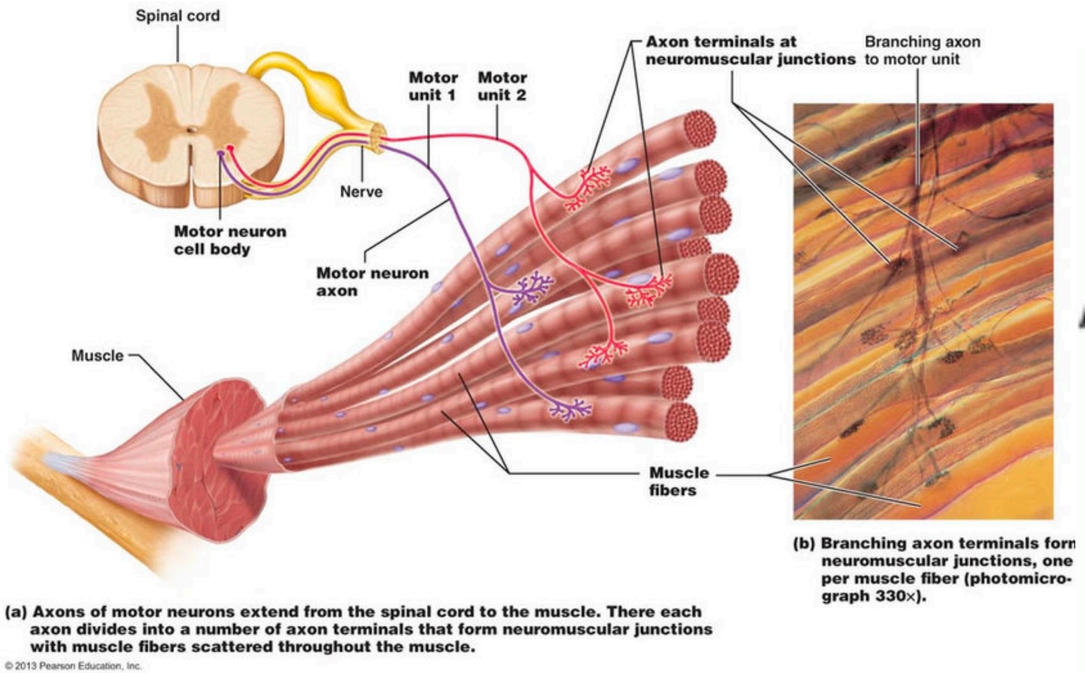
Perioperative neuromuscular monitoring

Nophanan Chaikittisilpa, MD
Department of Anesthesiology, Faculty of Medicine, Siriraj Hospital, Mahidol University

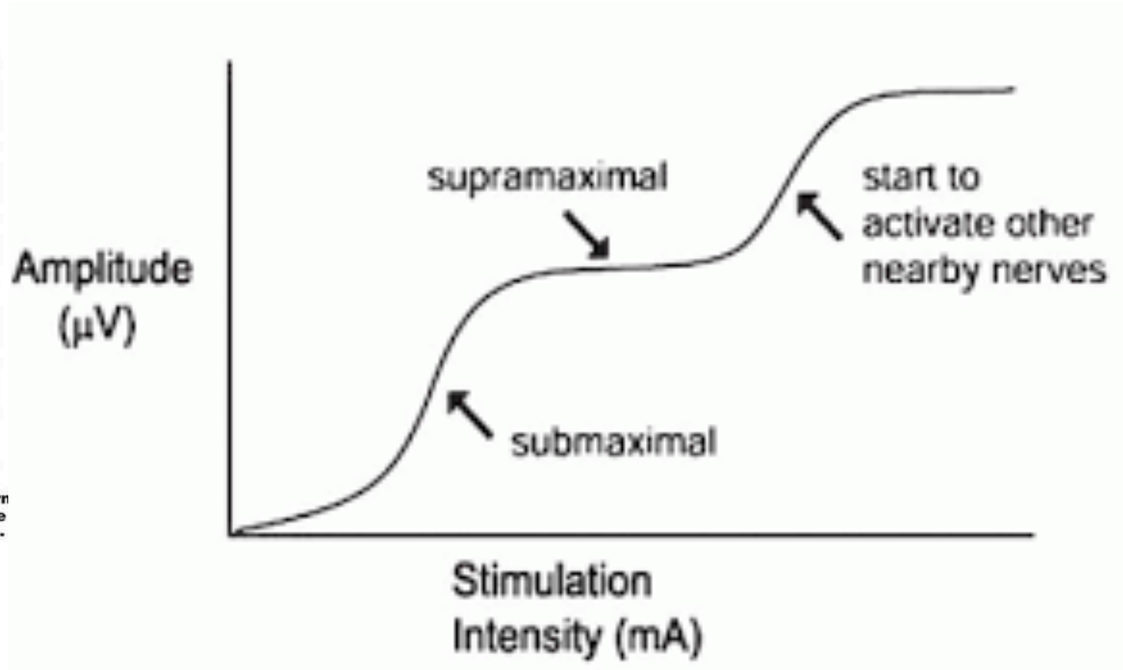
Outline

- Principles of neuromuscular blockade monitoring
  - Neuromuscular stimulation patterns
  - Nerve stimulator
  - Sites of monitoring
  - Evaluation of recorded evoked responses
- Perioperative modes of monitoring
- Implementing neuromuscular monitoring in clinical practice
- Current practice guidelines and recommendations

Principles of peripheral nerve stimulation



Supramaximal stimuli



- Single muscle fiber - **all-or-none pattern**
- A whole muscle - a group of muscle fibers

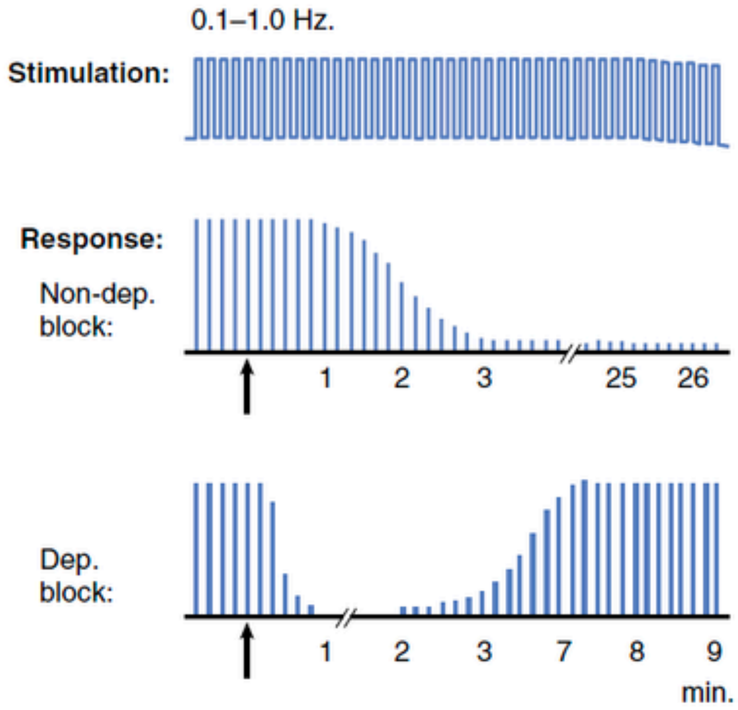
At least 20-25% above that require to ensure maximal response

