Value of Neuromuscular Monitoring in the Era of Sugammadex

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Blobner M, Hollmann MW, Luedi MM, Johnson KB:
Pro-con debate: do we need quantitative neuromuscular monitoring in the era of sugammadex?
Anesth Analg 2022;135: 39-48

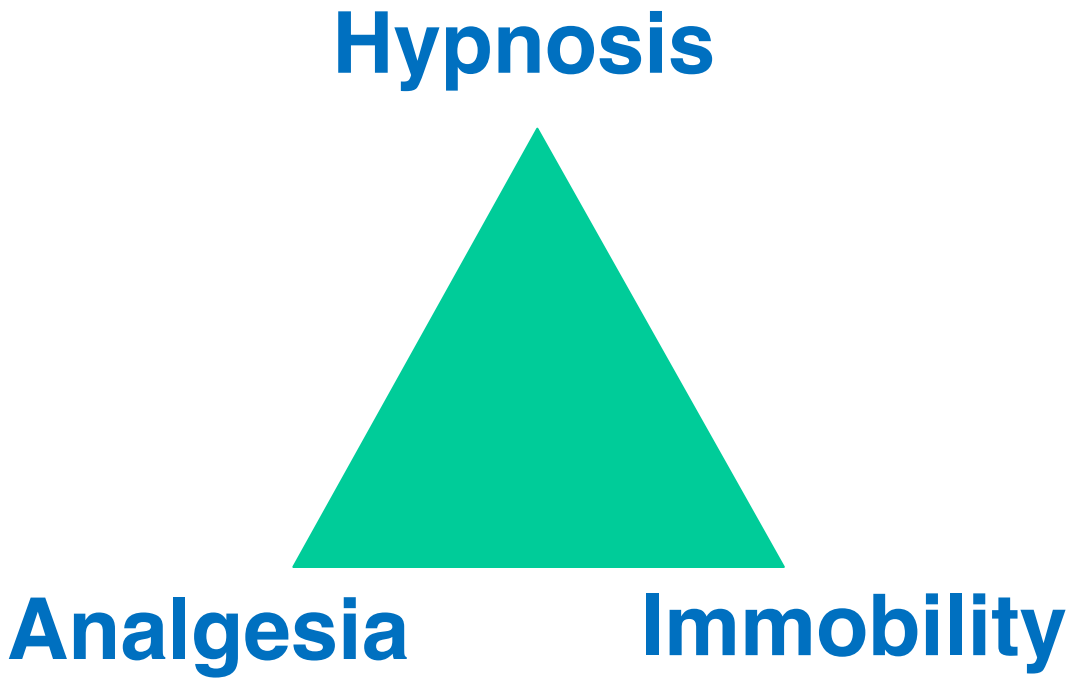
Conflict of interest

- Research grants and personal fees from MSD, Haar, Germany
- Personal fees from Grünenthal, Aachen, Germany
- Personal fees from GE Healthcare, Helsinki, Finland
- Medical Advisor HW Pharmaconsulting, Germany
- Chair of the steering committee of the ESAIC-CTN POPULAR study

Monitoring during anaesthesia

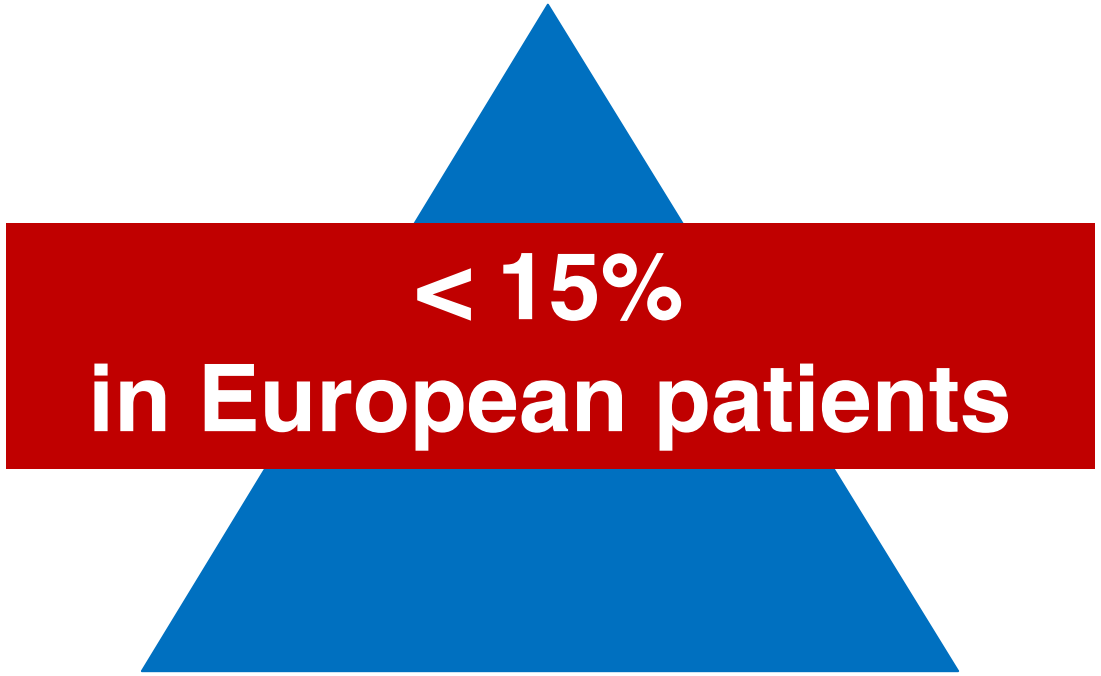
- Cardiovascular monitoring
- Respiratory monitoring
- Monitoring of the function of the anaesthesia machine
  - Endtidal concentration of volatiles

Monitoring of anaesthesia?



