Muscular relaxation & neuromuscular monitoring in the Perioperative environment

Imagination at work

JB42454XE

- Muscular relaxation and neuromuscular monitoring: facts & figures
- Anaesthesia societies recommendations and guidelines
- Residual neuromuscular blockade: a patient safety hazard
- Remarkable clinical scenarios
- Benefits of applying systematic neuromuscular monitoring
- NMT stimulation modes and application
- NMT monitoring technology: state of art
- Conclusion and take away

Muscular relaxation and neuromuscular monitoring: Facts & Figures

Neuromuscular block often persists in PACU, even with the administration of reversal. The frequency ranges between

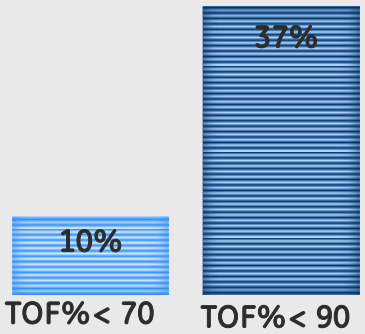
4% and 50%

(Butterly A. et al., 2010; Plaud, B et al. , 2010)

45% of patients had a TOF%<90 on arrival in the PACU after only a single intubating dose of NMBA

(Debaene et al. Anesthesiology 2003)

PACU: post anesthesia care unit
NMBA: neuromuscolar block agent
TOF: train of four



>2 hs between administration of muscle relaxants and arrival in PACU (n=238)

In those patients for whom only 'clinical criteria' (e.g. head lift, leg lift, hand grip) were considered before tracheal extubation,

more than 40% had a TOF%<90

(Cammu Anesth. Analg., 102, 426-429, 2006)

NMBA use was associated with a **40%** increase in relative risk of reintubation, which itself increased the risk of hospital mortality 90-fold (Grosse BMJ., 345, e6329, 2012)

Lack of agreement among anaesthesia providers for optimal monitoring of neuromuscular function

(Naguib et al. A&A 2010)

Muscular relaxation and neuromuscular monitoring: Facts & Figures

Neuromuscular transmission is insufficiently monitored in daily clinical practice

Spain

763 patients from 26 hospitals, **26.7%** of patients showed residual paralysis in PACU
(Errando Minerva Anes 2016)

France

A study shows that between 1995 and 2004, a **significant decrease** in PORC in PACU was noted with an increased use of NMT monitoring and education
(Baillard BJA Br. J. Anaesth., 95, 622-626, 2005)

Denmark, Germany, UK

Surveys have suggested that respectively only **43%, 28%, 10%** of clinicians routinely use neuromuscular monitors
(Naguib A&A 2010)

UK

In a study of 12 large anaesthesia departments, TOF monitors were only routinely used in **9%** of cases; in **62%** of cases, the monitors were never used
(Sweeney Anaesthesia, 62, 806- 809, 2007)

Europe

Only **one third** of the survey sample, considered necessary to monitor neuromuscular block with objective NMT monitoring
Only **45%** of anaesthetists in Europe base their decurarization decision on TOF values
(Naguib et al. 2007)

PACU: post anesthesia care unit
PORC: Post operative residual curarization
NMT: Neuromuscolar transmission
TOF: train of four

TOF: train of four
NMTM: Neuromuscolar transmission monitoring
PORC: Post operative residual curarization

Anaesthesia societies recommendations

Missing Guidelines

AAGBI[1]

2015 Recommendations for standards of monitoring during anaesthesia and recovery mandates that "a peripheral nerve stimulator must be used whenever neuromuscular blocking drugs are given. It should be applied and used from induction until recovery from blockade and return of consciousness"[1]

APSF (ASA)[2]

Residual neuromuscular blockade in the postoperative period is a patient safety hazard that could be addressed completely by applying quantitative (objective TOF) monitoring along with traditional subjective observations to eliminate the problem[2]

* ASA & ESA guidelines still missing

Currently, there is a gap in terms of guidelines and recommendations of scientific societies on NMTM and PORC. In daily practice this coincides with a variety of management strategies for neuromuscular blockade [3]

1)Association of Anaesthetists of Great Britain and Ireland. Recommendations for standards of monitoring during anaesthesia and recovery 2015. Anaesthesia 2016; 71: 85-93.
2) An Updated Report by the American Society of Anesthesiologists Task Force on Postanesthetic Care - Anesthesiology, V 118 • No 2- 2013
3)Post-Operative Residual Curarization (PORC): A Big Issue for Patients' Safety Innocenti, Melotti