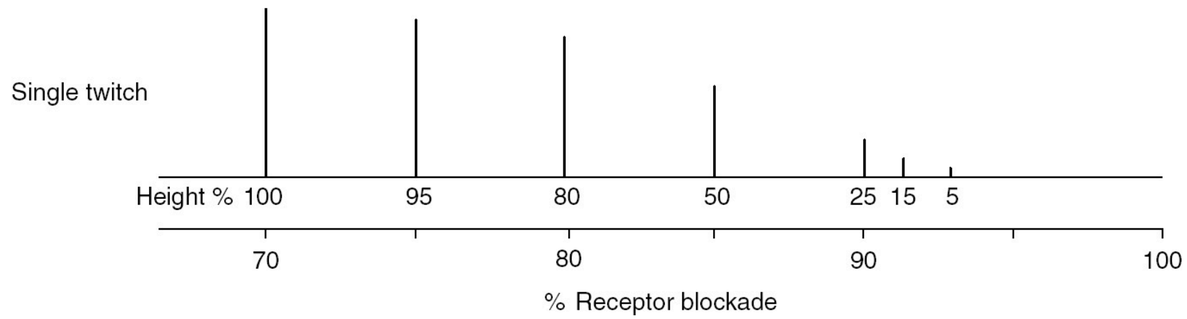
Neuromuscular monitoring

- Single-twitch
- Train-of-four (TOF) stimulation
- Tetanic stimulation
- Post-tetanic count
- Double-burst stimulation

Single-twitch

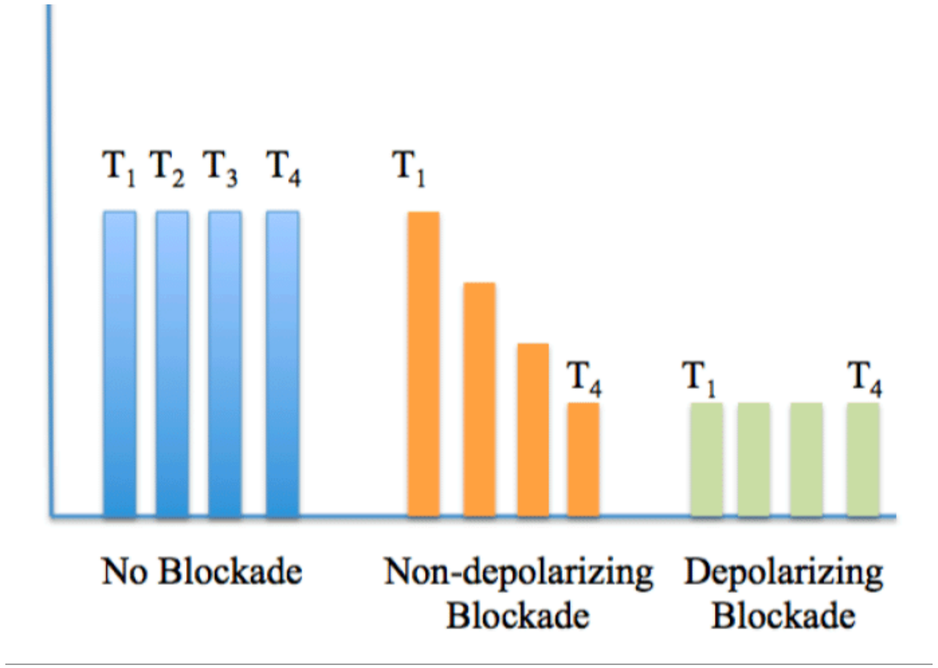
- Single stimuli
- 0.1 - 1.0 Hz
- May appear normal with considerable weakness
- Poor indicator of deep paralysis
- No clinical utility





Train-of-four (TOF) stimulation

- 4 supramaximal stimuli every 0.5 seconds (2 Hz)
- Each set (train) of stimuli is repeated every 10-20 seconds
- Number of responses = TOF count
- With 4 responses
- “No fade” Vs. “Fade”
- T4:T1 ratio = TOF ratio (%)



Train-of-four (TOF) stimulation

TOF count	% NM blockade	Reversal agent
4	0-75%	20 mcg/kg of Neostigmine
3	75%	40 mcg/kg of Neostigmine
2	80%	50 mcg/kg of Neostigmine
1	90%	WAIT
0	100%	WAIT

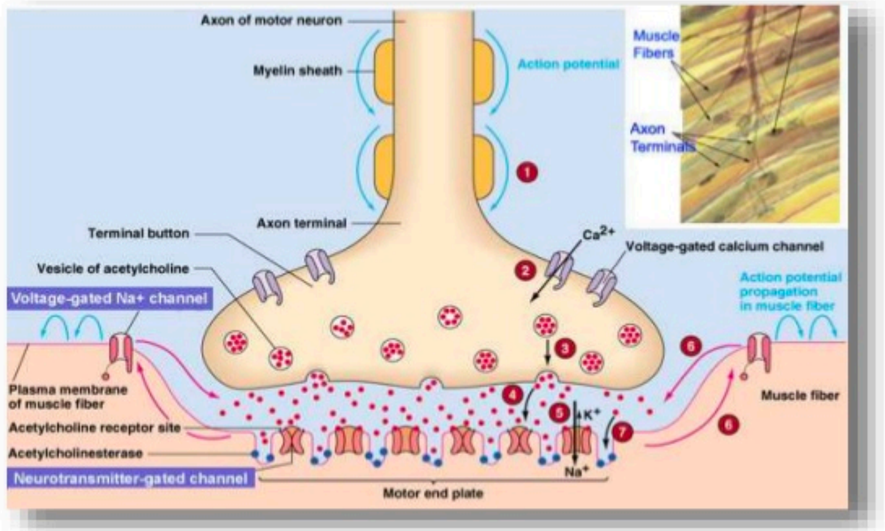
TOF ratio (%)

TOF ratio > 0.9 before extubation

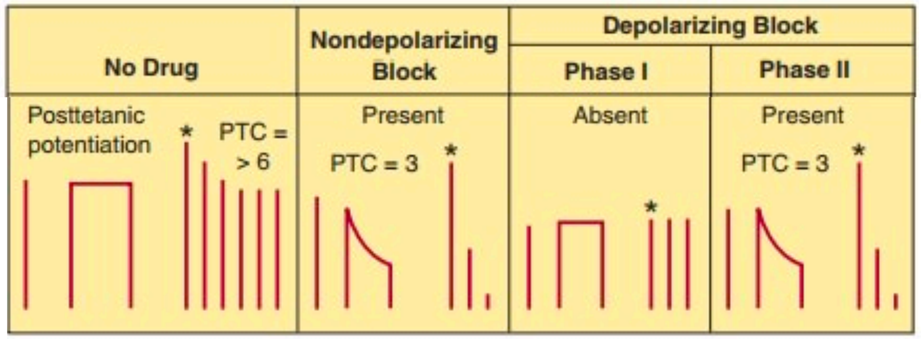
Tetanic stimulation

- Very rapid (e.g. 30, 50, or 100 Hz)
- Normal and pure depolarizing block
  - Sustained response, no fade
- Nondepolarizing block and phase II block after succinylcholine
  - Start of stimuli - large amounts of acetylcholine (Ach) are released
  - Presynaptic - Ach stores deplete, the rate of Ach release decreases
  - Postsynaptic - decrease the number of free cholinergic receptors
  - Fade in response to tetanic and TOF stimulation

