TOF 3D

NEUROMUSCULAR MONITORING

A new Era!

HOMINUM SALUTI MEDICINAM EXERCENS ®

MIPM

mipm.com

Product presentation_02/2026

AGENDA

- Reminder – NM Block and Monitoring
- Methods
- Acceleromyography – Good enough?
- Alternatives
- TOF3D MMG Technology
- Q&A

NMT MONITORING BASICS

NEUROMUSCULAR BLOCKING AGENTS

- Onset as well as duration depend on the condition of the respective patient.
- Duration of relaxation as well as muscular recovery depend on several external factors
  - Accompanying disease, Interaction with other drugs, pharmacogenetic factors*

*Fuchs-Buder

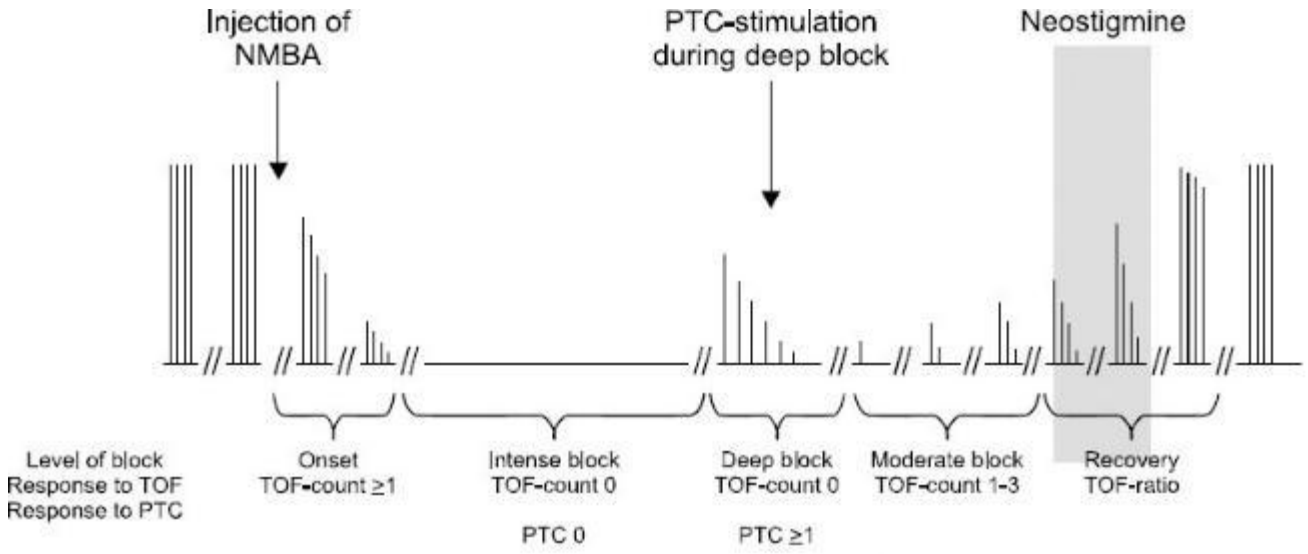
Residual Paralysis

What if the patient wakes up while blocking agents still influence the patient's muscles?

- Risk for pulmonary events
- Impaired ability to swallow
- Post operative malaise of patients

NEUROMUSCULAR MONITORING

NEUROMUSCULAR BLOCK AND THE RECOVERY PHASE

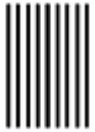


Muscle reaction to NMBA and sequence of recovery

- Pharyngeal muscles
- Masseter muscle
- Genioglossus muscle
- Adductor pollicis muscle
- Abdominal muscles
- Orbicularis occuli muscle
- Vocal cord muscles
- Corrugator supercilia muscle
- Diaphragm