GA: general anaesthesia
PORC: Post operative residual curarization

Residual neuromuscular blockade: a patient safety hazard

Worldwide [2]

- 250M Ane procedures /year
- 50% in GA
- 51,75 M patients have PORC

100 Patients / min PORC

PORC Implications [1]

- Need for tracheal intubation
- Impaired oxygenation and ventilation
- Reduced pulmonary function
- Risk of aspiration and pneumonia
- Discomfort for patients and operators
- Increased lenght of stay*

Can patient surveillance be considered adequate in the Post Anaesthesia Care Unit?

1) Journal of anaesthesia patient safety foundation: Feb 2016: Monitoring of Neuromuscular Blockade: What Would You Expect If You Were the Patient?
* Butterly ae Al BJA 2010 Sep;105(3):304-9. doi: 10.1093/bja/aeq157. Epub 2010 Jun 24.
2) Debaene et al. Anesthesiology 2003

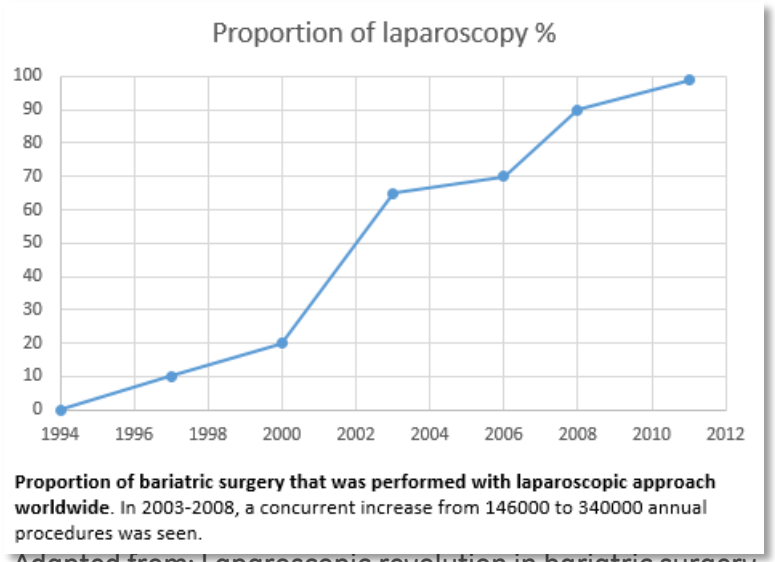
NMB: neuromucolar block
NMBA: neuromucolar blocking agents
TOF: train of four

Remarkable clinical scenarios

Laparoscopy: when deep NMB is required

Deep NMB can improve surgical conditions during laparoscopic surgery:

- Helps improving laparoscopic workspace
- Allows to work at lower insufflation pressure
- Avoids unwanted abdominal or diaphragmatic movements



Proportion of bariatric surgery that was performed with laparoscopic approach worldwide. In 2003-2008, a concurrent increase from 146000 to 340000 annual procedures was seen.

Adapted from: Laparoscopic revolution in bariatric surgery. World J Gastroenterol. Nov 7, 2014; 20(41): 15135-15143

- How to measure intense/deep/moderate block?
- How to optimize continuous NMBA infusion?
- When do you inject anatagonist? In which dose?
- When do you extubate safely?

Surgeon

S: I don't have enough workspace.

S: Look at the video screen. I can't work.

S: It is already 18 mmHg. Do you want me to change to a laparotomy?

Anesthesiologist

A: Your problem. I am okay.

A: If you want more volume you should increase the pressure. An experienced surgeon can handle this.

A: The patient has only one TOF response.

Mulier, Acta Anaesth Belg. 2009;60(3):177-80
Joshipura VP. Surg Laparosc Endosc Percutan Tech. 2009;19:234–240
Carron, BJA 113 (1): 186–98 (2014)
Cabrera, Anesthesiology 2012 Jul;117(1):93-8

Remarkable clinical scenarios

Obese: how to dose and how to measure drugs effect?