Neuromuscular Blocking Agents



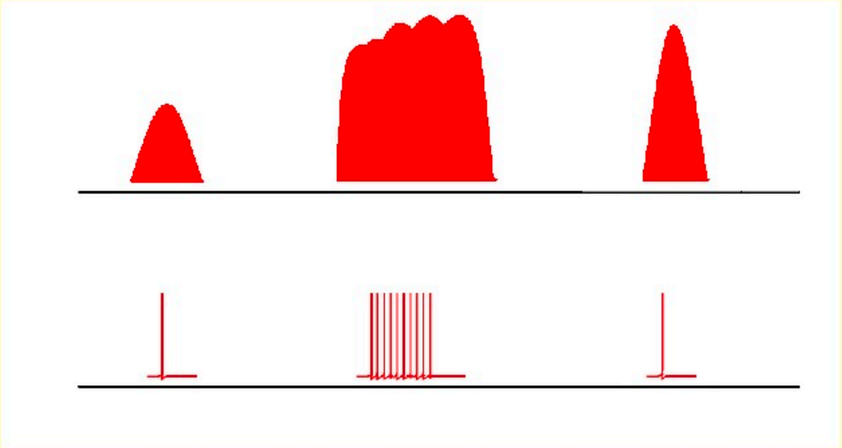
Resident: B.Ankhzaya *(MNUMS)*



Post-tetanic potentiation

- Increase in twitch tension following tetanic stimulation
- Increase in mobilization and synthesis of Ach continues after discontinuation of tetanic stimulation
- Degree and duration depend on the degree of NMB
- Usually disappear within 60 seconds

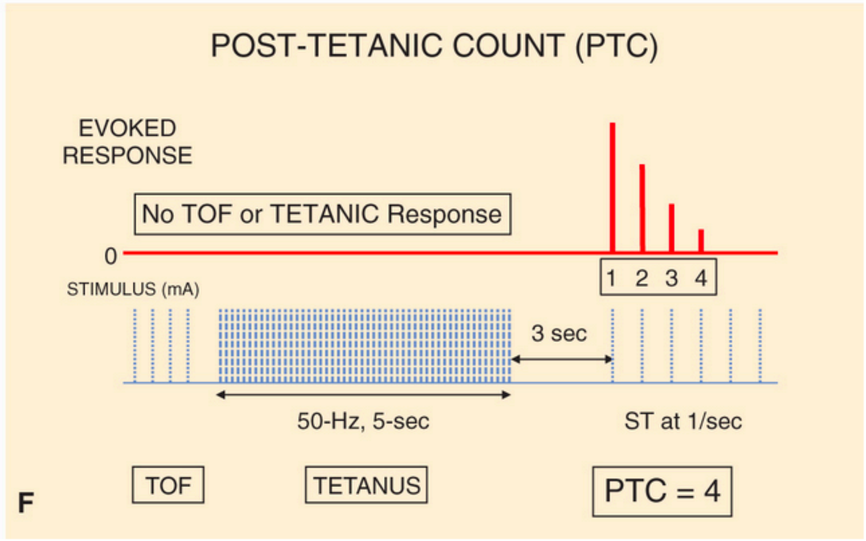
Post-tetanic potentiation (Long-term potentiation) – amplification of reflex reaction on weak stimulus

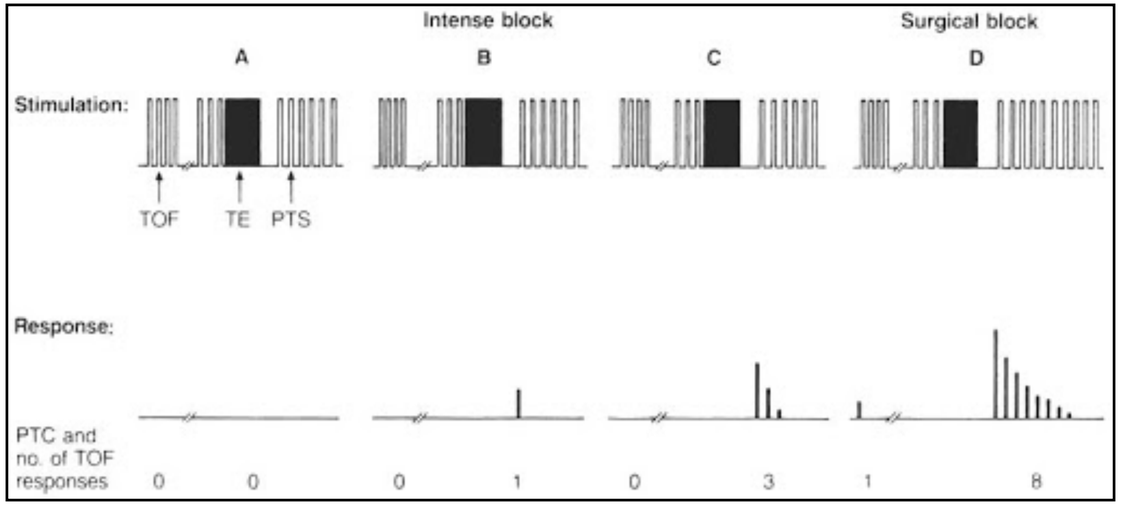


The reason *- accumulation in presynapse calcium ions.*

Post-tetanic count (PTC) stimulation

- Apply single-twitch at 1 Hz 3 seconds after the end of tetanic stimulation
- To quantify intensity of blockade during intense NMB (no response to TOF or single twitch)
- Main application in surgery requiring intense block (ophthalmic surgery)