Monitoring of anaesthesia

Processed EEG monitoring

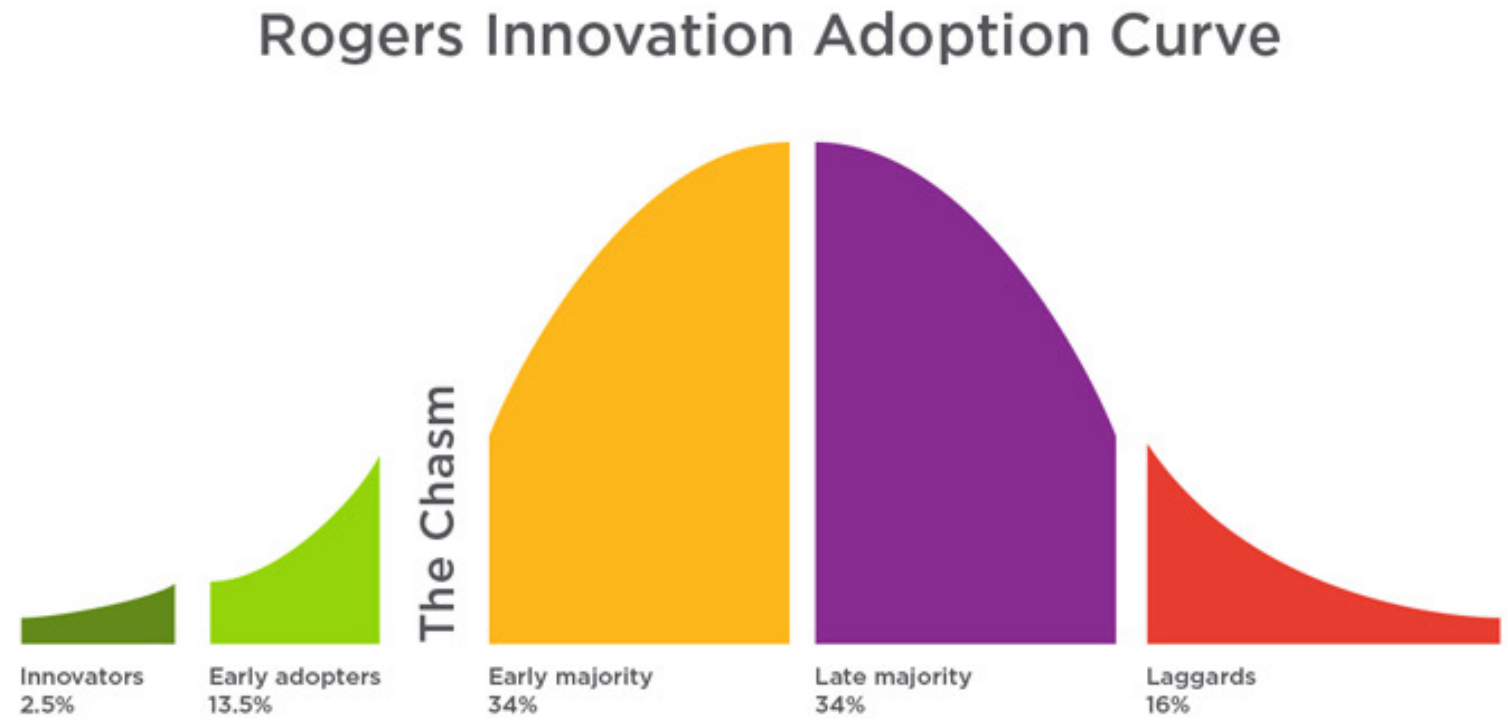


(Surogates)

Quantitative NMM

E. Kirmeier et al. Lancet Respir Med 2019; 7:129-140

Have we crossed the ‘chasm’?



10 – 15 years

Quantitative NMT (EMG, AMG)

- since 1973
- ~ 15%

BIS / Entropy / …

- since 1995 devices with processed EEG-based
- ~ 5%

Fix M. : https://www.meddeviceonline.com/doc/take-the-narrow-path-to-wide-adoption-here-s-why-and-how-0001

Quantitative neuromuscular monitoring in the era of sugammadex: not needed

- Using a peripheral nerve stimulator, a TOF count of 4/4 with sustained 5-s tetanus at eye or wrist muscles provides an adequate assessment of NMB reversal.
- Sustained head lift, strong hand grasp, following commands, and sustained tetanus using a peripheral nerve stimulator are adequate for assessing whether a patient is suitable for tracheal extubation.
- Quantitative NMM is not needed when sugammadex is available
- The incidence of clinically meaningful residual neuromuscular bl… a postoperative adverse pulmonary event is very low.
- Quantitative NMM is expensive. The devices a… e. There is a recurring cost for an electrode sensor array wit…
- Less-expensive qualitative N… erve stimulators are adequate for detecting residual NMB
- Quantitati… difficult to interpret or fail during surgical procedures.
- Q… requires unimpeded thumb movement making their use difficult when … are tucked.

None of this is correct

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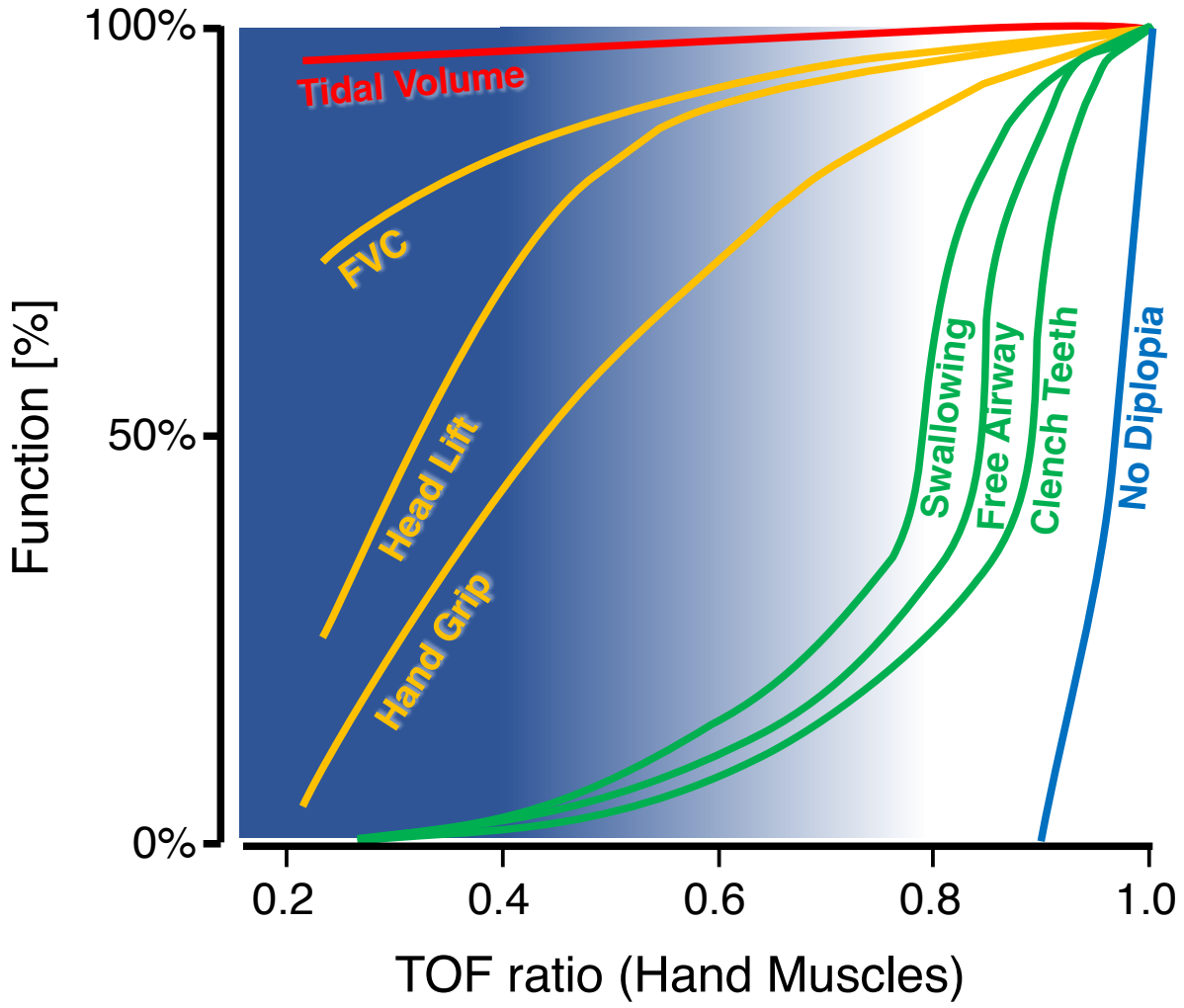
Neuromuscular Blockade Related to TOFR at the Hand

Depth of Block at specific musles	Quantitative NMM	Qualitative NMM (tactile, visual)
	at the adductor pollicis	
Complete block, even of the diaphagm	PTC = 0	

Meistelman C, Current Opinion in Anaesthesiology 2001; 399-404

Clinical assessment of muscle function does not prevent residual neuromuscular blockade