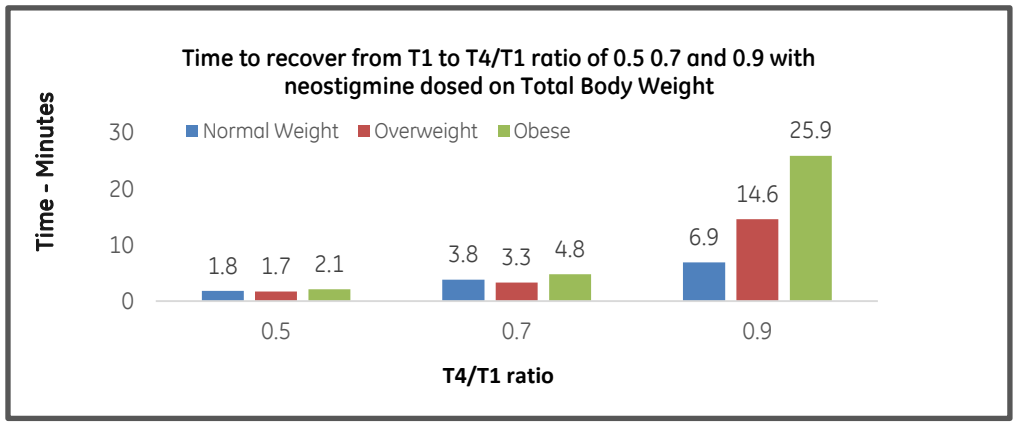
Effect (onset and duration) of Rocuronium in obese

Onset Time, Duration 25%, Spontaneous Recovery Index, Intubation Dose of Rocuromium

Variable	Onset (s)	Duration 25% (min)	Recovery index (min)	Dose (mg)
Real Body Weight	77.0 (37-92)	55.5 (43.6-60.1)	16.6(11.0-24.0)	67 (59-82)
Ideal Body Weight	87.5 (54-99)	22.3 (21.1-24.9)	13.6 (8.0-16.0)	33 (28-28)
Normal Body Weight	66.5 (50-85)	25.4 (18.4-31.1)	11.3 (4.8-18.3)	38 (31-43)
P value	0.201	0.003	0.102	0.03

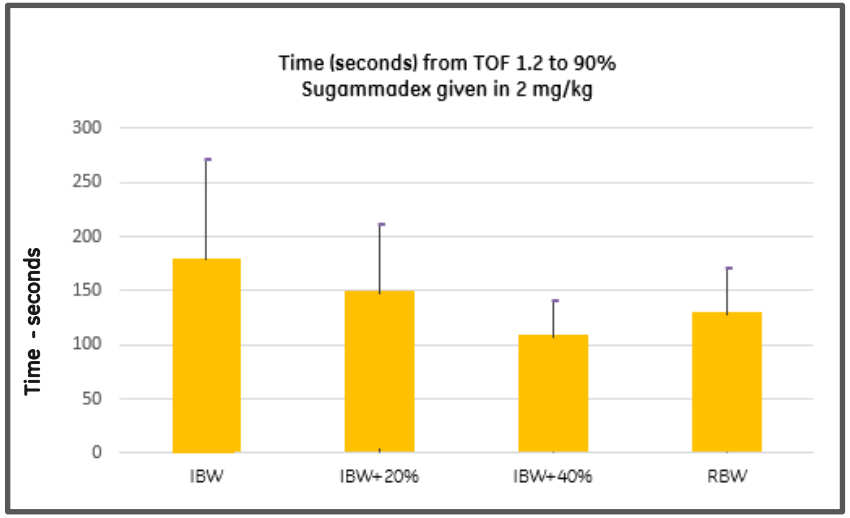
Leykin Y et al. Anesthesia & Analgesia 2004;99:1086-9
Ingrande BJA 2010 V105 i16-i23

Neostigmine: unpredictable timing on obese to full reversal



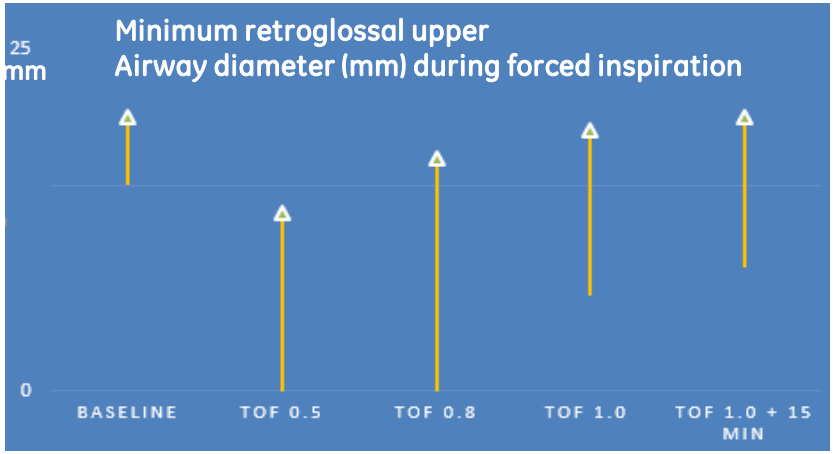
Adapted from Suzuki T, et al. Br J Anaesth. 2006; 97 (2): 160–163

Ideal vs Corrected Body Weight Dosage of Sugammadex in Obese?



