



# Neuromuscular Monitoring in Clinical Practice

Possible Solutions and practical realization



# Neuromuscular Blocking Agents (NMBA)

- **NMBA belong to the most frequently used agents in general anesthesia**
- **Support Intubation**
- **Maintain surgical conditions**

# Neuromuscular Blocking Agents (NMBA)

- 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<sup>\*</sup>

<sup>\*</sup>Fuchs-Buder



# Neuromuscular Blocking Agents (NMBA)

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

# Neuromuscular Monitoring

- **„No Monitoring“ (Duration of effect)**
  - **„Clinical Signs“**
- **Subjective Neuromuscular Monitoring (tactile / visual evaluation)**
- **Objective (quantitative) Neuromuscular Monitoring**

## „No Monitoring“

- In many cases NMBA are administered without proper monitoring.

### Survey (2018) Use of NMT monitoring

Europe: 20%

US: 10%

Australia: 10%

### Never use NMT Monitoring!

Subjective monitoring in < 40% of all patients

Objective monitoring in < 20% of all patients

## **„No Monitoring“**

- In 12% of hospitals and 67% of private centers NMT monitoring is not available.**
- In 44% of hospitals and 63% of private centers decisions about additional relaxation are based on clinical signs! (Coughing, Bear Down) or „fixed time intervals“.**
- Even if reversal agents are administered the incidence of residual blockade is between 20-40%**

## „No Monitoring“

- In 54% of hospitals and 70% of private centers clinical signs are the most frequently used criteria for the decision of neuromuscular reversal
- Evaluation of residual paralysis based on clinical tests
  - Tongue spatula test
  - Head Lifting >5 Sec. (possible at TOF = 0,5!)

**The tests can only be applied in the very late phase of anesthesia. Only AFTER extubation!**



# Neuromuscular Monitoring

## Mechanomyography - MMG

- Measures the force of the muscle (Pressure sensor)
- Preload of muscle is necessary
- Sensitive technical setup
  - Small changes in the positioning of the patient may influence the measurement result
- Mostly used for research and studies
- Reference method for NMT Monitoring

# Neuromuscular Monitoring

## Electromyography - EMG

- Measures the electric action potentials of the muscle
- Digital signal processing
- Provided a low noise level, the signal quality and measurement results are close to MMG.
- Susceptible to electric interferences, temperature and movement

# Neuromuscular Monitoring

## Acceleromyography - AMG

- Measures acceleration of the muscle
- 2. Newtons Law:  $F = m \times a$  (*force = mass times acceleration*)
- Mass constant → Force proportional to acceleration
- Piezo crystal changes potential during acceleration. Changes are measured and amplified.
- Free movement of the respective muscle is necessary!

# Subjective Monitoring

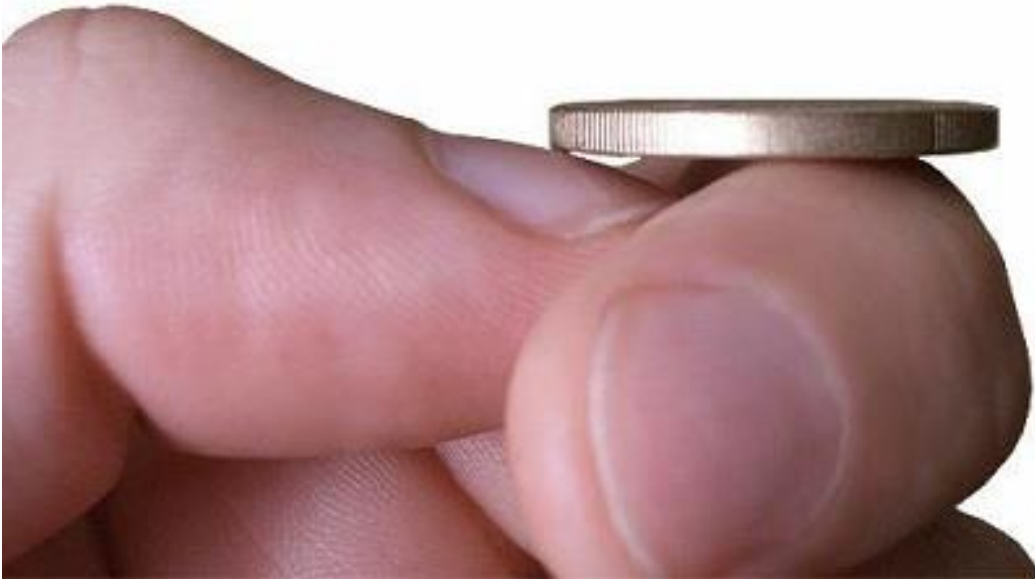
- **Various peripheral Nerve stimulators**
  - Evaluation is done visually / tactile
- **Stimulation modes**
  - Single Twitch (Single Stimulation)
  - Train of Four (TOF)
  - Double Burst (DBS)
  - Tetanic Stimulation
  - Post Tetanic Stimulation (PTC)

