Application Notes

EMG and Direct Nerve Stimulation During Thyroid Surgery

• CLEO Nerve Monitor
• C2 Nerve Monitor
• NeMo NeuroMonitor
• ISIS IOM System
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Introduction
Basic Principles of Intraoperative Neuromonitoring

1 Introduction

1.1 Basic Principle

The term intraoperative neuromonitoring refers to the graphic and acoustic portrayal plus the documentation of the neurophysiological activity of one or more nerves during a surgical procedure.

The electrical stimulation of peripheral motor nerves will highlight action potentials and thus contraction of the innervated muscle. Muscle contraction is recorded by means of electrodes which are placed in or on the muscle. The electrical potentials created are known as electromyographical (EMG) recording.

EMG signals can be portrayed acoustically via a loudspeaker and visually on a display/monitor. The nerves can be clearly identified using this technique. In thyroid gland surgery, neuromonitoring is recommended to facilitate identification of the recurrent nerve. This is achieved by transmitting the total action potential of the vocal muscle (EMG) following prior direct nerve stimulation (DNS) of the recurrent nerve. Moreover, recording spontaneous activity by means of continuous EMG recording is beneficial as direct manipulation at the nerve site is immediately visible and audible in this way.

The purpose of this measurement is to locate and check the function of nerves in the proximity of the thyroid gland, essentially the recurrent nerve, which can be damaged as a result of thyroid gland surgery. In the worst case scenario, such damage can paralyse the vocal cords. Potential consequences include hoarseness, loss of voice and even the risk of suffocation.

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DQS – certified management system
for DIN EN ISO 13485:2003
CE 0297
1.2 Application

Preparation

Preparation begins with selecting the appropriate measuring programme on the respective neuromonitor:
• „Thyroid 1 channel“ for recording via needle electrodes
• „Thyroid 2 channel“ for recording via an adhesive laryngeal electrode.

The recording electrodes are then attached to the patient and connected to the pre-amplifier and headbox of the device via the recording cable.

The recording of an impedance measurement sometimes highlights recording electrodes with poor contact. However when using an adhesive laryngeal electrode, the recording can be checked prior to the procedure. An intraoperative check procedure is carried out by positioning a needle.

1.3 Stimulation Parameters

The following stimulation parameters can be set by the user:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>The stimulation frequency can be set from 1 – 30 Hz. A frequency of 1 - 3 Hz is usually selected for the stimulation of the recurrent and vagus nerve.</td>
</tr>
<tr>
<td>Current</td>
<td>The maximum adjustable current in thyroid gland surgery is 5 mA for direct nerve stimulation (DNS) and 10 mA for continuous vagus stimulation. Typical values are 1 - 3 mA with DNS and 2 - 6 mA with continuous vagus stimulation.</td>
</tr>
</tbody>
</table>

Please refer to your Monitoring System Manual before setting the stimulation parameters for the various types of device.
2. Stimulation

An inomed stimulation probe is used because it immediately stimulates the vagus and recurrent nerve.

Vagus stimulation is initially performed in order to ensure that the recording electrode(s) has (have) been positioned correctly, that the measuring system has the right settings and that the nerve is functioning over its entire distance.

If no stimulation response in the form of an EMG signal can be seen or heard, trouble-shooting must be carried out to pinpoint the fault – see Chapter 5, “Trouble-shooting”.

During the procedure, the nerve is detected by scanning the area in question with the stimulation probe. The signal in the EMG window of the respective nerve monitor is the response signal triggered by the stimulation.

Genuine nerve stimulation can be initiated in thyroid gland surgery with a time-delay of approximately 2 - 9 ms. Short post-stimulation responses, i.e. < 1 ms, indicate stimulation artefacts. In this case, the current quickly flows from the stimulation site via the body tissue (fast) to the recording point.

To pinpoint the nerve, the motor threshold must be exceeded in order to generate a stimulation response. (motor threshold = lowest current for a response to a stimulation).

To obtain a reliable response, the motor threshold should be slightly exceeded so as to ensure that the stimulation response is perfectly visible or audible via the loudspeaker throughout the procedure. The figure on the left shows vagus nerve stimulation.
3. Recording

Various techniques can be used to record the muscle response potential into the voice muscles:

3.1 Recording via Needle Electrodes
Various options are feasible for recording total action potentials. When using the bipolar needle electrodes (article no. 530 666), the needle is placed below the thyroid cartilage in order to record the muscle response potential into the vocal muscle. The second green needle should preferably be placed in the sternocleidomastoid muscle on the side undergoing surgery. The same procedure is feasible when using monopolar needle electrodes but the positioning procedure is more difficult.

3.2 Recording via an Adhesive Laryngeal Electrode
Recording via an adhesive laryngeal electrode (article no. 530 655 and 530 656) is a safe, reliable and less invasive intraoperative monitoring method. Monitoring is carried out by recording a surface EMG potential using a surface electrode attached to the endotracheal tube. The electrode is positioned close to the vocal cords.