NEUROMUSCULAR MONITORING

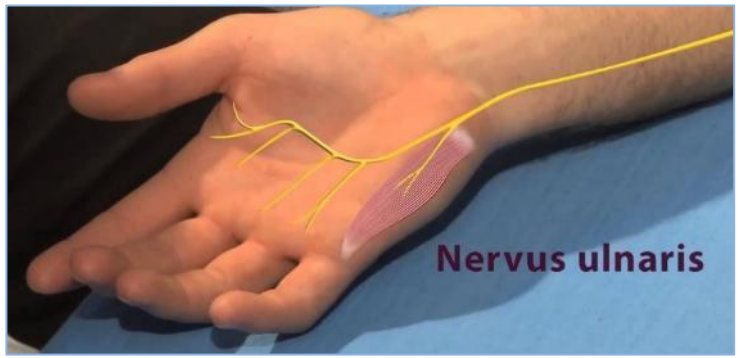
PATTERNS OF NERVE STIMULATION

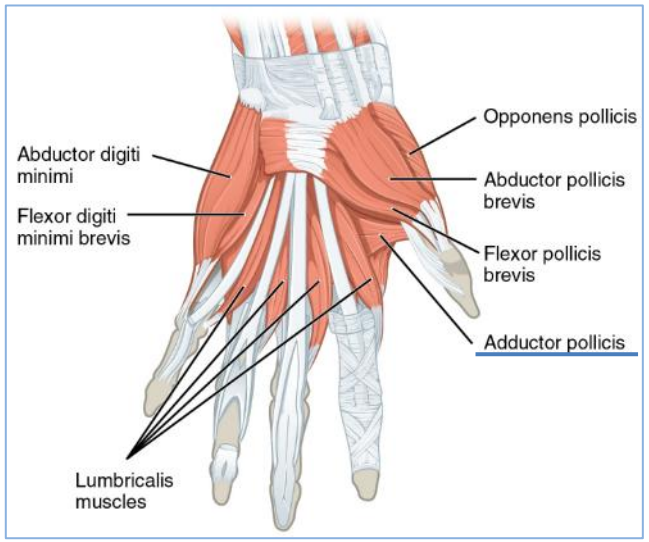
Monitoring Test	Definition	Comments	Stimulation Characteristics
Single twitch	A single supramaximal electrical stimulus ranging from 0.1-1.0 Hz	Requires baseline before drug administration; generally used as a qualitative rather than quantitative assessment	
Train-of-four	A series of four twitches at 2 Hz every ½ second for 2 sec	Reflects blockade from 70%-100%; useful during onset, maintenance, and emergence Train-of-four ratio is determined by comparing T_1-T_4	
Double-burst simulation	Two short bursts of 50 Hz tetanus separated by 0.75 sec	Similar to train-of-four; useful during onset, maintenance, and emergence; may be easier to detect fade than with train-of-four; tactile evaluation	
Tetanus	Generally consists of rapid delivery of a 30-, 50-, or 100-Hz stimulus for 5 sec	Should be used sparingly for deep block assessment; painful	
Posttetanic count	50-Hz tetanus for 5 sec, a 3-sec pause, then single twitches of 1 Hz	Used only when train-of-four and double-burst stimulation is absent; count of less than eight indicates deep block, and prolonged recovery is likely	

NEUROMUSCULAR MONITORING

TOF STIMULATION – TOF RATIO / TOF COUNT

- Nervus ulnaris is innervated with 4 impulses
- Depending on neuromuscular block, 0-4 responses of Musculus Adductor Pollicis are received by TOF Monitor
- TOF Ratio = T4/T1
- TOF Ratio can only be calculated if 4 responses are detected.
  - T1 must be >20% compared to base line (Individual 100% answer)
  - T2, T3, T4 must be >3%
- Otherwise TOF Count 0 – 4
- If 4 responses are detected TOF Ratio is shown as “percentage of recovery”





ACCELEROMYOGRAPHY -AMG

ADVANTAGES AND LIMITATIONS

A piezoelectric myograph, used to measure the force produced by a muscle after it has undergone nerve stimulation.
Acceleromyographs measure muscle activity using a miniature piezoelectric transducer that is attached to the stimulated muscle. A voltage is created when the muscle accelerates, and that acceleration is proportional to force of contraction.

ADVANTAGES

- Has been shown to better alleviate residual blockade and associated symptoms of muscle weakness, and to improve overall quality of recovery compared to subjective monitoring.
- The signal is not prone to extraneous noise from electromagnetic fields
- Only one sensor is needed and placement is less crucial with regard to the recorded signal.
- An accepted and proven technology.

LIMITATIONS

- Requires free muscle (thumb) movement.
- Results may vary depending on hand setup.