# Subjective Monitoring

- Studies have shown that when using TOF stimulation even experienced physicians cannot tell the difference between muscular response if TOF is  $> 0,5$ .
  - Unexperienced users if TOF = 0,4
- Using DBS the result is „improved“ to TOF = 0,6.
- DBS is better than TOF if subjective monitoring is used.

# Subjective Monitoring

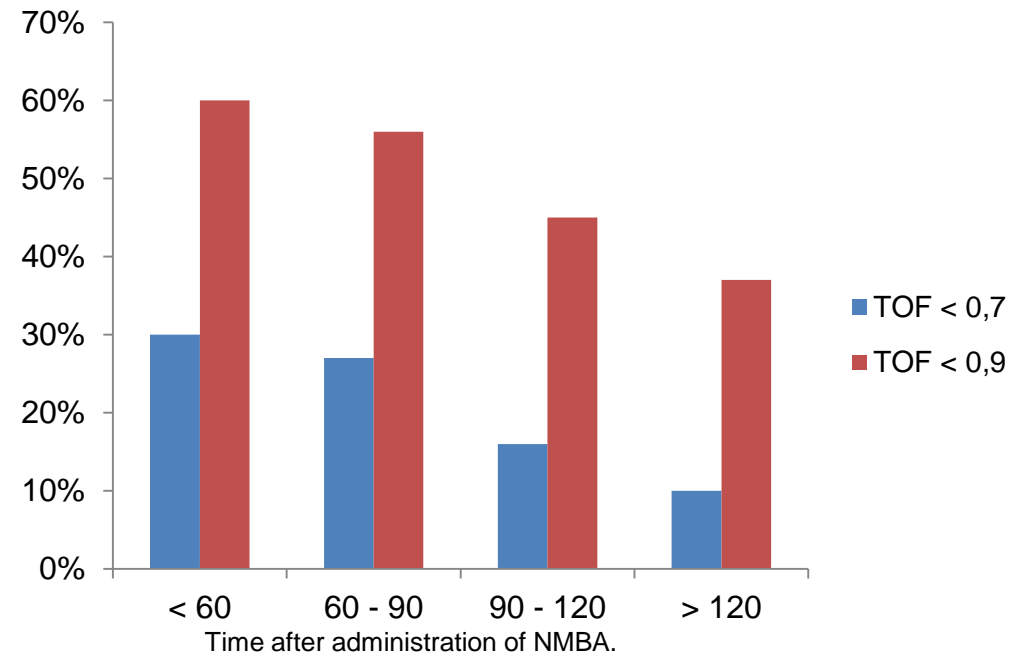
**A study recently conducted in the USA showed that the assessment of TOF = 0,9 has a 47% hit rate.**