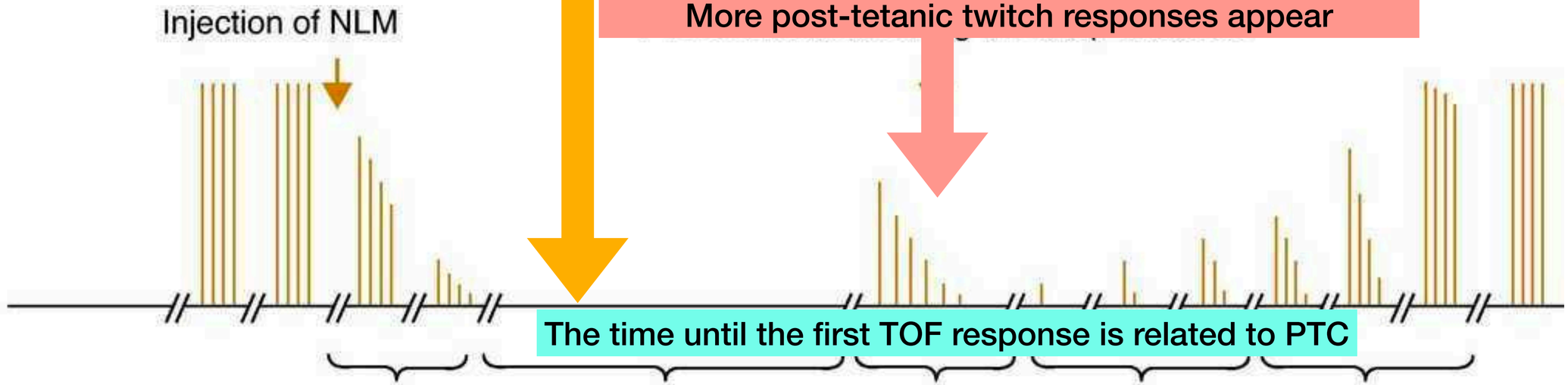




Post-tetanic count

During intense block
no response to either tetanic or post-tetanic stimulation

Intense block dissipates
More post-tetanic twitch responses appear

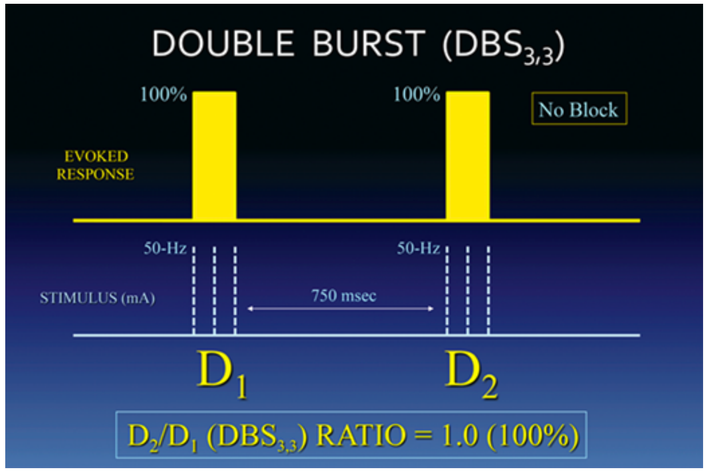


Degree of blocking	Start	Intense blockade	Deep blockade	Moderate blockade	Recovery
Response to the TOF Response to the CPT	Count of TOF ≥1	Count of TOF 0 CPT 0	Count of TOF 0 CPT≥1	Count of TOF 01-3 PTC≥1	Quotient TOF

Rev Colomb Anestesiol. 2012;40:293–303

Double-burst stimulation

- Two short bursts of 50-Hz tetanic stimulation separated by 750 msec
- Duration of each square wave impulse in the burst is 0.2 msec
- $DBS_{3,3}$ ratio
  - Nonparalyzed - Equal strength
  - Partial blockade - the second response is weaker than the first (fade)
- Correlates closely with the TOF ratio
- Aim to allow manual detection of small amounts of residual blockade
- Absence of fade in the manually evaluated response to DOES NOT exclude residual NMB



No drug	Nondepolarizing block	Depolarizing block	
		Phase I	Phase II
Train-of-four TOF–R = 1.0	Fade TOF–R = 0.4	Constant but diminished TOF–R = 1.0	Fade TOF–R = 0.4
Double burst	Fade	No fade	Fade

The nerve stimulator

https://www.youtube.com/watch?v=IyVOGq6leso

The TOFscan device generates several modes of neuromuscular stimulation:

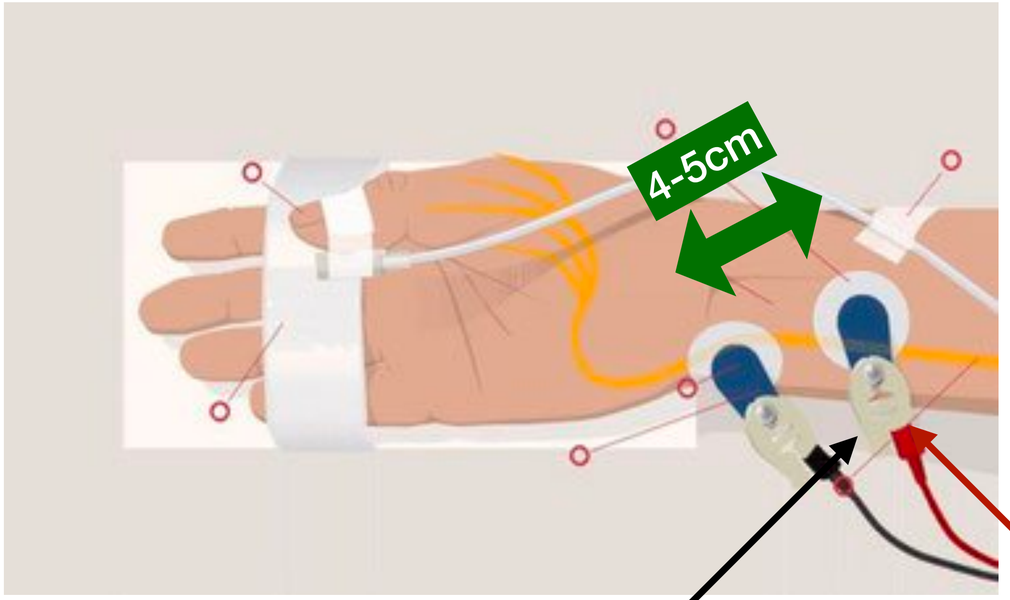
- TOF (Train Of Four)
- PTC (Post Tetanic Count)
- TOF plus PTC
- DBS (Double Burst) (3,3) (3,2) (2,3)
- ST (Single Twitch) 0.1 Hz and 1 Hz
- TET (Tetanus 50 Hz)

TOFscan's 3D accelerometer produces measurements from the induced muscle responses:

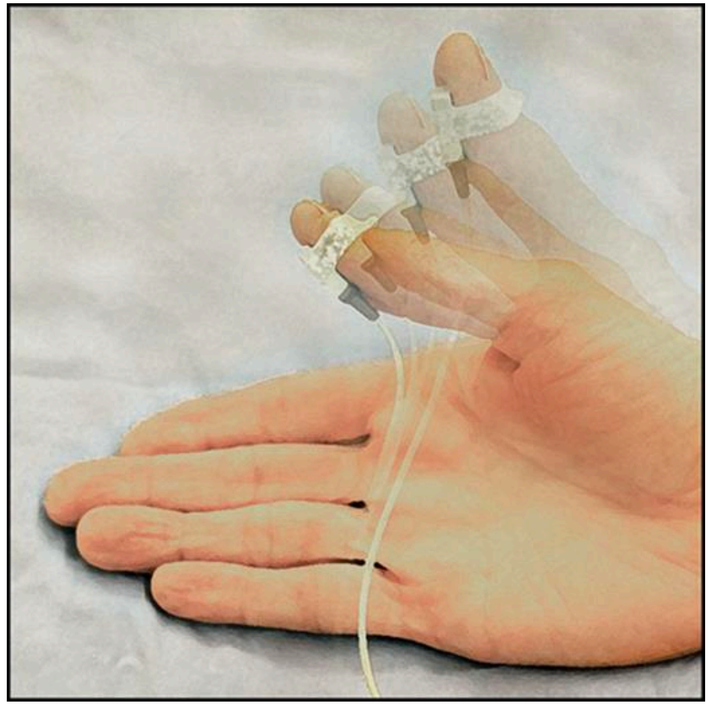
- TOF % : T4/T1
- TOF % : T4/Tref
- PTC : Number of responses detected