ELECTROMYOGRAPHY - EMG

ADVANTAGES AND LIMITATIONS

EMG is a technique for evaluating and recording the electrical activity produced by stimulation of a peripheral nerve. The signal picked up by the analyzer is processed by an amplifier, a rectifier, and an electronic integrator. The results are displayed either as a percentage of control or as a TOF ratio.

ADVANTAGES

- Equipment for measuring evoked EMG responses is easier to set up,
- The response reflects only factors influencing neuromuscular transmission, and
- The response can be obtained from muscles not accessible to mechanical recording.

LIMITATIONS

- The results are not always reliable. For one thing, improper placement of electrodes may result in inadequate pickup of the compound EMG signal.
- Affected by and very sensitive to electrical interference

MECHANOMYOGRAPHY -MMG

ADVANTAGES AND LIMITATIONS

A piezoelectric myograph is used to directly measure the force produced by a muscle after it has undergone nerve stimulation.

ADVANTAGES

- Has been shown to better alleviate residual blockade and associated symptoms of muscle weakness, and to improve overall quality of recovery compared to subjective monitoring or AMG based monitoring.
- The signal is not prone to extraneous noise from electromagnetic fields
- Only one sensor is needed, and placement is less crucial with regard to the recorded signal.
- Not dependent on moving muscles – Easier setup during surgery

LIMITATIONS

- Can only be used at m. Adductor Pollicis

NEUROMUSCULAR MONITORING

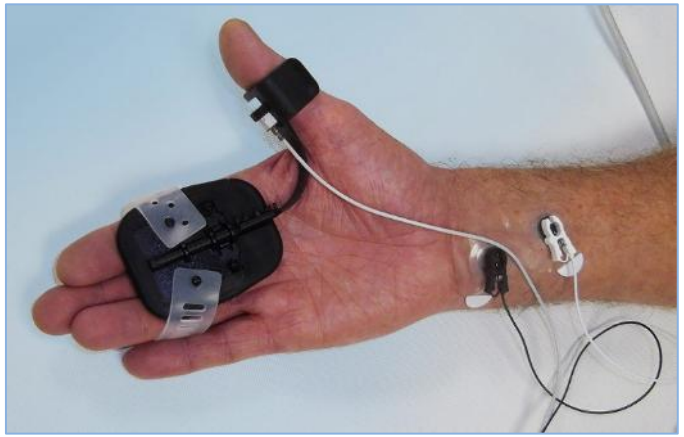
AMG – STANDARD OF CARE

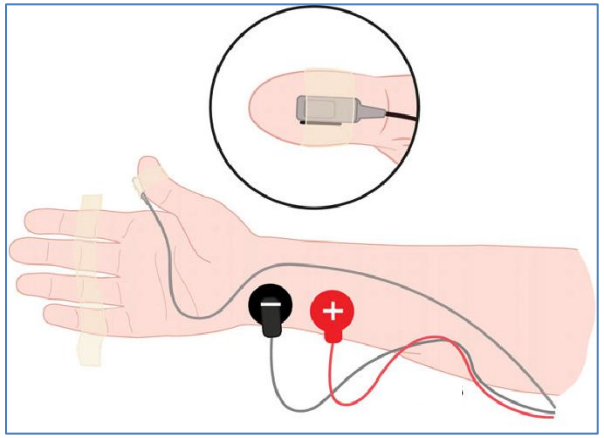
It all starts with the correct setup of stimulation electrodes and acceleration sensor! The hand should be fixed to the OR table, or the hand adapter should be used.

Use small (pediatric) electrodes to ensure proper placement and skin contact.

Observe polarization of the stimulation cables.

- Positive (White) cable: Proximal
- Negative (Black) cable: Distal





NEUROMUSCULAR MONITORING

AMG – GOOD ENOUGH?

The shortcoming of AMG technology is that the observed muscle (e.g. adductor pollicis) requires space to move.

Only the movement (acceleration) of the muscles can be picked up by the sensor.

If hands are tucked to the body in an unfavorable way or if the free movement of the muscle is blocked by blankets or surgical drapes AMG will not work!

Using the hand adapter improves the performance by holding up the thumb providing space to move.

If the monitor cannot be used on adductor pollicis (thumb) there are different setups:
Orbicularis occuli muscle, Flexor hallucis brevis muscle

NEUROMUSCULAR MONITORING

AMG – GOOD ENOUGH?