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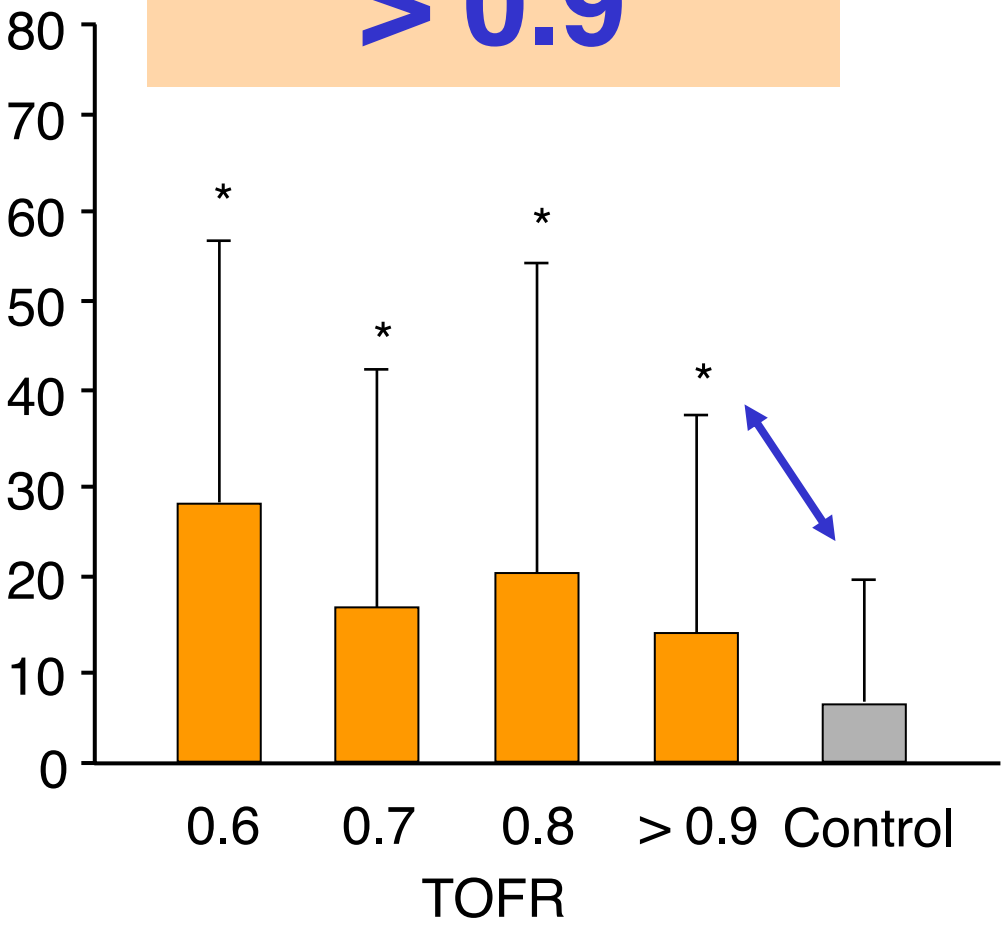
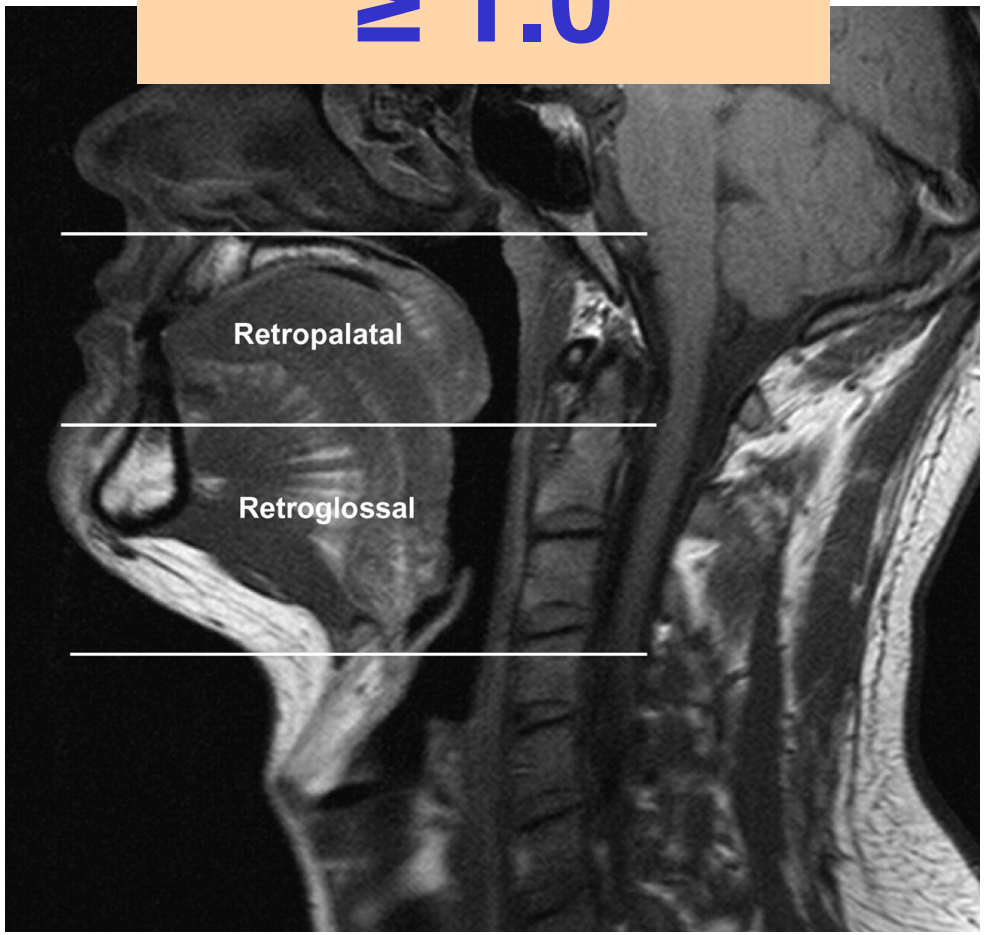
What TOFR measured at the hand is tolerable after extubation?