Adapted from Van Lancker P, et al. Anaesthesia. 2011;66(8):721-725.

Why do we need TOF > 90% before extubation?



- To reduce the risk of obstructive breathing
- Pharynx Dysfunction Increases the aspiration risk

Adapted from Eikermann, et al. Am J Respir Crit Care Med. 2007;175:9-15.

Remarkable clinical scenarios

Guiding reversal with Neuromuscular Transmission Monitoring[1]

Block level	NMT monitoring (Adductor pollicis) : Objective Quantitative	Reversal agent	Comments
Full recovery	TOF ratio > 0.9 **(≥ 1.0 with AMG?)**		There is no monitoring able to confirm full recovery
Safe extubation	TOF ratio 0.5 - 0.9	Not needed	
Recovery in process	TOF ratio 0.5 - 0.9	Neostigmine low dose 0.02 mg/kg	Pay attention to the delay and variability of neostigmine reversal!
Moderate NMB	TOF count 3-4	Neostigmine standard dose 0.05 mg/kg	Reversal threshold for neostigmine Maximal dose 0.07 mg/kg, ceiling effect
	TOF count 1-2	Sugammadex 2 mg/kg	
Deep NMB	PTC 1-5-20	Sugammadex 4 mg/kg	Deep NMB (PTC 1-5) is useful to improve oro-tracheal intubation and surgical conditions
Intense NMB	PTC 0	Sugammadex 16 mg/kg	Rescue reversal if cannot intubate/ventilate There is no monitoring able to investigate intense NMB, which is of little interest in clinical practice

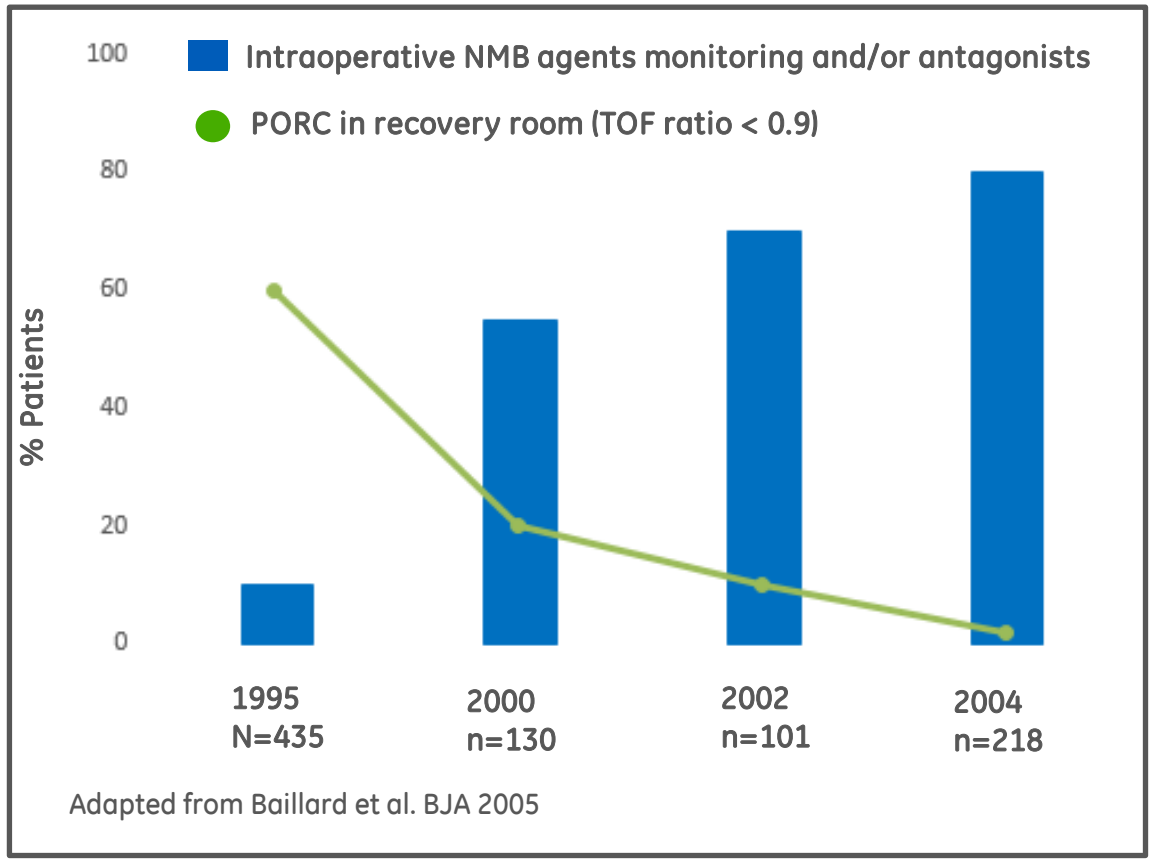
The use of a "one size fits all" dose of Sugammadex has been identified and requires further staff education[2]