**= 50 : 50**

# Subjective Monitoring

## Residual paralysis in the PACU



# Vital functions during recovery

	<b>TOF 0,5</b>	<b>TOF 0,8</b>	<b>TOF 1</b>
<b>Tidal volume</b>	Normal	Normal	Normal
<b>Forced Vital capacity</b>	Often compromised	Often normal	Normal
<b>Pharyngeal Function (Swallowing)</b>	Certainly compromised	Often compromised	In general normal
<b>Integrity of upper Airway</b>	Certainly compromised	Often compromised	In general normal
<b>Hypoxic breathing response</b>	Often compromised	Often normal	Normal



# Objective Monitoring

**AMG has shown to be a practical method for NMT monitoring in clinical practice.**

**Measurement of muscle acceleration using an acceleration transducer (Piezo Crystal) – Quantifiable! Strength of the muscle response can be measured by transducer.**

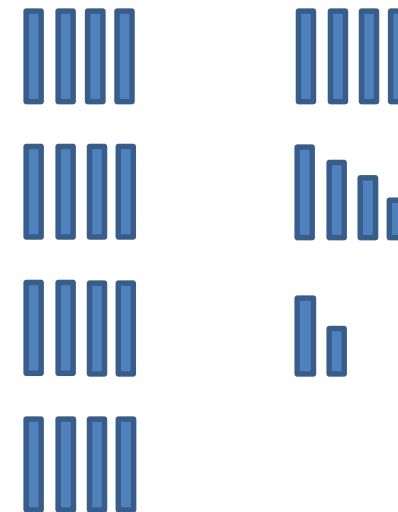
**Can be used on different muscles – Adductor pollicis is most suitable.**

# Objective Monitoring

- Calculation of TOF ratio: 4 Stimulation impulses  
0-4 Responses.

$$\text{TOF Ratio} = T4 / T1$$

- No block
- Partly NM block
- Strong NM block – TOF Count
- Complete NM block



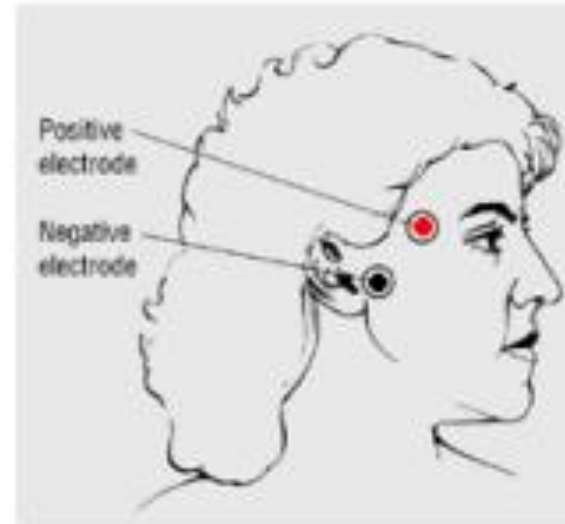
# Objective Monitoring

- **Different NMT modules on the market**
  - (GE, Philips)
- **Handheld Devices**
  - TOF 3D
  - TOFScan
  - StimPod
  - TetraGraph
  - TwitchView

# Alternative electrode placement

**Facial nerve:** place negative electrode (black) by ear lobe and the positive (red) 2cms from the eyebrow (the along facial nerve inferior and lateral to eye)

- Response: Orbicularis oculi muscle – eyelid twitching



# Alternative electrode placement

**Sural (posterior tibial) nerve:** place the negative electrode (black) over inferolateral aspect of medial malleolus (palpate posterior tibial pulse and place electrode there) and positive electrode (red) 2-3cm proximal to the negative electrode

- Response: Flexor hallucis brevis muscle – planter flexion (curl) of big toe



## References

- Neuromuskuläres Monitoring in Klinik und Forschung (Fuchs-Buder)
- Einsatz des Neuromuskulären Monitorings in Deutschland (Der Anästhesist – 09/2008 pp. 908-914)
- Residual Paralysis in the PACU after a Single Intubating Dose of Nondepolarizing Muscle Relaxant with an Intermediate Duration of Action (Debaene et al. Anesthesiology 2003; 98:1042–8)
- A Survey of Current Management of Neuromuscular Block in the United States and Europe (Naguib et al. International Anesthesia Research Society, 2009)