> 0.9



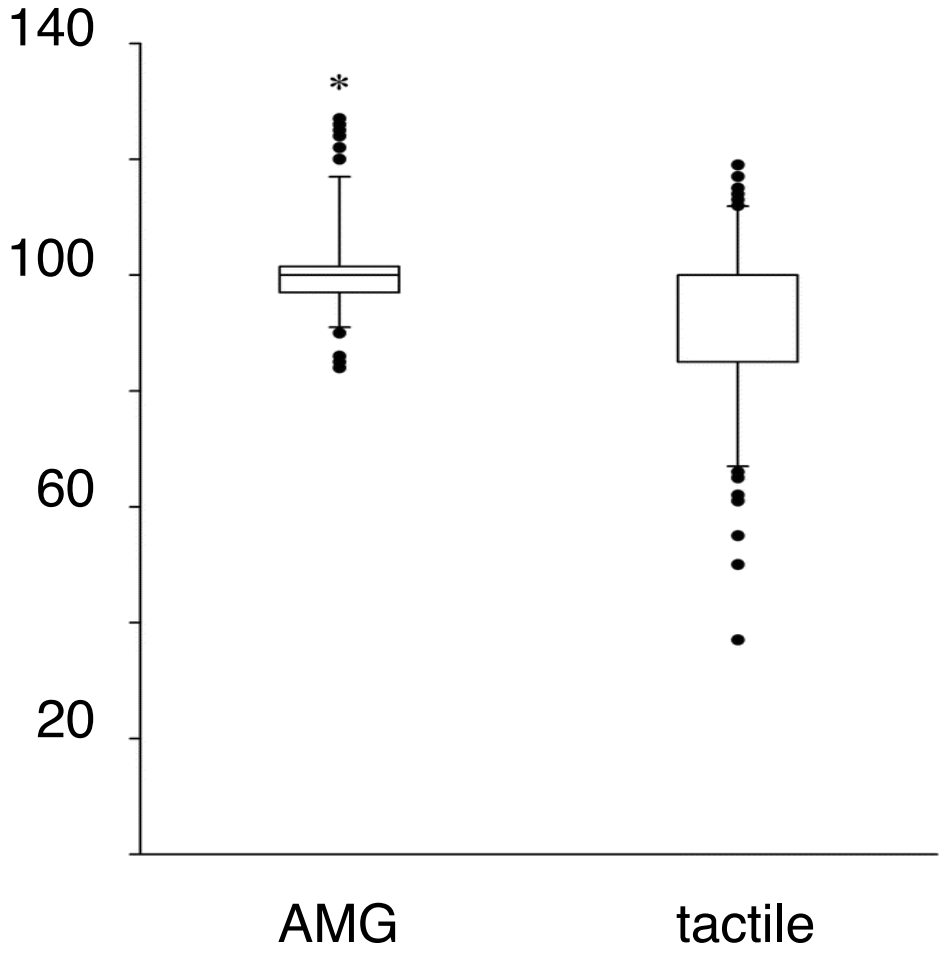
≥ 1.0



Sundman E. Anesthesiology 2000; 92: 977-84

Eikermann M. Am J Respir Crit Care Med 2007: 9-15

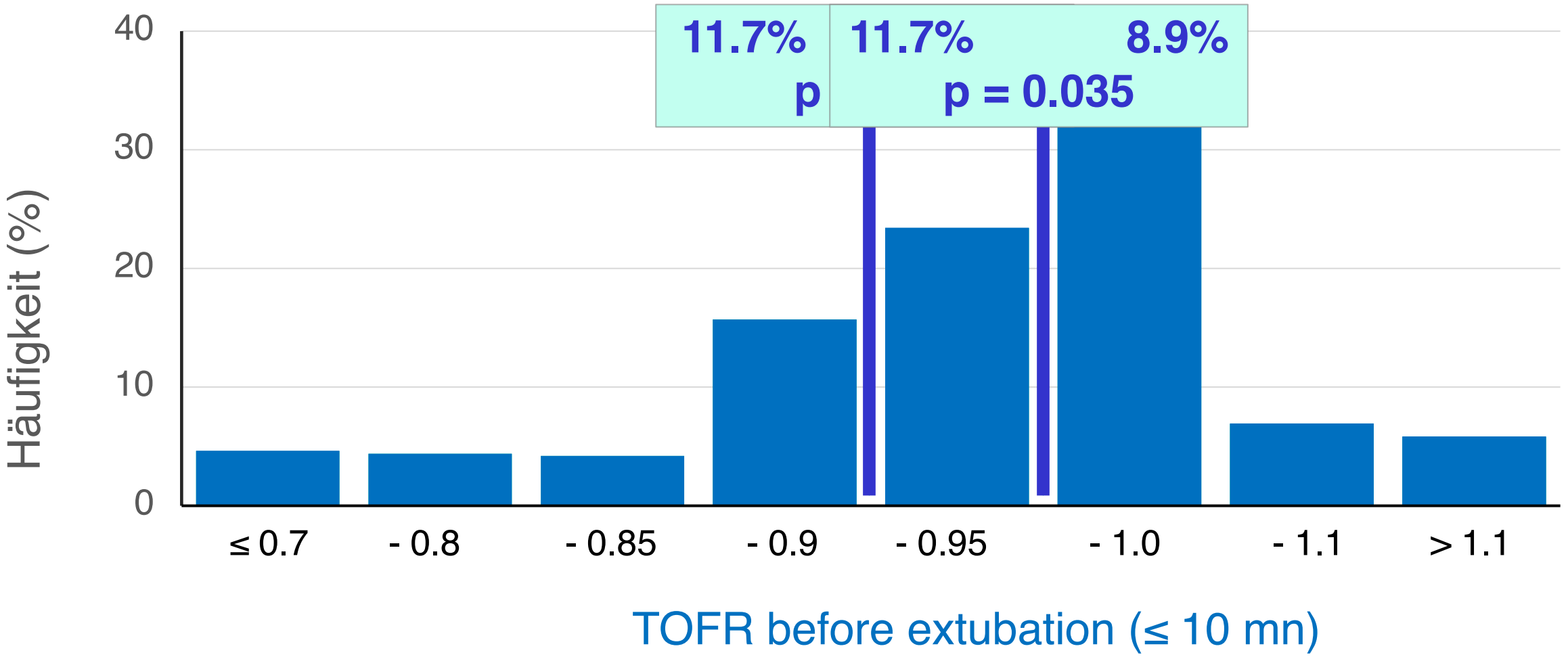
Quantitative (AMG) reduces critical respiratory events compared to tactile monitoring (PNS)



	AMG	PNS
Transport		
Episodes of $SpO_2 < 90\%$	0	21%
Requiring airway manoeuvre	0	11%
PACU		
SpO2 < 90%	0	21%
Requiring airway maneuver	0	4%
Requiring stimulation to maintain SpO_2	0	8%

Murphy GS et al. Anesthesiology 2008;109: 389-98

Risk of POPC



Blobner et al. POPUALR. BJA 2020;124(1): 63-72

Sugammadex does not avoid residual NMB without NMM

	TOFR < 0.9 (AMG)	TOFR < 1.0 (AMG)
Spontanous (n = 23)	13% (3%–34%)	70% (47%–87%)
NEO (n = 109)	24% (16%–33%)	67% (57%–76%)
SGX (n = 117)	4% (2%–9%)	46% (40%–56%)