[1]A review of the interest of sugammadex for deep neuromuscular blockade management in Belgium – Mulier *Acta Anaesth. Belg., 2013, 64, 49-60*

[2]Neuromuscular Monitoring, Muscle Relaxant Use, and Reversal at a Tertiary Teaching Hospital 2.5 Years after Introduction of Sugammadex: Changes in Opinions and Clinical Practice Thomas Ledowski,Jing Shen Ong,and Tom Flett

Why applying systematic neuromuscular monitoring?

TOF: train of four
NMB: Neuromuscolar block
PORC: Post operative residual curarization



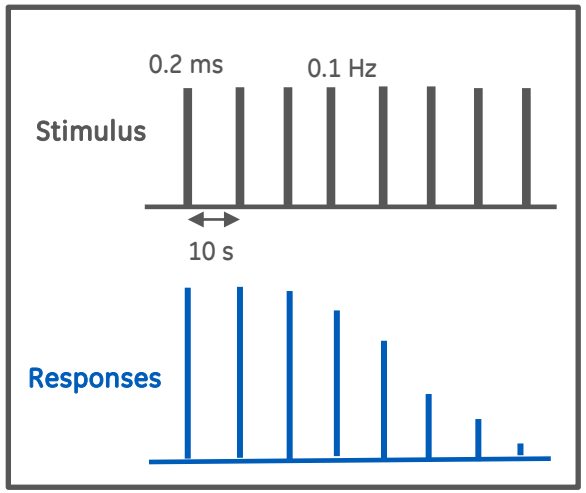
Adapted from Baillard et al. BJA 2005

- To analyse block onset time, duration of muscle relaxant and dose repetition
- To analyse block level
- To establish the right time of reversal injection
- For medical processes standardization
- To establish the right time for safe extubation
- To establish the appropriate reversal dosage (depending on degree of block)
- To reduce risks of PORC
- To manage continuous infusion of muscle relaxants and avoid 'unwanted' accumulation
- To manage critic patients (diabetic, obese etc.)

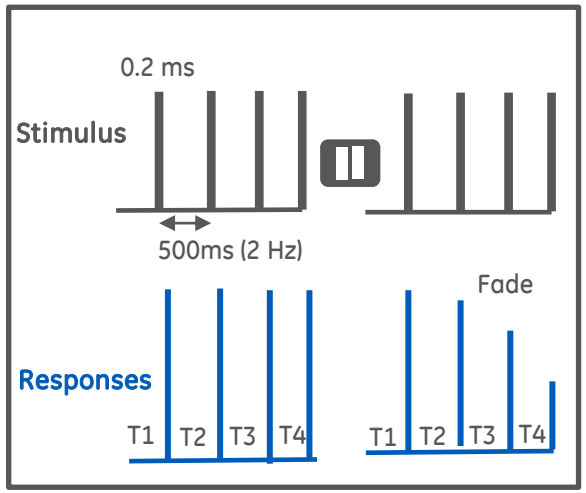
Kopman et al. 2010
Mulier Acta Anaesth. Belg., 2013, 64, 49-60
Anesth&Analg August 2013 • Volume 117 • Number 2