3.3 Recording via Hooked Wire Electrodes
The hooked wire applicator (article no. 530 101 and 530 103) and the related hooked wire electrodes (article no. 530 600 and 530 601) are used for secure, patient-friendly oral positioning and subsequent recording of muscle response potentials. The insulated platinum wires have a blank tip and “hook” to the target muscle. They remain firmly and securely in position even with more vigorous handling procedures, e.g. in the larynx.

3.4 The response curve: the triggered EMG
The EMG stimulation response immediately following DNS stimulation is displayed. As the time delay with stimulation of the recurrent nerve is approximately 2 - 3 ms and that with vagus nerve stimulation around 3 - 7 ms, a short time window of 3 - 12 ms is sufficient to display the stimulation response.

3.5 Latency Overview of the EMG Signal

<table>
<thead>
<tr>
<th></th>
<th>Recurrent Nerve</th>
<th>Vagus Nerve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>2.0 – 3.0 ms (2.5 ms)</td>
<td>3.0 – 4.0 ms</td>
</tr>
<tr>
<td>Left</td>
<td>2.0 – 3.0 ms (2 ms)</td>
<td>6.0 – 7.0 ms</td>
</tr>
</tbody>
</table>
4. Measuring Setup

4.1 Measuring Setup I - Recording with Needle Electrodes

Step 1
Sterile area
• Insert the bipolar needle electrodes (white needle) into the vocal muscle.
• Insert the reference needle (green needle) into the surrounding tissue.

Step 2
Non-sterile area
• Connect the recording cable plug to the matching connections on the EMG box (same colour and number).

Step 3
Non-sterile area
• Connect the blue plug on the EMG box to the connector with the matching colour on your nerve monitor.

Step 4
Non-sterile area
• Connect the plug on the hand probe to the stimulator connections on the nerve monitor
  Sterile area
• Use the hand probe to stimulate in the surgical field.
4.2 Measuring Setup II - Recording via a Laryngeal Electrode

Step 1:
Sterile area
- Attach the adhesive laryngeal electrode to the tube (under sterile conditions). Do not use endotracheal tubes made of silicone.
- The adhesive laryngeal electrode is attached to the vocal muscle via intubation.

Step 2:
Non-sterile area
- Connect the recording cable plug to the matching connections on the EMG box (same colour and number).

Step 3:
Non-sterile area
- Connect the blue plug on the EMG box to the connector with the matching colour on your nerve monitor.

Step 4:
Non-sterile area
- Connect the plug on the hand probe to the stimulator connections on the nerve monitor
Sterile area
- Use the hand probe to stimulate in the surgical field.
### Measuring Setup

**Stimulation via V3 tripolar Vagus Stimulation Electrode**

#### 4.3 Measuring Setup III - Stimulation via V3 Tripolar Vagus Stimulation Electrode and Switch Box (not for C2 NerveMonitor)

**Step 1:**
- **Non-sterile area**
  - Connect the switch box (art. no. 520 220) to the stimulation output of the nerve monitor.
  - Connect the footswitch to the switch box (output: Footswitch).

**Step 2:**
- **Sterile area**
  - Connect the probe to the stimulation cable.
- **Non-sterile area**
  - Connect the plug on the hand probe and the stimulation cable of the V3 tripolar stimulation electrode to the switch box. The hand probe is connected to the “Probe” output and the V3 to the “Continuous” output.
  - Now position the switch box near the patient (e.g. on the operating table).
- **Sterile area**
  - Create a small pocket in the adventitia between the carotid artery and the jugular vein.
  - Check the position and function of the vagus nerve using the hand probe by activating the foot switch and depressing it when operating with the hand probe.
  - Position the V3 tripolar vagus stimulation electrode in the pocket on the vagus nerve. Stimulation is continued without activating the foot switch.
Measuring Setup

Stimulation Using the ABBA Technique

4.5 Measuring Setup IV.

Stimulation using the ABBA Technique

Sterile area
- Connect the stimulation cable to the stimulation probe
Non-sterile area
- Connect the stimulation cable to the stimulation output of your nerve monitor.

Sterile area
- Insert the stimulation probe into the surgical field using a trocar and stimulate the tissue to be identified.

Background information on the ABBA Technique:
The ABBA (Axillo Bilateral Breast Approach) technique is a minimally invasive surgical procedure used in total video endoscopic thyroid gland surgery. Subcutaneous trocars are inserted just below the platysma via incisions in the axial region and at the breast margin. The thyroid gland is prepared under videoscopy. The surgical stages are consistent with those of a conventional procedure whereby the preparation is extricated via the axilla.