Sites of monitoring

Ulnar nerve



- Adductor pollicis
  - *Thumb adduction*
- Flexor carpi ulnaris
  - *Finger flexion*

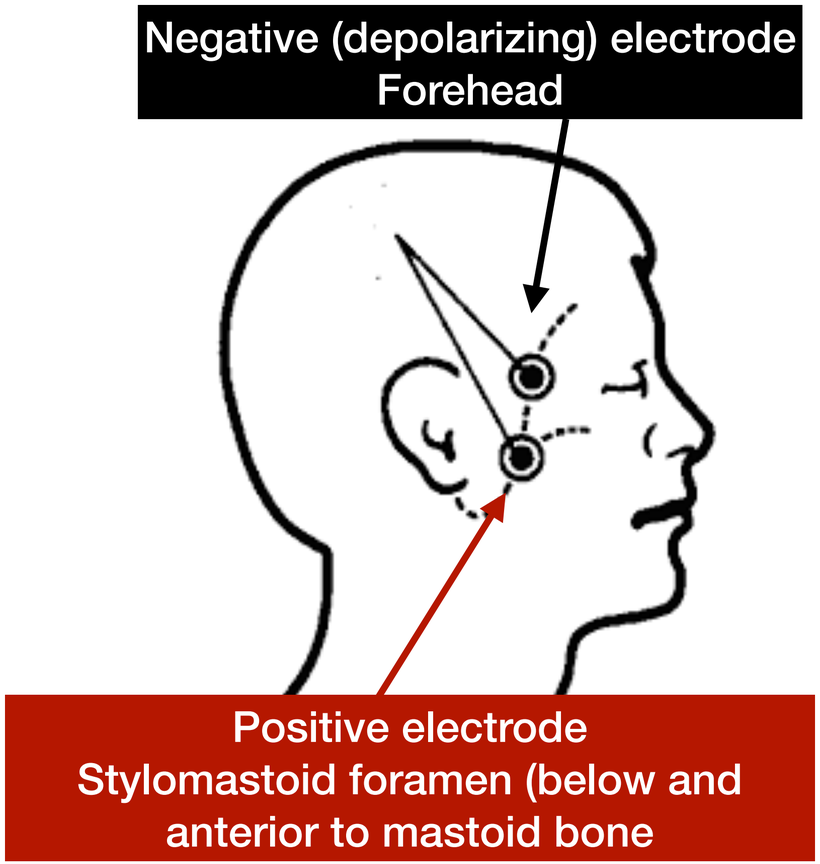


Free movement of the thumb must be ensured

Sites of monitoring

Facial nerve

- Orbicularis oculi (eyelid closure) and corrugator supercilii (eyebrow winks)
- More resistant to NMBAs than peripheral extremities
- The evoked response is usually evaluated subjectively (not recommended)
- Difficult to evaluate *degree* of NMB
- *Should not be used to access adequacy of reversal*



Different muscle response to NMBAs

- Different muscle groups - different sensitivities to NMBAs
- Diaphragm & vocal cord
  - The most resistant to both depo and non-depolarizing NMBAs
  - Requires higher dose of NMBA & recovers more quickly
- Orbicularis oculi present the laryngeal adductor muscles better than adductor pollicis
- Upper airway muscles are more sensitive than peripheral muscles

Muscle	Sensitivity
Vocal cord	Most resistant
Diaphragm	
Orbicularis oculi	
Abdominal rectus	
Adductor pollicis	
Masseter	
Pharyngeal	
Extraocular	Most sensitive

Monitoring of Neuromuscular Junction. - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Relative-sensitivities-of-muscle-groups-to-nondepolarizing-muscle-relaxants_tbl3_269691464 [accessed 28 Nov, 2020]

Evaluation of the evoked response

- Mechanomyography (MMG) - Evoked mechanical response of the muscle
- Electromyography (EMG) - Evoked electrical (peak-to-peak amplitude) response of the muscle
- **Acceleromyography (AMG) - Acceleration of the muscle response**
- Kinemyography (KMG) - Electrical response in a piezoelectric film sensor attached to the muscle

Acceleromyography

- Newton’s second law: force = mass x acceleration
- If mass is constant, acceleration is directly proportional to force
- Measure acceleration of the thumb using piezoelectric ceramic transducer with electrodes on both sides
- Not possible when free movement of the thumb cannot be assured
- TOF-Watch is no longer commercially available
- 3-dimensional technology to make the transducers less dependent on the correct alignment

Subjective (Tactile) Vs. Objective (Quantitative) measurements

Table. Levels of Neuromuscular Block

Depth of Block	Objective Measurement at Adductor Pollicis Muscle	Subjective Measurement at Adductor Pollicis Muscle
Complete block	Posttetanic count = 0	Posttetanic count = 0
Profound block	Posttetanic count = 1–3	Posttetanic count = 1–3
Deep block	Posttetanic count ≥4, train-of-four count = 0	Posttetanic count ≥4, train-of-four count = 0
Moderate block	Train-of-four count = 1–2	Train-of-four count = 1–2
Modest block	Train-of-four count = 3–4	Train-of-four count = 3–4
Shallow block	Train-of-four ratio <0.40	Train-of-four count = 4, fade
Minimal block	Train-of-four ratio = 0.40–0.90	Train-of-four count = 4, no fade
Acceptable recovery	Train-of-four ratio ≥0.90	Cannot be determined

Anesth Analg 2019 Jun;128(6):1063-1064.

Intraoperative Acceleromyography Monitoring Reduces Symptoms of Muscle Weakness and Improves Quality of Recovery in the Early Postoperative Period

Glenn S. Murphy, M.D.,* Joseph W. Szokol, M.D.,* Michael J. Avram, Ph.D.,†
Steven B. Greenberg, M.D.,‡ Jesse H. Marymont, M.D.,* Jeffery S. Vender, M.D.,§ Jayla Gray, B.A.,‖
Elizabeth Landry, B.A.,‖ Dhanesh K. Gupta, M.D.#

Table 2. Perioperative Data

	Control Group	Acceleromyography Group	Difference (99% CI)	*P* Value
Anesthesia duration (min)	145 (64–381)	156 (65–387)	−11 (−38 to 19)	0.367
Blood loss (ml)	50 (20–900)	100 (10–1,400)	0 (−50 to 15)	0.552
Crystalloid volume (ml)	1,350 (130–3,995)	1,500 (400–6,500)	−100 (−450 to 200)	0.394
Temperature at end of procedure (°C)	36.2 ± 0.6	36.2 ± 0.6	0 (−0.3 to 0.2)	0.699
Temperature at arrival postanesthesia care unit (°C)	36.6 ± 0.3	36.6 ± 0.4	0 (−0.2 to 0.1)	0.934
Total rocuronium dose (mg)	60 (30–160)	60 (20–160)	0 (−10 to 10)	0.440
Number of rocuronium repeat doses	1 (0–10)	1 (0–11)	0 (−1 to 1)	0.948
Number of twitches at reversal	4 (1–4)	4 (0–4)	0 (0 to 0)	0.009
Time neostigmine to extubation (min)	10 (1–43)	10 (1–37)	0 (−4 to 2)	0.662
Time neostigmine to post-anesthesia care unit (min)	16.5 (5–47)	18 (6–45)	−1 (−5 to 2)	0.196
Time neostigmine to train-of-four (min)	20 (8–52)	20.5 (6–48)	−1 (−5 to 2)	0.370
Train-of-four ratio in PACU	0.88 (0.33–1.26)	0.98 (0.48–1.28)	− 0.1 (− 0.18 to − 0.01)	0.004
Train-of-four ratio <0.9	37 (50.0%)	11 (14.5%)	35.5% (16.4% to 52.6%)	<0.0001
Train-of-four ratio <0.7	14 (18.9%)	3 (4.0%)	15.0% (1.8% to 29.8%)	0.004