- In the past many customers got frustrated.
  - Many customers were willing to do NMT monitoring but stopped when getting poor results.
  - This got better when 3D transducers were introduced.
- Many OR setups do not allow for AMG based monitoring.
  - Even the alternatives might be difficult to setup.
- It is easy to block the muscle even if the initial setup was good.
- Change in patient position might have an effect on the results.
- Many customers consider AMG monitoring as the “smallest evil”.

NEUROMUSCULAR MONITORING

ALTERNATIVES – EMG

Users start to move away from AMG devices and use the next best alternative.

EMG

Meanwhile some competitors have EMG based monitors or offer EMG as an option.

- Senzime
- Blink Device
- Xavant

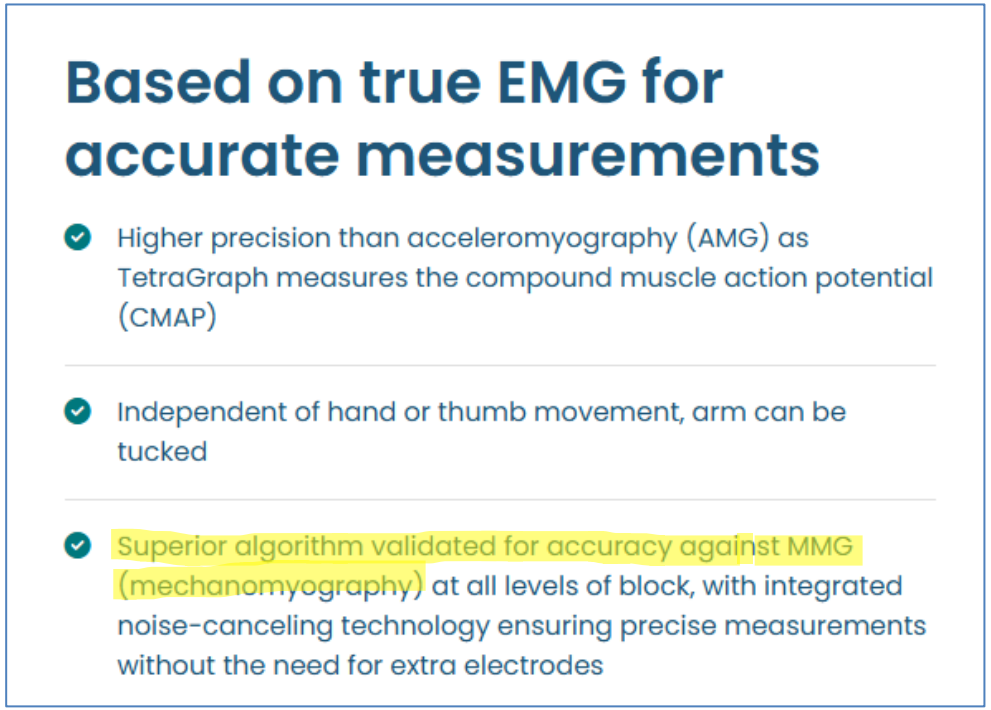
- Precise measurements
- Independent of hand position

But!

NEUROMUSCULAR MONITORING

ALTERNATIVES - ELECTROMYOGRAPHY

- More precise than AMG
- No muscle movement required.
  - Independent of patient position
- Reliable data throughout the complete case
- Exploding cost for NMT monitoring
- Single use electrodes bring prices through the roof.
- Validated against MMG!