Intraoperative nerve monitoring is carried out using long stimulation probes (article no. 522 128 or 522 123). The stimulation probes for direct nerve stimulation are inserted into the operation field via the trocar. The EMG response signals are recorded via the adhesive laryngeal electrode (article no. 530 655 or 530 656).

The ABBA technique is a procedure used for thyroid gland resection without scarring the throat. This offers a considerable cosmetic advantage.
### 5. Troubleshooting

If poor signals or virtually no signals are received:

<table>
<thead>
<tr>
<th>Error</th>
<th>Check in the non sterile area</th>
<th>Check in the sterile area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable connections</td>
<td>• Check to ensure that all non-sterile plug connections are firmly connected.</td>
<td>• Check that all connections in the sterile field are correctly connected.</td>
</tr>
<tr>
<td>Loose connections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defective needle electrodes</td>
<td>• Plug the needle electrodes into the pre-amplifier. A loud droning noise should be audible and the bar graphs on the relevant channel should deflect (NS 100/CLEO), measure the impedance (C2 NerveMonitor/ NeMo Neuromonitor / ISIS IOM system), these should be illuminated green.</td>
<td>• Visibly inspect the needle electrodes for damage;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Immerse the recording needle electrodes and stimulation probe in a container filled with saline solution. A 3-Hz knocking sound should be audible on passing a stimulation current of 0.5 mA and a frequency of 3 Hz;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ensure that the needle electrodes are correctly positioned in the target muscle.</td>
</tr>
<tr>
<td>Incorrect placement of the laryngeal electrode</td>
<td>• Carry out laryngoscopy to check that the adhesive laryngeal electrode has been positioned correctly.</td>
<td>• No option to test in the sterile area.</td>
</tr>
<tr>
<td></td>
<td>• Gently tap the larynx. The device should reflect the tapping sound and the bar graph should deflect (NS 100/ CLEO).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Check impedance on the device; if this is illuminated green, the electrode has tissue contact (C2 NerveMonitor, NeMo, ISIS IOM system).</td>
<td></td>
</tr>
<tr>
<td>Defective stimulation probe</td>
<td>• Check the non sterile connections;</td>
<td>• Immerse the stimulation probe in a container filled with saline solution. As a stimulation current of 0.5 mA is passed through, the “Current Confirm” display should be illuminated.</td>
</tr>
<tr>
<td></td>
<td>• Check that the stimulation parameter are set correctly, e.g. is the stimulation current switched on? Has the correct channel been selected? Has the correct stimulation current been set?</td>
<td></td>
</tr>
<tr>
<td>Anaesthesy: inappropriate time of relaxation</td>
<td>• Select the relaxant and set the relaxation time as close as possible to surgery.</td>
<td>• Co-ordinate the time to administer the relaxant during the operation.</td>
</tr>
<tr>
<td>Incorrect configuration of the device</td>
<td>• Check the mains connection. The main switch should be set to “On”.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Check whether the device loudspeaker is activated. Turn up the volume if need be.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Check the stimulation and recording parameters.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Check whether the correct channel has been selected (NS 100/ CLEO nerve monitor).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Check whether the correct stimulator is activated (C2 NerveMonitor).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Check the Auto Mute function for CLEO:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- if the switch is set to “Auto”, the volume can only be heard during stimulation with Current Confirm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- if the switch is set to “OFF”, the Auto Mute Sensor is switched off.</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If a sterile cover sheet is used for the C2 NerveMonitor and the NeMo Neuromonitor, points 2, 3 , 4 and 5 can be tested in the sterile area.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


6. Literature

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*Kontinuierliches Monitoring des Nervus laryngeus recurrens in der offenen Schilddrüsenchirurgie*  
Zentralblatt für Chirurgie, 3 - 2010
**Device Accessories for CLEO/NeMo/C2/ISIS Touch**

Art. no. 510 005
**Mute Sensor**
for suppressing RF interference signal, cable 4 m

**Disposible Accessories for Stimulation**

Art. no. 522 603 (10 pieces)
**Bipolar concentric stimulation probe, length 4.5 cm**
angled, for direct nerve stimulation, cable 3 m, instrument total length with handle 15.5 cm
- single use
- ETO sterilised

Art. no. 520 220
**Stimulation switch box**
Switch between controlling and continuous stimulation, for devices and systems with one stimulation output
- delivered non-sterile
- not autoclavable

**Accessories for Continuous Vagus Stimulation**

Art. no. 522 200
**V3 – Tripolar stimulation electrode for the vagus nerve**
Work piece: outer diameter 5 mm, length 21 mm, contact ring: width 3 mm, with 4 pole male connector, cable length 40 cm
- delivered non-sterile
- autoclavable

Art. no. 540 415 (2 channel)
Art. no. 540 425 (4 channel)
**EMG electrodes mini box with ground,**
4 x 1.5 mm or 8 x 1.5 mm touch-proof connectors DIN 42802, cable 4 m