- An RCT
- 155 patients
- Acceleromyography Vs. qualitative TOF
- Lower incidence of residual NMB at PACU using intraop AMG
- Less overall symptoms of muscle weakness ($p < 0.0001$)

Anesthesiology 2011; 115:946–54

Intraoperative use of different modes of nerve stimulation

	During induction			
	Induction drugs	Supramaximal stimulation	Tracheal intubation	
Single twitch		1.0 Hz	0.1 Hz	
TOF				
PTC				
DBS				

During induction

- Attach before induction
- Do not turn on until the patient is unconscious
- Seeking supramaximal stimulation single twitch
- Change to TOF (or 0.1 Hz of single-twitch) before administer NMBAs
- Intubate when the response of TOF disappears for 30-90 seconds

Chapter 39 – Neuromuscular Monitoring Jørgen Viby-mogensen. Available from http://faculty.washington.edu/ramaiahr/Chapter_39_Neuromuscular_Monitoring.pdf

- If succinylcholine was used for intubation
  - Do not give any more muscle relaxant until the response to nerve stimulation reappears
  - 4-8 minutes in normal plasma cholinesterase activity

	During induction			During operation			Recovery room
	Induction drugs	Supramaximal stimulation	Tracheal intubation	Intense blockade	Moderate blockade	Reversal	
Single twitch		1.0 Hz	0.1 Hz				
TOF							
PTC							
DBS							

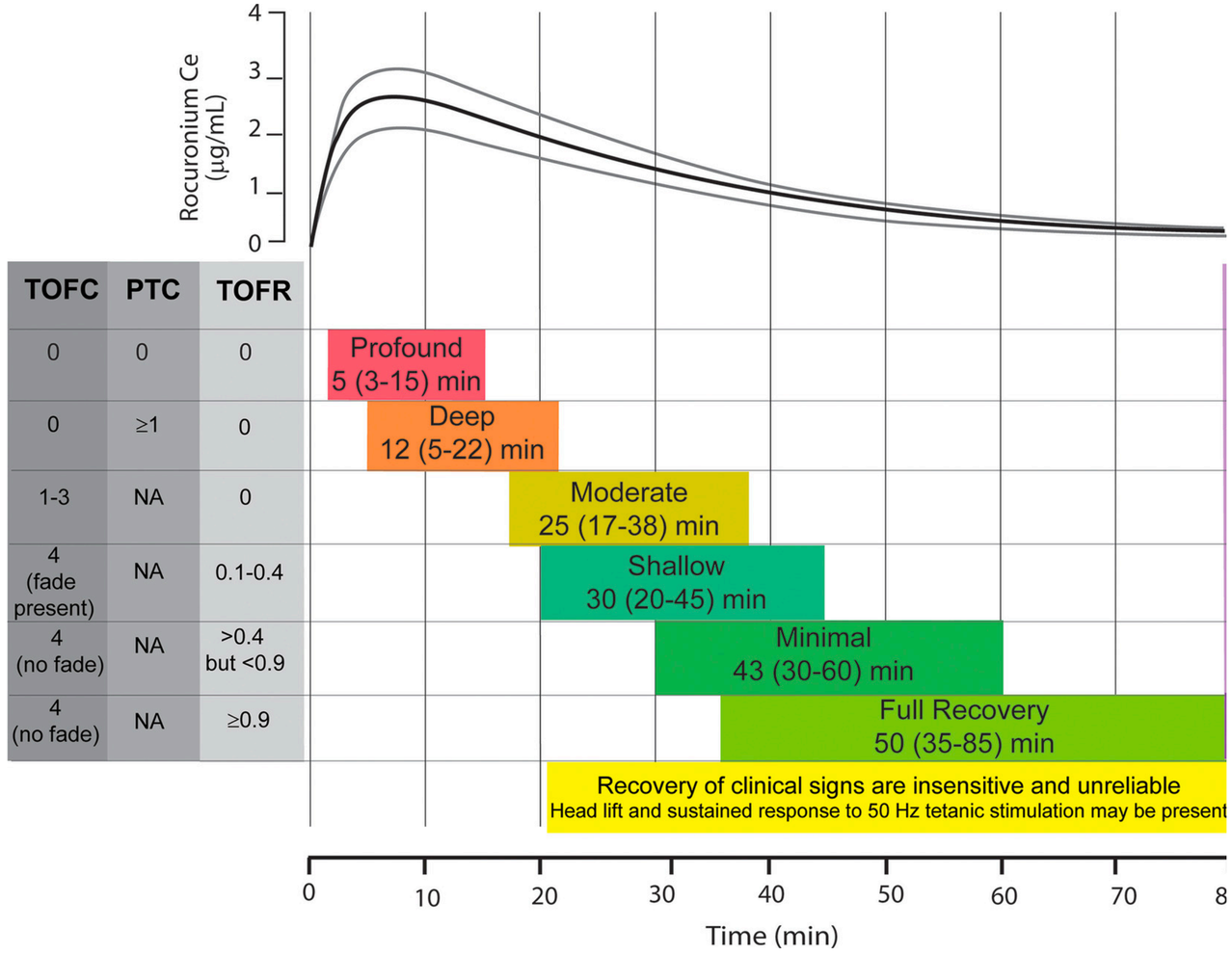
Chapter 39 – Neuromuscular Monitoring Jørgen Viby-mogensen. Available from http://faculty.washington.edu/ramaiahr/Chapter_39_Neuromuscular_Monitoring.pdf

During surgery

3 levels of blockade: intense blockade, moderate or surgical blockade and recovery

Intense blockade

- No response to TOF or single-twitch stimulation
- Unable to determine how long intense blockade will last
- PTC stimulation