NMT stimulation modes and applications

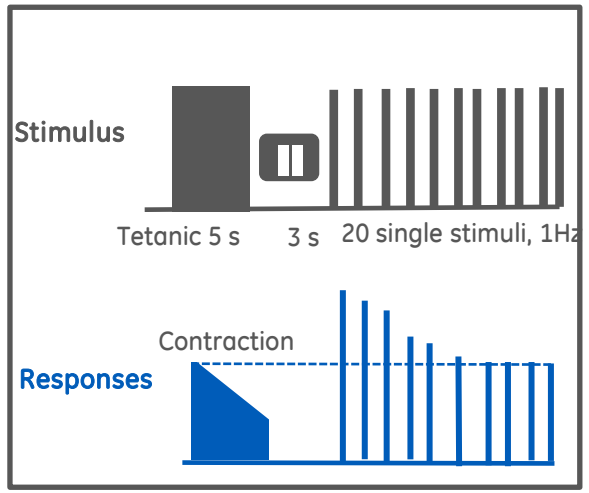
Single Twitch



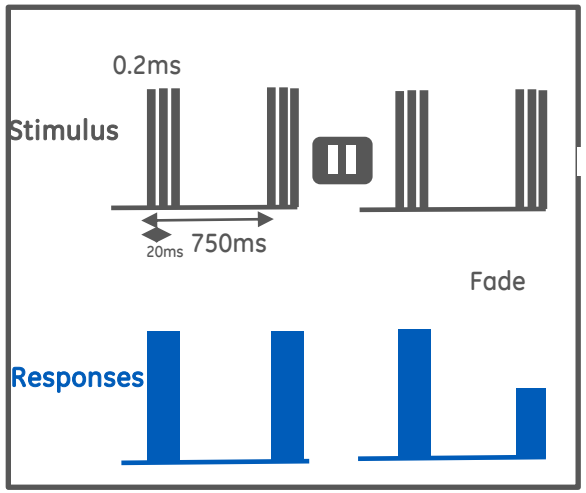
Train of Four



Post Tetanic Count



Double Burst Stimulation



Different types of peripheral nerves stimution modes

Type	Frequency	Duration	Interval	Repetition	Application
Single twitch	0.1 Hz	0.2 ms	1-10s	1-10s	Induction
Tetanus	50 Hz	5 s		>6 min	
TOF	2 Hz	2 s	10 s	10 s	Induction , Maintenance, Intubation, Awakening
PTC	50 Hz	2 s		>6 min	Deep block
DBS	50 Hz	40 ms	750 ms	>6 min	Residual Curarization

To observe onset time at induction

No calibration most used but only for light block

When TOF is 0 it allows to monitor the level of deep block and recovery from block:
PTC 10 light block; PTC 2 deep block

Adapted from : Post-Operative Residual Curarization (PORC): A Big Issue for Patients' Safety
A. Castagnoli, Innocenti et al. *Anesthesiology and Intensive Care, S. Orsola-Malpighi Hospital, University of Bologna*

NMT monitoring technology: state of art

*TOF Cuff; Modified blood pressure cuff with Integrated Stimulation Electrodes. It senses pressure peaks through the cuff.Brachila Plaxus stimulated.Clinical evidence needed.

Accelerography (ACG)?

Measure accelation of muscles

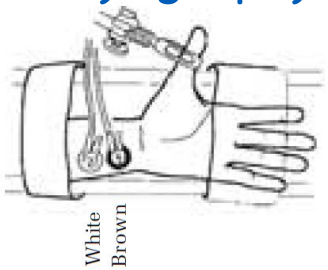
Kinemyography (KMG)?

Measure force of muscle contraction

Electromyography (EMG)?