Art. no. 522 610 (10 pieces)
**Microfork probe, length 4.5 cm**
straight, bipolar, for direct nerve stimulation, cable 3 m, instrument total length with handle 15.5 cm
- single use
- ETO sterilised

Art. no. 540 415 (2 channel)
Art. no. 540 425 (4 channel)
**EMG electrodes mini box with ground,**
4 x 1.5 mm or 8 x 1.5 mm touch-proof connectors DIN 42802, cable 4 m
**Reusable Accessories for Stimulation**

**Art. no. 522 103**

*Bipolar concentric stimulation probe, length 4.5 cm*

- angled, bipolar concentric, total length with handle 15 cm, for direct nerve stimulation
- delivered non-sterile
- autoclavable

**Art. no. 522 010**

*Microfork probe, length 4.5 cm*

- straight, bipolar, total length with handle 15 cm
- delivered non-sterile
- autoclavable

**Art. no. 520 024**

*Direct nerve stimulation cable*

- for inomed bipolar concentric stimulation probes
- silicon cable red 4 m, with 4 pole device connector and 4 pole instrument connector
- delivered non-sterile
- autoclavable

**Art. no. 522 123**

*Bipolar concentric stimulation probe, length 31 cm*

- angled, bipolar concentric, total length with handle 41.5 cm, for direct nerve stimulation
- delivered non-sterile
- autoclavable

**Art. no. 522 128**

*Bipolar concentric stimulation probe, length 31 cm, straight*

- for direct nerve stimulation, total length with handle 41.5 cm, work length 310 mm, diameter 1.3 mm
- delivered non-sterile
- autoclavable

**Minimally Invasive Procedure (using the ABBA technique)**

**Art. no. 522 103**

*Bipolar concentric stimulation probe, length 31 cm*

- angled, bipolar concentric, total length with handle 41.5 cm, for direct nerve stimulation
- delivered non-sterile
- autoclavable

**Art. no. 522 128**

*Bipolar concentric stimulation probe, length 31 cm, straight*

- for direct nerve stimulation, total length with handle 41.5 cm, work length 310 mm, diameter 1.3 mm
- delivered non-sterile
- autoclavable

**Accessory Kits**

**Art. no. 522 503**

*Kit of stimulation probes for thyroid surgery*

- consisting of: microfork probe, bipolar concentric stimulation probe angled, 2 DNS stimulation cables and sterilisation box
- delivered non-sterile
- autoclavable

**Art. no. 522 900**

*Sterilisation box*

- plastic, for stimulation instruments.
- Inner dimensions: 267 x 159 x 16 mm
- delivered non-sterile
- autoclavable
**Accessories for Recording via Needle Electrode**

- **Art. no. 530 227**
  - Electrode for vocal muscle bipolar, length 15 mm with neutral electrode
  - 1.5 m shielded connecting cable white, shaft effective length 15 mm, outer diameter 0.5 mm, 30° angled, 1.5 mm touchproof connectors red/black/green
  - delivered non-sterile
  - autoclavable

- **Art. no. 530 666 (10 pieces)**
  - Disposable electrode for vocal muscle bipolar, with neutral electrode, needle length 15 mm, 30° angled, 1.5 mm touchproof connectors red/black/green, round cable 1.5 m, individually packaged
  - single use
  - ETO sterilised

**Accessories for Recording via Laryngeal Electrode**

- **Art. no. 530 228**
  - Electrode for vocal muscle bipolar, length 25 mm with neutral electrode
  - 1.5 m shielded connecting cable white, shaft effective length 25 mm, outer diameter 0.5 mm, 30° angled, 1.5 mm touchproof connectors red/black/green
  - delivered non-sterile
  - autoclavable

- **Art. no. 530 665**
  - Connecting cable S, shielded for inomed laryngeal electrodes
  - cable 2 m, channel 1 and 2 with ground, 5 x 1.5 mm touchproof connectors DIN 41801
  - identification: bend protection yellow
  - delivered non-sterile
  - can be disinfected
  - for maximum signal quality

- **Art. no. 530 667**
  - Connecting cable S, shielded for inomed laryngeal electrodes
  - cable 4 m, channel 1 and 2 with ground, identification: bend protection blue
  - delivered non-sterile
  - can be disinfected

- **Art. no. 530 665 (10 pieces)**
  - inomed adhesive laryngeal electrode for tube of 6 – 7 mm inner diameter
  - adhesive surface length 32 mm, width 29 mm, with neutral adhesive electrode
  - single use
  - ETO sterilised

- **Art. no. 530 666 (10 pieces)**
  - inomed adhesive laryngeal electrode for tube of 7.5 – 9 mm inner diameter
  - adhesive surface length 32 mm, width 37 mm, with neutral adhesive electrode
  - single use
  - ETO sterilised