Extract from Senzime product webpage

TOF3D MMG TECHNOLOGY

THE ALLROUNDER FOR NEUROMUSCULAR MONITORING

- Two measurement methods
  - AMG – Acceleromyography
  - MMG – Mechanomyography

TOF3D MMG TECHNOLOGY

EMG vs. MMG

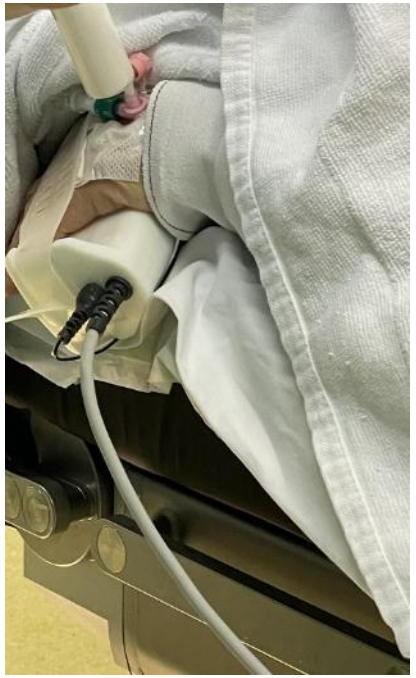
- Both technologies show equally good measurement results. (MMG is gold standard)
- TOF 3D MMG Technology offers the same precision as EMG technology* but without the problem of exploding cost.
  - Reusable MMG Sensor
  - Only standard electrodes for stimulation
- EMG Technology = >25€ per case!
  - Consider 10.000 anesthesia cases p.a.!

* Clinically proven

TOF3D MMG TECHNOLOGY

THE ALLROUNDER FOR NEUROMUSCULAR MONITORING

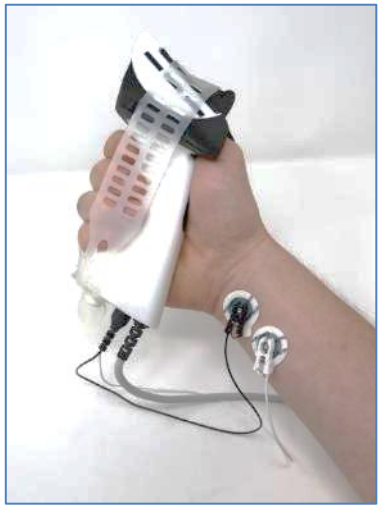
- MMG Mode
  - The MMG adapter works even if the hands are tucked to the body or are covered with drapes.



TOF3D® MMG TECHNOLOGY

DIRECT MUSCLE FORCE MEASUREMENT

Easy application
The thumb is embedded in the measurement compartment.
No need for thumb movement. MMG determines the muscle force directly.
Use standard electrodes for the stimulation.
No cost for additional disposable accessories.



TOF3D® MMG TECHNOLOGY

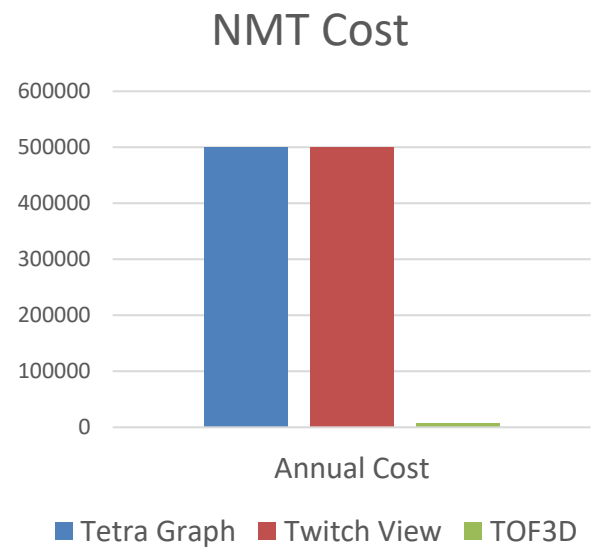
EMG vs. MMG - A COST EXAMPLE

Forget about the cost of the monitor. It's the accessories driving the operating cost.

Consider:
10.000 anesthesia cases per year.

Customers will use expensive pads for stimulation – 0,20€ per pad.

- Tetra Graph - Year 1
  - 25€ per disposable pad
  - Total cost for NMT monitoring: **250.000€**
- Twitch View - Year 1
  - 25€ per disposable pad
  - Total cost for NMT monitoring: **250.000€**
- TOF3D - Year 1
  - 0,40€ for disposable pads.
  - Total cost for NMT monitoring: **4.000€**



After **2** years the cost for **EMG** monitoring have accumulated to **0,5 MILLION €**. The cost for **MMG** monitoring accumulate to only **1,6%** of that amount.

In other words, **EMG** monitoring is **60 times more expensive** than **MMG** monitoring, giving the same result.

TOF3D MMG TECHNOLOGY

AREN'T WE SUPPOSED TO MAKE SMART DECISIONS?