Kotake et al. A&A 2013 117:345-51

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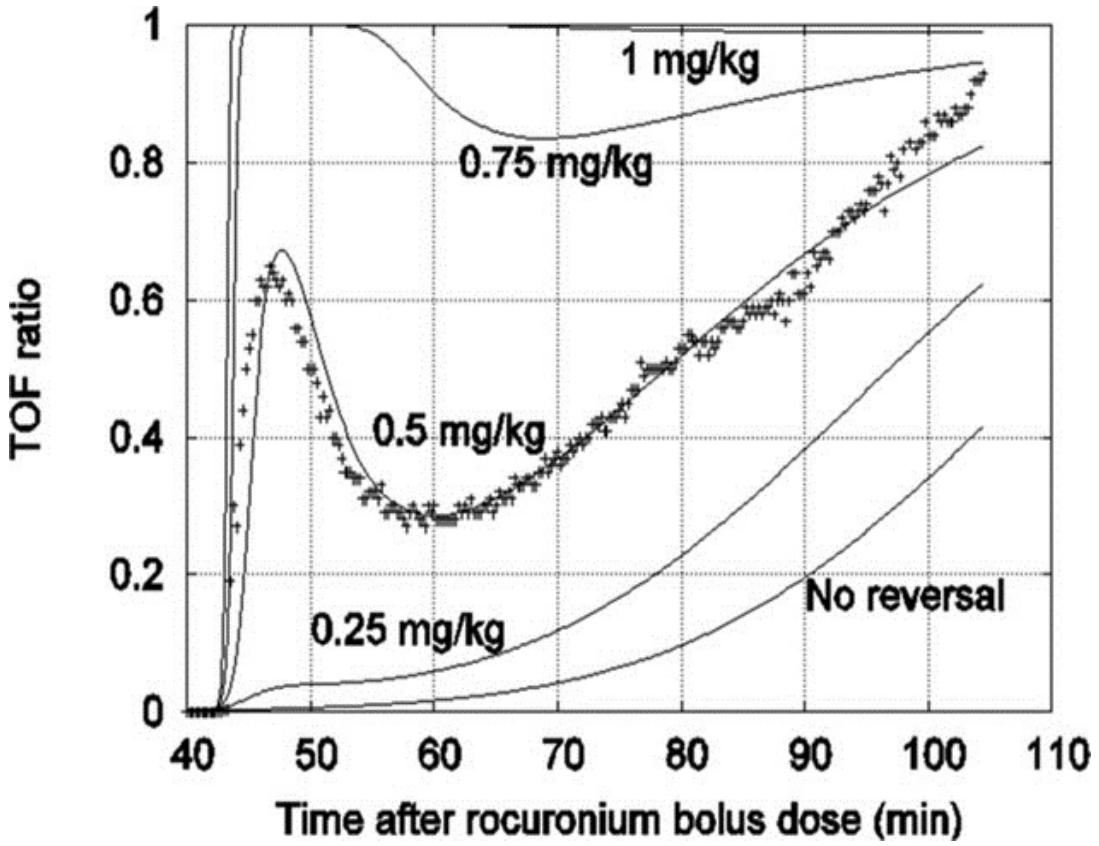
Risk of rebound – Recurarization



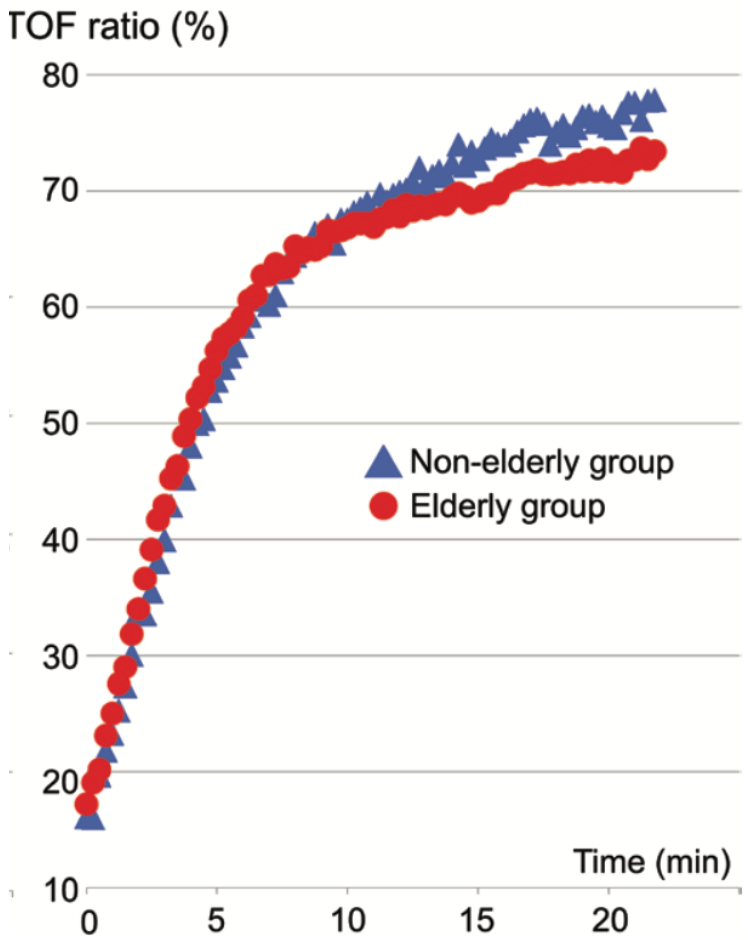
- Deep blockade (PTC 1-2)
- High dose of NMBA
- Pancuronium (Tubocurarin, Alcuronium, Gallamin)

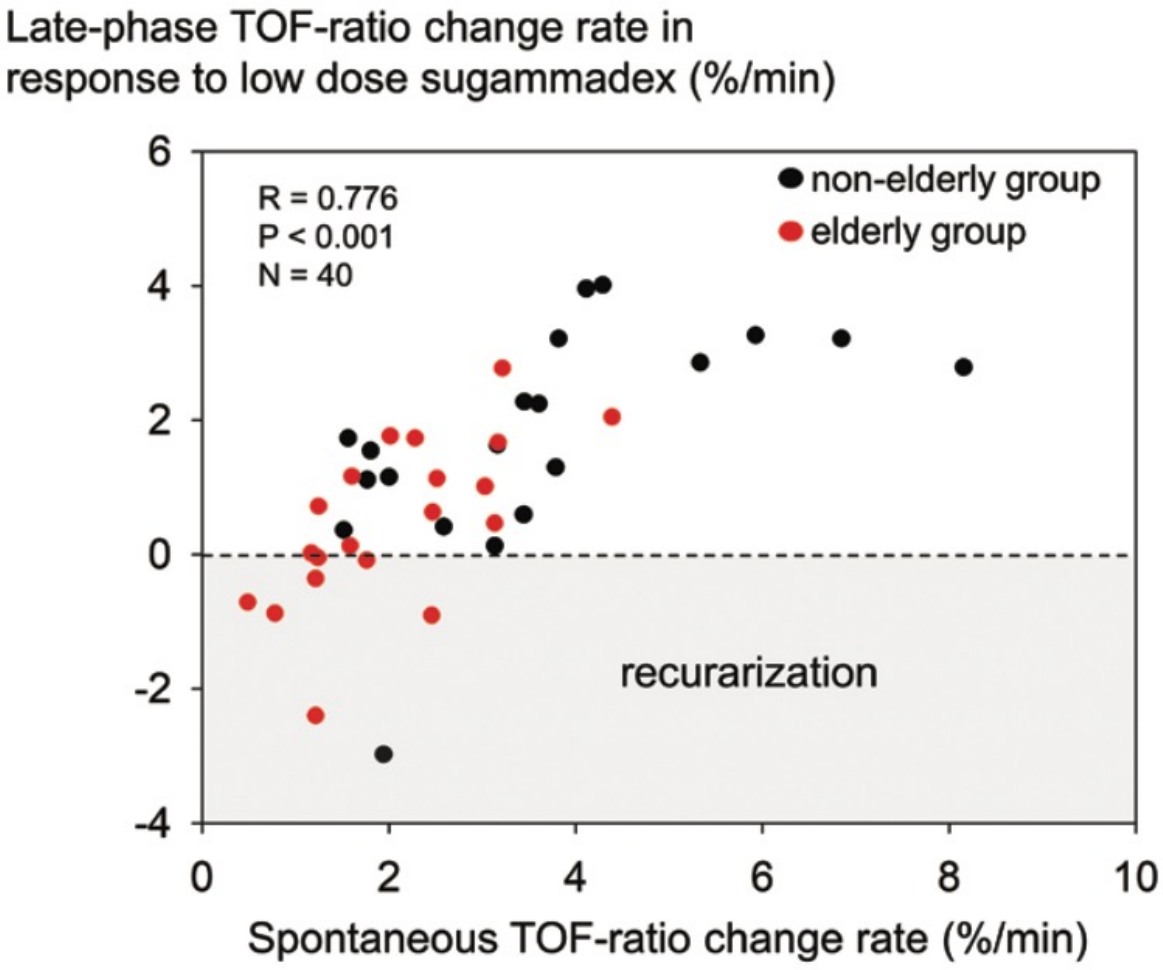
- Sugammadex
- (Too) low dose of Sugammadex
- High renal clearance of Sugammadex
- Low hepatic clearance of Rocuronium

