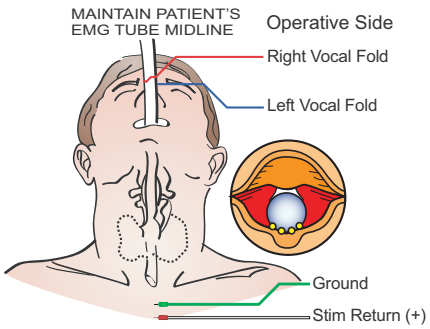
Glossopharyngeal Cranial Nerve IX

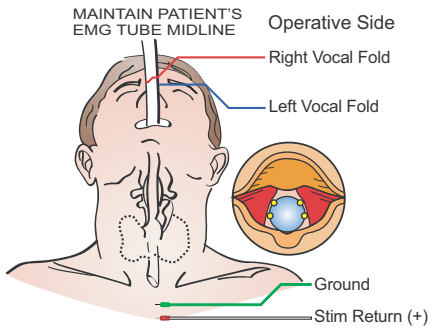


Hypoglossal Cranial Nerve XII

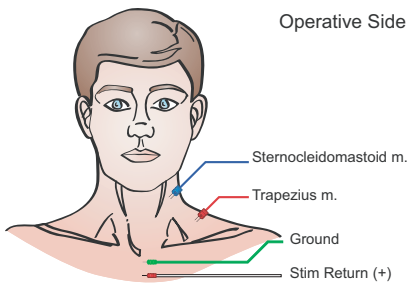


Vagus Cranial Nerve X





Spinal Accessory Cranial Nerve XI



TROUBLESHOOTING GUIDE

Please refer to the NIM-Response® 2.0 System User's Guide (82-50651) or the NIM-Neuro® 2.0 System User's Guide (82-50650) for complete operating instructions.

Symptom	Cause	Solution
No visual display or audio alarms at power-up.	Power cord not connected to outlet or to the NIM™ 2.0 system.	Plug in power cord.
	Power switch not turned on.	Turn power switch on.
Touching the screen has unexpected results.	Touch screen out of calibration.	Turn unit off, then press the screen until the screen calibration test is displayed. Follow the instructions on the screen to recalibrate.
Electrode impedance is too high. >10KΩ for subdermal electrodes >25KΩ for Prass Paired electrodes >10KΩ for EMG tube >40KΩ for hookwire electrodes	Electrode dislodged from patient, but not completely out.	Insert dislodged electrode; tape down in place.
	High resistance in electrode.	Remove and replace with new electrode.
	Electrode pin not firmly inserted into Patient Interface.	Check connection at Patient Interface box.
Electrode impedance = 0.0KΩ.	Positive and negative electrodes touching below surface of skin.	Remove and relocate electrodes.
	Extremely low impedance, particularly in EMG tubes.	Use "tap test" near electrodes to evoke EMG or artifact. If activity is noted on channel in question, proceed.
Channel button is flashing. Electrode reading is "— KΩ" or "OFF."	Electrode laying on skin surface. Electrode placement insecure.	Re-insert electrode in question.
	Dirty electrode tip. Electrode cable broken.	Remove and replace electrode in question.
	Electrode pin disconnected from Patient Interface.	Check connection to Patient Interface box.
Electrode difference is greater than 2KΩ (subdermal electrodes) or 10KΩ (Prass Paired electrodes).	Dirty electrode. Mismatched pair. Unequal placement.	Remove and replace electrode for appropriate channel with highest impedance reading first. Remove and replace electrode in question.
Electrosurgical interference.	Muting Probe not connected. Muting Probe input insufficient. Electrosurgical grounding inadequate. Source of interference unidentified.	• Check Muting Probe connections. • Move input to "MORE MUTE". • Check electrosurgical grounding pad on patient. • Identify source of interference; then eliminate or separate from the NIM 2.0 system.
	NIM 2.0 system or Patient Interface cable too close to ESU or its cables.	• Maintain separation between electrosurgical cable and the NIM 2.0 system. • For less coupling, coil up the Muting Probe next to the NIM 2.0 system.
Interference with anesthesia equipment.	Lead checking current near anesthesia electrodes.	Have anesthesia try alternate electrode channel. Turn stimulator to 0.0mA when not stimulating.
Excessive muting.	Unit receiving excessive signal into the Muting Probe or electrode leads.	Move the Muting Probe connector to a lower number unit until it stops muting. If it still mutes in position "1," disconnect the muting detector completely.
Inadequate muting.	Signal from ESU is inadequate to cause muting.	Move the Muting Probe connector to a higher number until it mutes. If it still does not mute in position "4," loop the ESU cable and clip the muting detector over the doubled cable.

Symptom	Cause	Solution
No response to direct stimulation.	Inadequate stimulus intensity.	Increase stimulus intensity.
	Paralyzing anesthetic in use.	Eliminate paralyzing anesthetic.
	White stimulation (+) electrode has fallen out or is not connected.	• Check that Stimulus Measure is approximately the same value as the Stimulus setting. Re-insert electrode in question. • Secure all recording and stimulating electrode connections and check the impedance values.
	Probe not connected.	Check stimulator anode(+) and cathode (-) connections.
	Patient safety fuse blown.	Check fuse in Patient Interface box (32 mA, x 250V). Replace if necessary.
	Not holding probe on nerve long enough.	Hold probe tip to nerve for at least 1 S.
	Nerve not contacted.	• Check stimulator tip for obstruction. Replace if necessary. • Check location of stimulation.
	Volume control too low. Event threshold set too high.	Check and correct all settings: volume, event threshold, stimulus intensity.
	Excessive current shunting in surgical field.	Remove fluids from surgical stimulating area.
	No electrodes in innervated muscle. Nerve not stimulable.	Place channel electrodes in muscle to be monitored.
Unexpected responses when not directly stimulating nerve.	Unexplained continuous "train" EMG response.	Identify and eliminate possible source of "train" stimulation: • Cold irrigation • Laser heat • Retraction on nerve or muscles being recorded • Patient waking from anesthesia • Nerve drying • Ultrasonic aspirator
	Nerve or monitoring area being stimulated or manipulated by thermal or mechanical means.	Identify and eliminate source of inadvertent manipulation.
	Metal-to-metal discharge artifact.	Determine response type from waveform pattern on 50 mS screen.
	Intertwined recording electrode and stimulator wires.	Disentangle recording electrode and stimulator cables.
	Inadvertent manipulation of electrode wires, Patient Interface cable, or recording area on patient.	Check area near recording electrodes for excessive stretching from tape, drapes, etc.
	Electrical interference from other equipment.	Check for intermittent stimulation from anesthesiologist (i.e., hand-held electrical stimulator). Move NIM 2.0 system away from source of interference. Make sure Patient Interface cable and electrode wires do not cross other electrical equipment or cables.

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