MMW

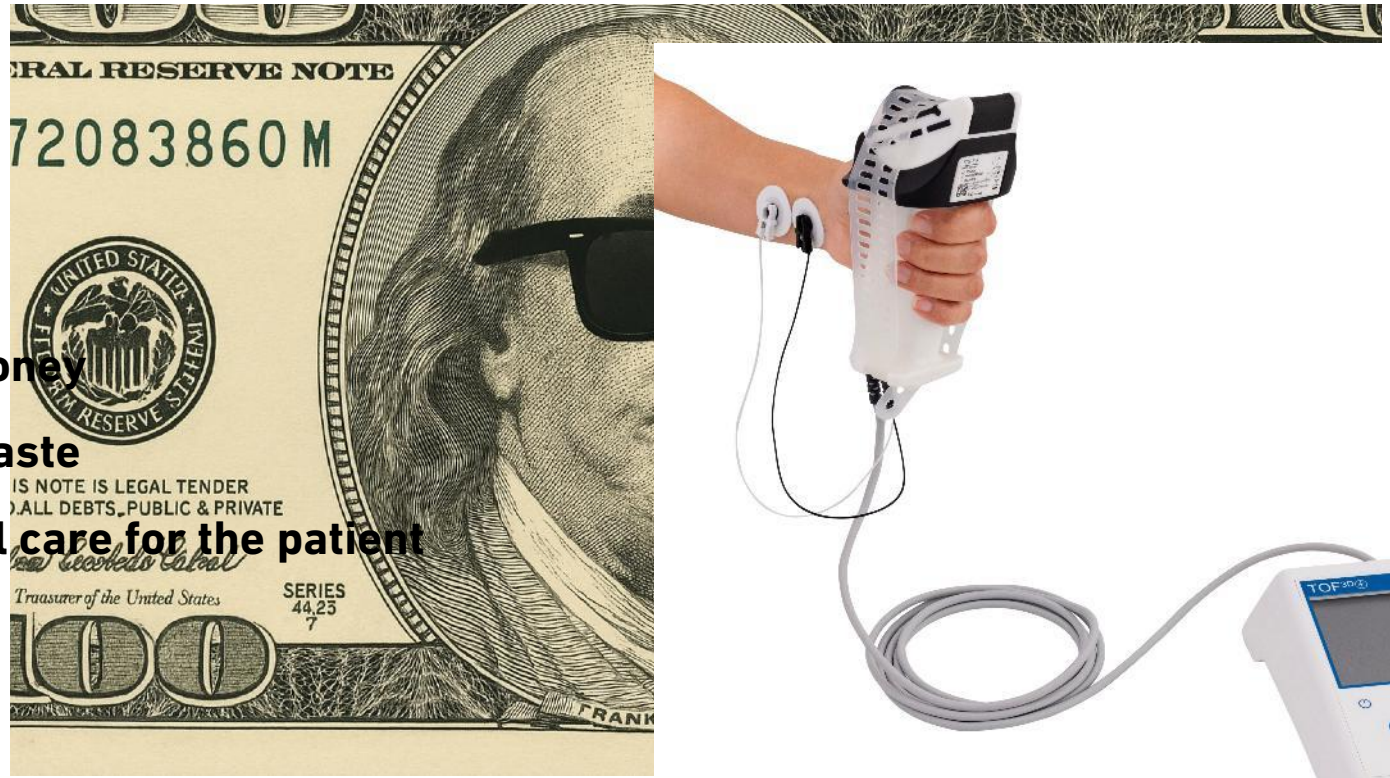
EMW

TOF3D MMG TECHNOLOGY

Safe Money

Less waste

Optimal care for the patient



TOF3D MMG TECHNOLOGY

WHAT TO DO WITH EXISTING CUSTOMERS?

It is possible to upgrade existing monitors with the MMG function.

You will need the Updater cable (can be used for future software updates as well).

The update file is free of charge.

After the software upgrade has been completed the monitor will realize the MMG sensor.

5750123	Updater Cable TOF3D		300,00 €

TOF3D - NEUROMUSCULAR MONITOR

QUESTIONS AND ANSWERS

TOF3D – https://www.youtube.com/watch?v=FUhKgeJxPek

If you have any further questions about our products or our company. Please contact us at https://www.mipm.com/en/contact

Or ask your local MIPM sales partner – www.mipm.com/en/dealer-locator