- Neostigmine
- Low clearance of the NMBA used

Eleveld et al: A&A 2007; 104: 582-4

Elderly patients recover slower … and have an increased risk of recurarization



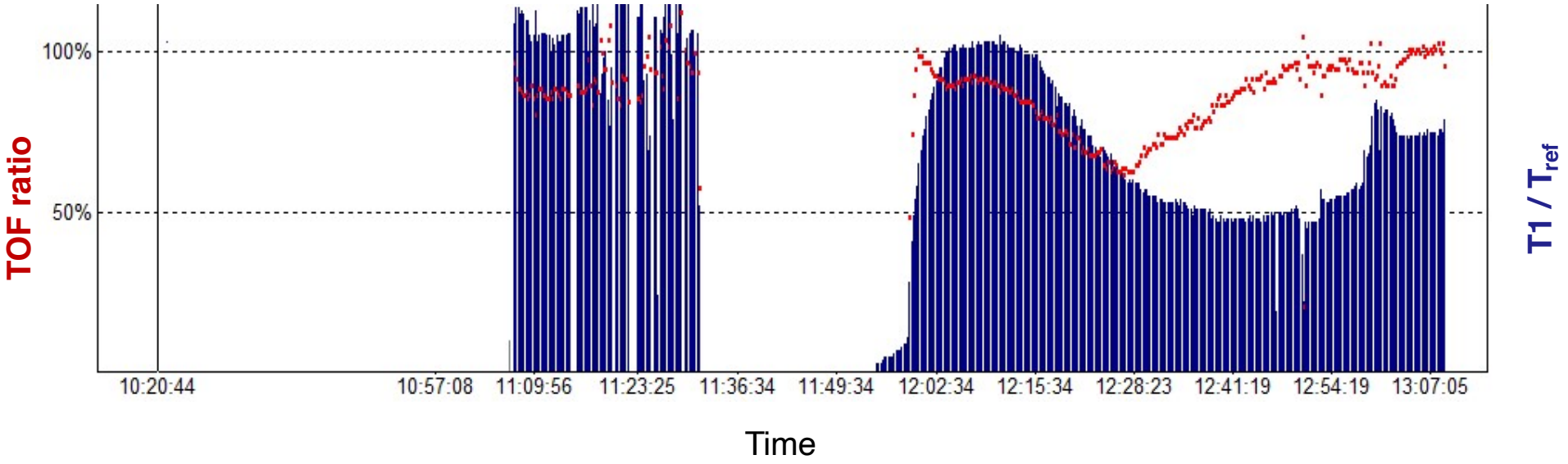


T. Muramatsu et al. Anesthesiology 2018; 129: 901-11

Actual Versus Ideal Body Weight Dosing of Sugammadex in the Morbidly Obese (MK 8616-146 - Study)

Recurarization

2 mg/kg IBW Sugammadex



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Deep neuromuscular blockade Improves Conditions During Gastric Bypass Surgery for Morbid Obesity

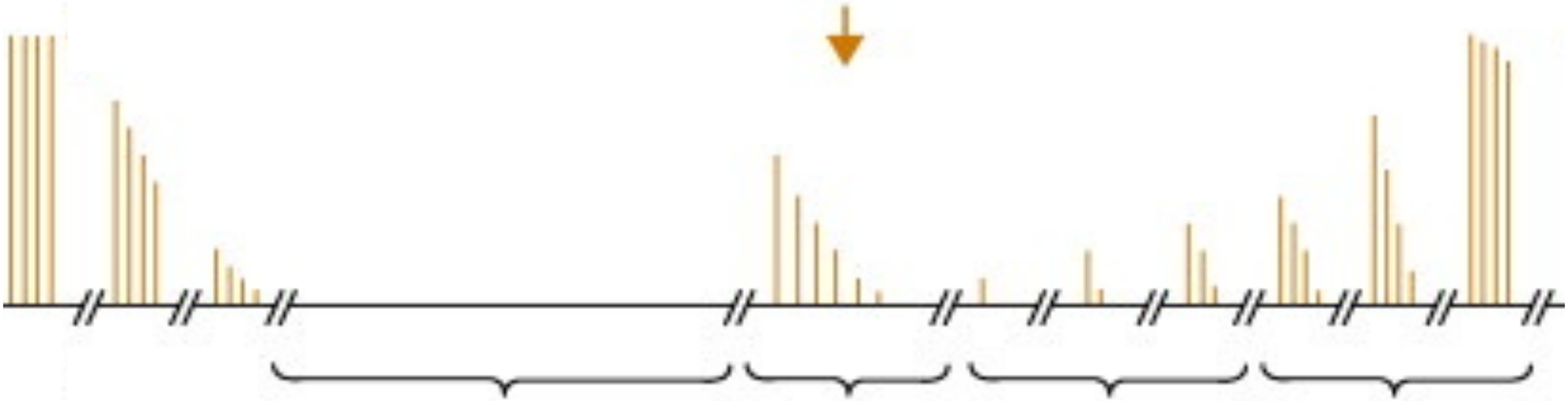
- Surgical conditions before gastro-jejunal anastomosis
  - 1 = exzellent
  - 2 = good
  - 3 = acceptable
  - 4 = poor or unacceptable
- 65 von 85 SRS ≥ 2
- Randomization and titration to …
  - PTC 1-3
  - TOFC 1-3

Primary Endpoint:			
Block:	**TOFC 1-3**	**PTC 1-3**	
Improvement	4 / 31	26 / 34	p<0.01

Secondary Endpoints:			
SRS	**1-3**	**4**	
Intraoperative complications	6 / 72	3 / 13	p=0.11

Fuchs-Buder T et al. Eur J Anaesthesiol 2019, 36:486-493.

Stimulation Modes at Distinctive Levels of Block



Stimulation	Intense block	Deep block	Moderate block	Recovery
TOF	TOF count = 0	TOF count = 0	**TOF count: 1 -3**	**TOF ratio < 0.9**
PTC	**PT count = 0**	**PT count > 0**	n.a.	n.a.