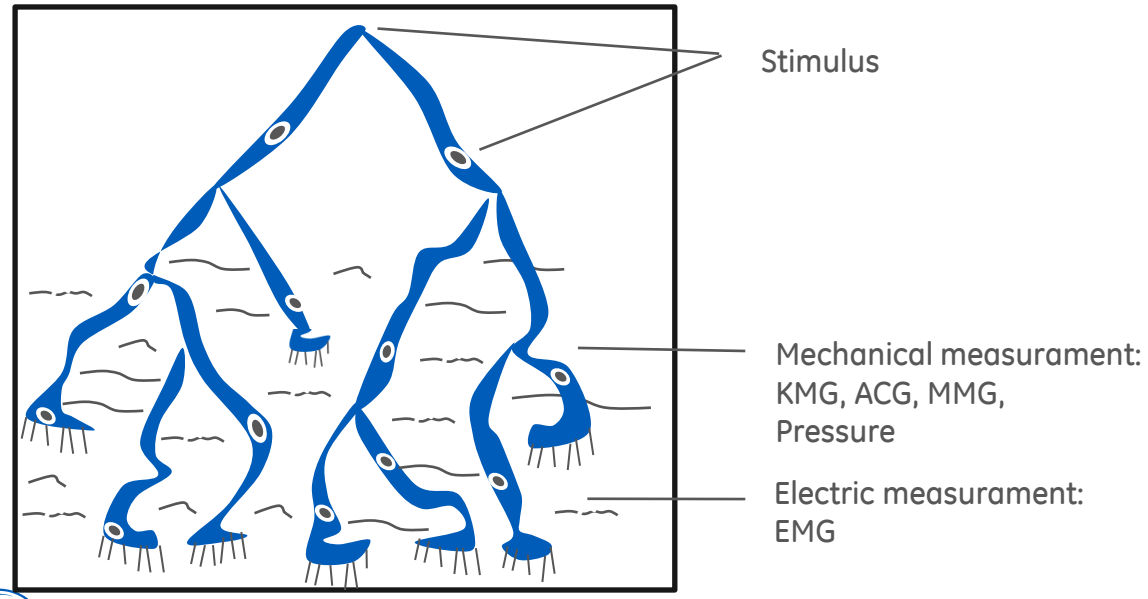
individual muscle fibre potentials

Mechanomyography (MMG)?



for research purpose only

Measurament level at neuromuscolar junctions:



Adapted from Mulier ESA 2015

TOF ratio of 0.90 measured with KMG will be approximately equivalent to a TOF ratio of 0.80 measured with EMG at the adductor pollicis muscle, but it may indeed be as low as 0.65 or as high as 1.00. Therefore, TOF ratios measured by KMG and EMG cannot be used interchangeably

Comparison of electromyography and kinemyography during recovery from non-depolarising neuromuscular blockade Steward AIC 2014 May;42(3):378-84.

Acceleromyography-derived twitch heights for individual patients are not necessarily interchangeable with information obtained using electromyography[1]

Dose-response relationship of rocuronium: a comparison of electromyographic vs. acceleromyographic-derived values. Kopman Acta Ane Scan 2005 Mar;49(3):323-7.

EMG technology is more accurate and robust than AMG

Clinical validation of EMG and AMG as sensor for muscle relaxation Haenzi et al. EJA 2007 24(10):882-8

NMT monitoring technology: state of art

ACG overestimates EMG TOF ratio by 0.176...

ACG TOF 90% is not the same EMG TOF 90%

[1]

? Is it possible to correct an ACG TOF ratio so that it can be used interchangeably with EMG?

* An ACG TOF ratio of at least 1.00 with an additional waiting period may be necessary to exclude residual NMB
* The waiting period would vary according to choice of relaxants and reversal drugs, patient age/gender, temperature, renal/liver function

ACG TOF >90% does not guarantee complete reversal and safe extubation

EMG offers a better compromise than ACG with respect to the duration of calibration process and surrogate for the optimal time of tracheal intubation in children

[2]

1)An Ipsilateral Comparison of Acceleromyography and Electromyography During Recovery from Nondepolarizing Neuromuscular Block UnderGeneral Anesthesia in Humans Sophie S. Liang, et al August 2013 • Volume 117 • Number 2 Anest&Analg
2) Comparison of clinical validation of acceleromyography and electromyography in children who were administered rocuronium during general anesthesia: a prospective double-blinded randomized study - Junk et al KJA Feb 2016 69(1): 21–26

NMT: Neuromuscolar transmission
PORC: Post operative residual curarization
EMG: Electromyograpy

Conclusion and take away

- Variety of management strategies for neuromuscular blockade and reversal efficacy. Anaesthesia societies guidelines still missing
- PORC is a recurrent silent enemy underestimated and patient hazard
- Still a lot of efforts on NMT education and NMT technology adoption needed
- Routine monitoring is not standard practice, but it improves patient safety when used systematically
- Antagonist dosage and injection time can be optimized with proper monitoring
- EMG can help measure accurately and precisely block levels and reversal Several publications show superiority of EMG to other commercially available technologies

Disclaimer

Important to use NMT correctly perioperatively. Users should always consult the monitor user manual for information and use of the NMT measurement. Contact your GE representative for the most current information.

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