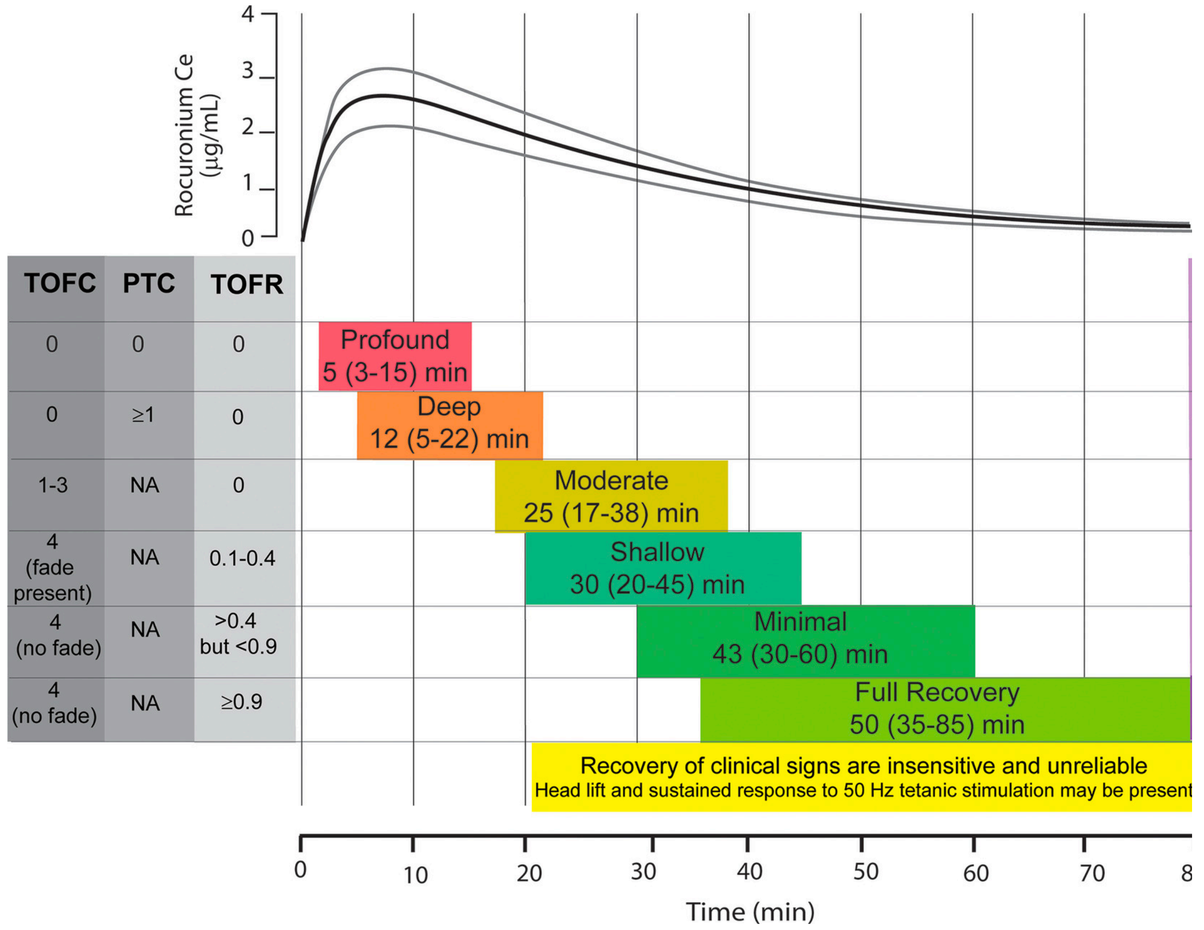


During surgery

3 levels of blockade: intense blockade, moderate or surgical blockade and recovery

Moderate or surgical blockade

- Begins at the first TOF to the return of the four TOF stimulation
- 1st response - 90-95% blockade
- 4th response - 60-85% blockade
- Sufficient relaxation for most surgical procedures -TOF 1 or 2 responses
- Light anesthesia, however, the patients may move, buck or cough
- More intense block can be evaluated by PTC = 0



Recovery

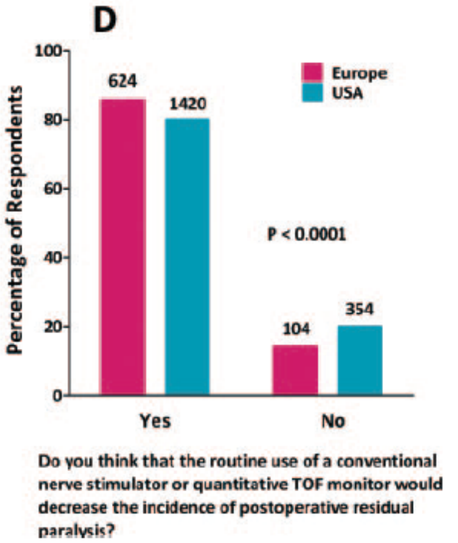
- Antagonism given with at least TOF 2 responses
- After 4 responses of TOF, estimation of TOF ratio
- Tactile stimulation is not sensitive enough to exclude possibility of residual blockade)
- Residual NMB (TOF < 0.9) is associated with functional impairment of the pharynx and upper esophagus >> regurgitation and aspiration

Why and when to monitor??

A Survey of Current Management of Neuromuscular Block in the United States and Europe

Mohamed Naguib, MD,* Aaron F. Kopman, MD,† Cynthia A. Lien, MD,†
Jennifer M. Hunter, MB, PhD, FRCA,‡ Adriana Lopez, MS,§ and Sorin J. Brull, MD‖

- Internet-based survey among anesthesia practitioners in Europe and USA
- 2,636 respondents in 2008
- More than half estimated the incidence of residual NMB < 1%
- Most respondents reported not using NM monitoring as part of the minimal standard monitoring



Question	No. (%) European respondents	No. (%) United States respondents
	N = 739	*N* = 1792
In your opinion, conventional nerve stimulators should (choose all that apply)[b]		
a) Be a part of the minimal monitoring standards	240 (32.5)	1011 (56.4)
b) Be available in the operating room	435 (58.9)	1416 (79.0)
c) Be regarded as unnecessary	87 (11.8)	41 (2.3)
d) No opinion	98 (13.3)	20 (1.1)
	N = 739	*N* = 1792
In your opinion, quantitative TOF monitors should (choose all that apply)[b]		
a) Be a part of the minimal monitoring standards	247 (33.4)	194 (10.8)
b) Be available in the operating room	474 (64.1)	804 (44.9)
c) Be regarded as unnecessary	37 (5.0)	151 (8.4)
d) No opinion	86 (11.6)	757 (42.2)

Anesth Analg 2010;111:110–9

A survey of the management of neuromuscular blockade monitoring in Australia and New Zealand

S. PHILLIPS*, P. A. STEWART†, A. B. BILGIN‡

Department of Anaesthesia, Sydney Adventist Hospital, Sydney, New South Wales, Australia

- 678 survey questionnaires completed (21% response rate)
- 71.4% underestimated the incidence of residual NMB
- Objective NM monitoring was used routinely by only 17%
- Only 25% correctly indicated that quantitative TOF > 0.9 were criteria for safe extubation
- 29% believed NM monitoring should be routine

How often do you monitor neuromuscular function in your patients receiving muscle relaxant?

	n (%)
Never	65 (10)
Rarely	166 (25)
Sometimes	171 (25)
Frequently	158 (23)
Often	117 (17)
Total	677 (100)

Rarely=once a year, sometimes=once a month, frequently=once a week, often=almost daily.