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Consensus Statement on Perioperative Use of Neuromuscular Monitoring

Electromyography:

- EMG is **not affected** by changes in muscle contractility
- **Immobilization** of the muscle to be studied is not essential
- **No preload** is needed
- Free motion of the thumb is not necessary
- EMG is less dependent on **normothermia**
- EMG has **inbuilt noise filtering**
- EMG does **not overestimate TOF ratio**

M. Naguib et al. Anesth Analg 2018; 127: 71-80

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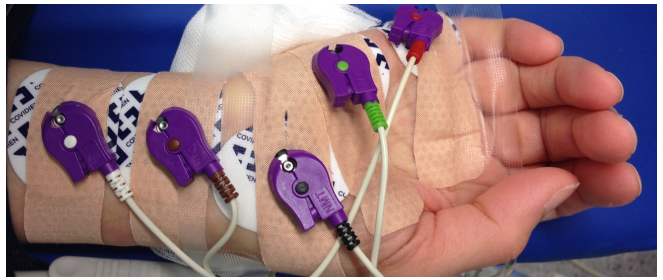
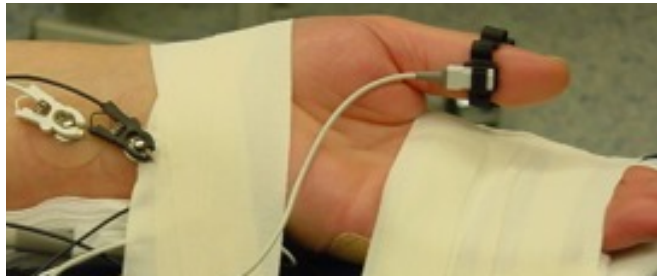
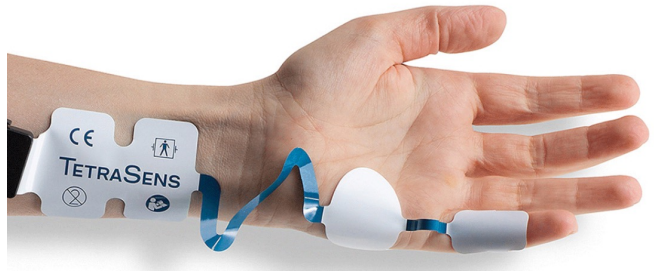
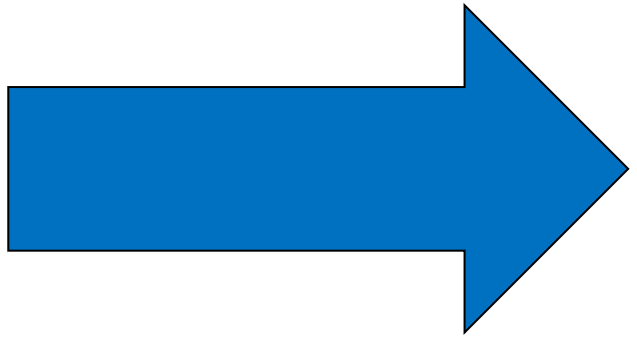
Costs of the disposables and drugs





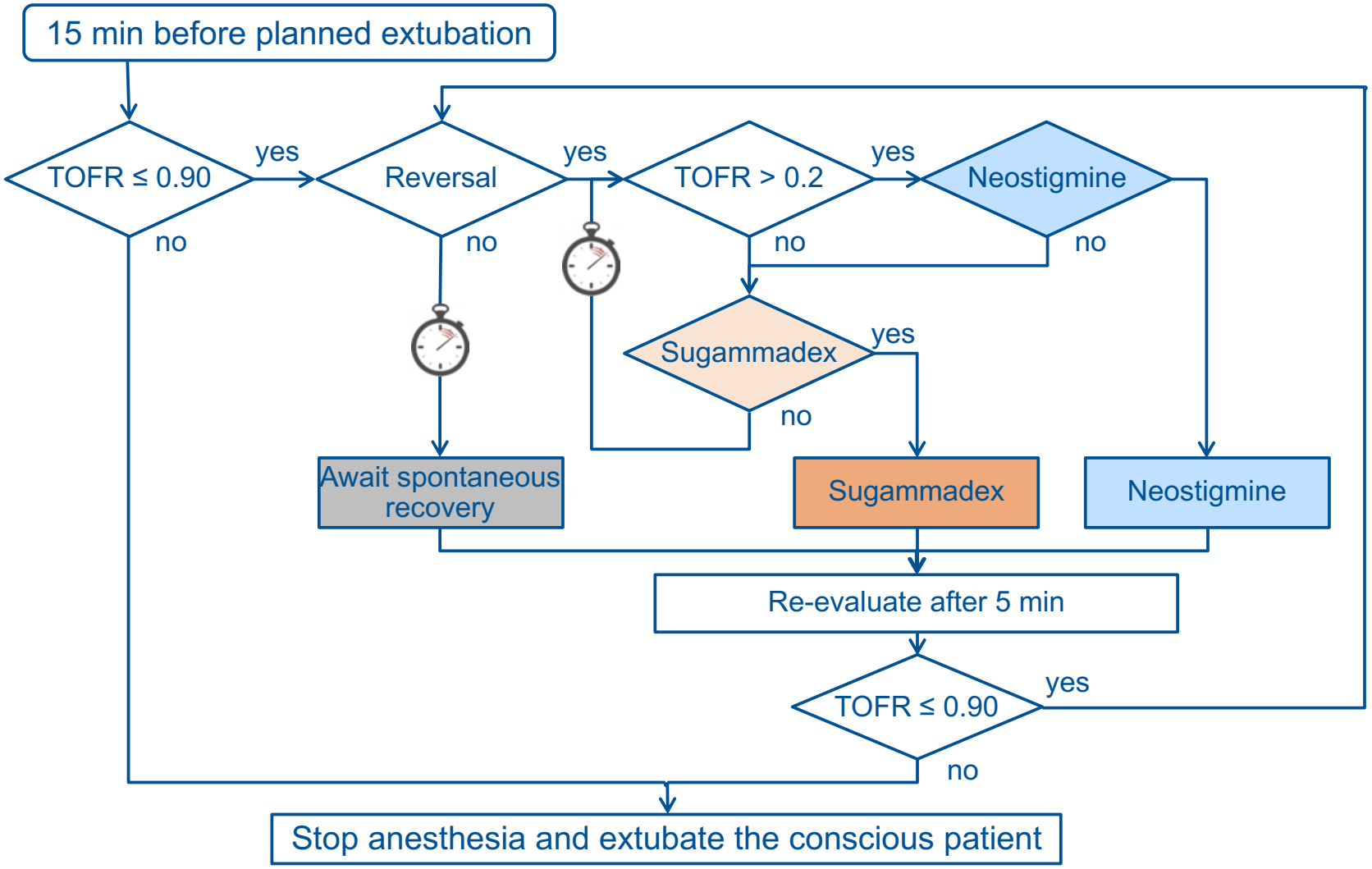




Implementation of evidence into clinical practice

- Bundles of measures, e.g., algorithms, guidelines, …
  - Rudolph MI et al. **Implementation of a new strategy to improve the peri-operative management of neuromuscular blockade and its effects on postoperative pulmonary complications.** Anaesthesia 2018;73:1067-78

Algorithms including monitoring devices, medicines and hospital equipment



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- Multifaceted approaches are superior to single interventions
  - Johnson MJ, May CR: **Promoting professional behaviour change in healthcare: what interventions work, and why?** BMJ Open 2015, 5(9):e008592
  - Mostofian F, Ruban C, Simunovic N, Bhandari M: **Changing physician behavior: what works?** Am J Manag Care 2015, 21(1):75-84

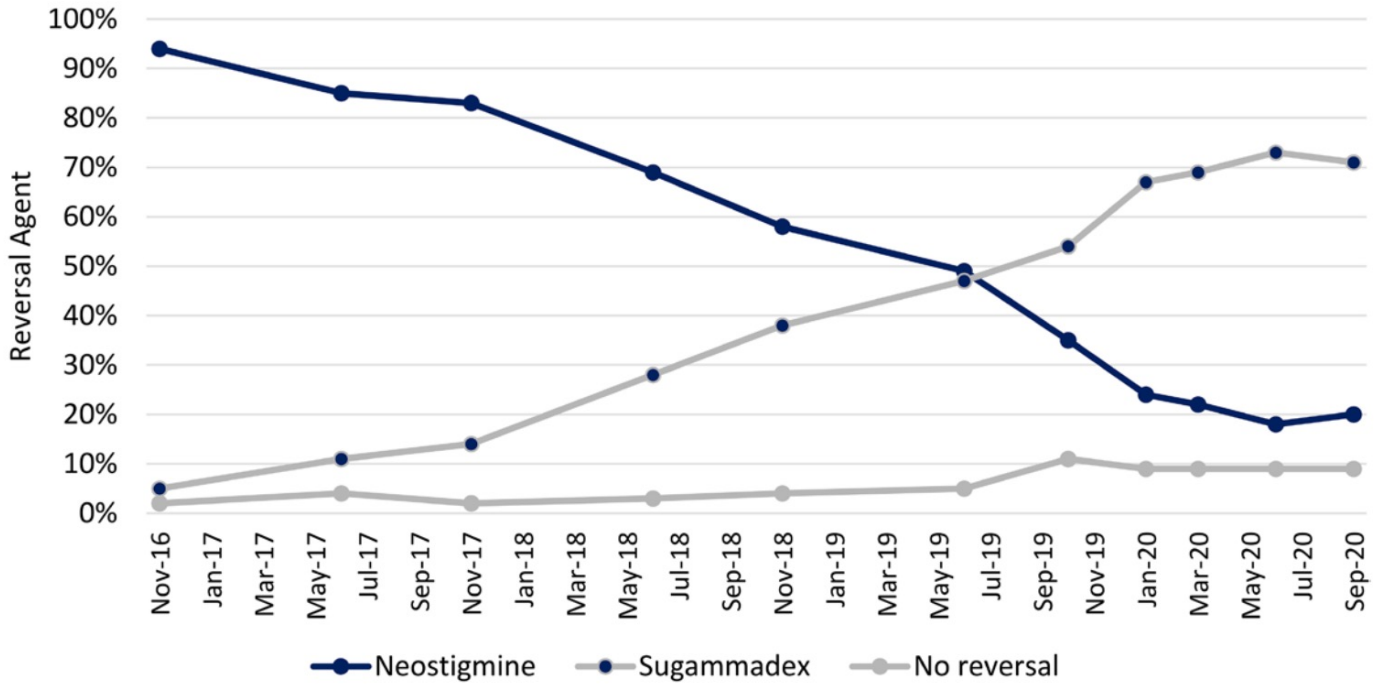
Neuromuscular monitoring needs neuromuscular monitors

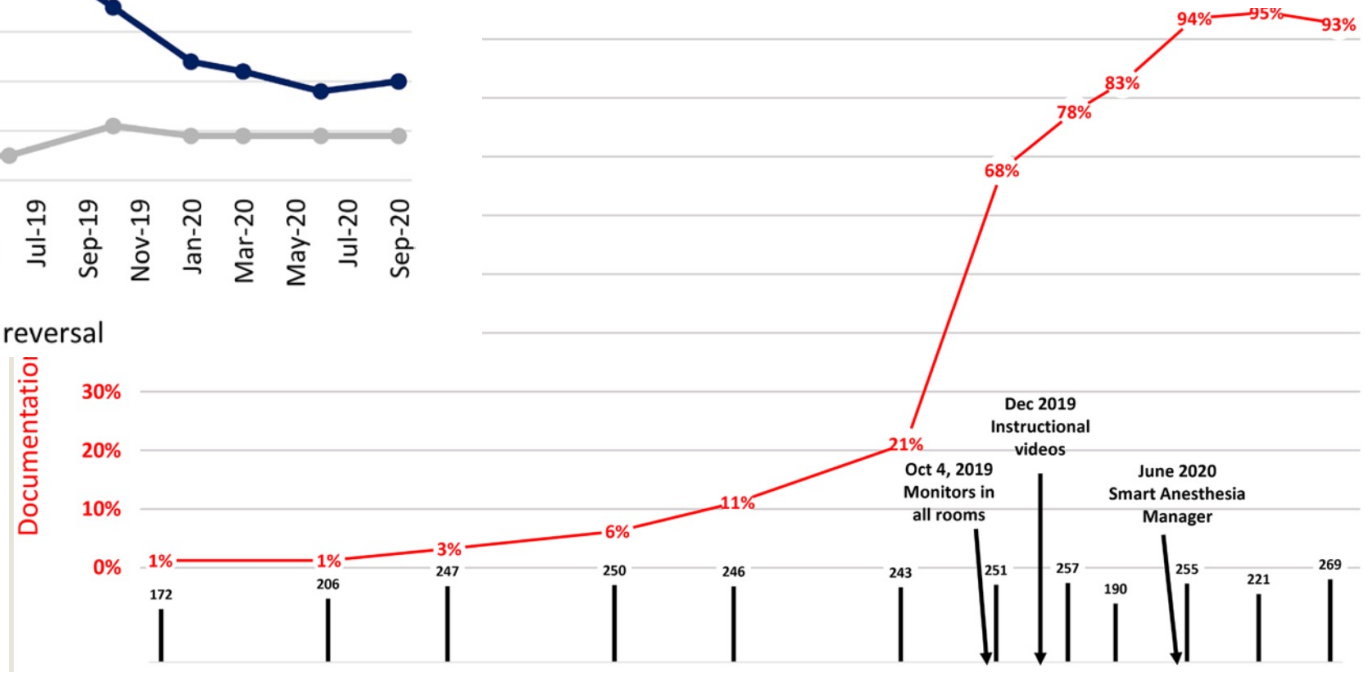
Quantitative Neuromuscular Monitoring in Clinical Practice: A Professional Practice Change Initiative

Year	Equipment	Location/Availability
2016	DigiStim II and EZ Stim II peripheral nerve stimulators	All operating rooms
	TOF-Watch SX neuromuscular monitor	Available
	IntelliVue NMT neuromuscular monitor	Available
2017	Stimpod 450× neuromuscular monitor	Available
2018	TwitchView neuromuscular monitor	Available
2019	Stimpod 450× and TwitchView	All operating rooms

W. A. Weigel et al. Anesthesiology 2022; 136: 901-915

Quantitative NMM and SGX promote each other





W. A. Weigel et al. Anesthesiology 2022; 136: 901-915

Summary of the Pro-Con Debate: Clinical implications

- Anytime a neuromuscular blocking agent is administered, neuromuscular monitoring **must** be used to guide administration and ensure adequate reversal of neuromuscular blockade. **Sugammadex is only available under this condition.**
- Adequate reversal of neuromuscular blockade is defined as a train-of-four ratio >0.9**5** measured at the adductor pollicis. Measurements at the face are inaccurate and should not be used to confirm adequate reversal of neuromuscular blockade.
- Peripheral nerve stimulators cannot confirm a train-of-four ratio >0.9**5.**
- Clinical signs are unreliable and **must** not be used to confirm adequate reversal of neuromuscular blockade in unconscious patients.
- Standardized definitions of profound, deep, moderate, shallow, and minimal neuromuscular blockades should be used based on quantitative neuromuscular monitoring.

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Summary of the Pro-Con Debate: Department Implications

- Quantitative neuromuscular monitoring **must be available.** If not given, departments must define a transition phase within which a peri… stimulator may be accepted yet.
- Professional organizations should develop… monitoring standards and guidelines.
- Professional organizati… promote practice standards and guidelines de… perioperative administration of neu…

Routine NMM is a mission and thus a benchmark for leadership

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