Anaesthetists' opinions of neuromuscular function monitors

	n (%)
Are unnecessary	42 (6)
Are unreliable	64 (9)
Should be minimum monitoring	201 (29)
Be available in every operating room	532 (79)
Be quantitative	263 (39)
Total	1102 (162)

BRIEF REPORT

Postoperative Residual Paralysis in Outpatients Versus Inpatients

Guy Cammu, MD, PhD*, Jan De Witte, MD*, Jan De Veylder, RN*, Geert Byttebier, MSc†, Dirk Vandeput, MD*, Luc Foubert, MD, PhD*, Geert Vandenbroucke, MD*, and Thierry Deloof, MD*

*Department of Anesthesiology and Critical Care Medicine, OLV Clinic, Aalst, Belgium; and †General Biometric Services and Consulting, Ghent, Belgium

Table 3. Diagnostic Attributes of the Clinical Tests; Sensitivity, Specificity, Positive and N Individual Clinical Test for a Train-of-Four <90%

Variable	Sensitivity	Specificity	Positive Pred Value
Inability to smile	0.29	0.80	0.47
Inability to swallow	0.21	0.85	0.47
Inability to speak	0.29	0.80	0.47
General weakness	0.35	0.78	0.51
Inability to lift head for 5 s	0.19	0.88	0.51
Inability to lift leg for 5 s	0.25	0.84	0.50
Inability to sustained hand grip for 5 s	0.18	0.89	0.51
Inability to perform sustained tongue depressor test	0.22	0.88	0.52

The sensitivity of a test is the number of true positives divided by the sum of true positives + false negatives; the specificity is the number of true negatives divided by the sum of true negatives + false positives. True positives are patients scoring positive for a test and having a train-of-four (TOF) <90%. False negatives are patients with a negative test result but a TOF <90%. True negatives have a negative test score and a TOF not <90%; false positives score positively but have a TOF not <90%. A *positive* test result means *inability* to smile, swallow and speak, general muscular weakness, etc.

Table 4. Sensitivity and Specificity for a Train-of-Four (TOF) <90 of Each Possible Sum of Eight Clinical Tests

Sum of 8 clinical test results per patient	Sensitivity	Specificity
>7	0.07	0.94
>6	0.12	0.92
>5	0.16	0.90
>4	0.20	0.88
>3	0.24	0.85
>2	0.33	0.81
>1	0.37	0.75
>0	0.46	0.67

The sum is calculated by giving one point for a positive test result and zero for a negative one. A positive test result means inability to smile, swallow and speak, general muscular weakness, etc.

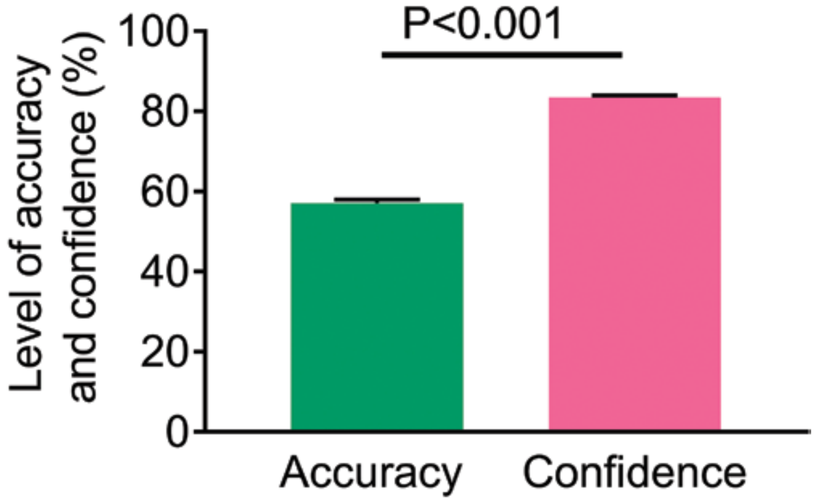
Low ability of clinical tests to detect TOF < 90%

Anesth Analg 2006;102:426 –9

Anesthesiologists' Overconfidence in Their Perceived Knowledge of Neuromuscular Monitoring and Its Relevance to All Aspects of Medical Practice: An International Survey

Mohamed Naguib, MD, MSc, FCARCSI,* Sorin J. Brull, MD, FCARCSI (Hon),†
Jennifer M. Hunter, MBE, MBChB, PhD, FRCA, FCARCSI (Hon),‡ Aaron F. Kopman, MD,§
Béla Fülesdi, MD, PhD, DSci,‖ Ken B. Johnson, MD,¶ and Hal R. Arkes, BA, PhD#

- Internet-based multilingual survey
- 9 true/false questions related to the use of NMBAs
- 1,629 anesthesiologists from 80 countries
- 57% of the questions answered correctly
- Mean confidence exhibited was 84%
- 1,496 (92%) overconfident



Anesth Analg 2019;128:1118–26

Problems related to the use of neuromuscular monitoring

- Low frequency of routine neuromuscular monitoring
- Lack of anesthesia practitioner awareness of high incidence (40-60%) of residual NMB and associated morbidity
- Poor awareness of inability of clinical signs and tests to detect modest level of NM blockade

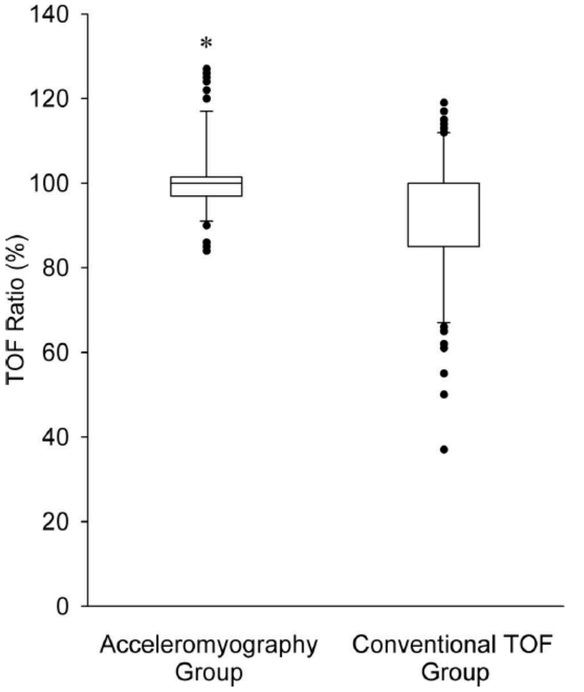
The patient responses to NMBAs varied, the use of NM monitoring will ensure effective antagonism and prevent residual NMB and its complications

Intraoperative Acceleromyographic Monitoring Reduces the Risk of Residual Neuromuscular Blockade and Adverse Respiratory Events in the Postanesthesia Care Unit

Glenn S. Murphy, M.D., Joseph W. Szokol, M.D.,* Jesse H. Marymont, M.D.,* Steven B. Greenberg, M.D.,†*
Michael J. Avram, Ph.D.,‡ Jeffery S. Vender, M.D.,§ Margarita Nisman, B.A.‖

Table 4. Postanesthesia Care Unit Variables

	Acceleromyography Group	Conventional TOF Group	Difference (99% CI)	*P* Value
Number	89	90	—	—
Dose fentanyl, μg	0 (0–200)	0 (0–100)	0 (0 to 0)	0.09
Dose hydromorphone, mg	1 (0–4)	1 (0–5)	0 (−0.5 to 0.5)	0.75
Temperature on PACU arrival, °C	36.35 ± 0.57	36.50 ± 0.67	−0.14 (−0.39 to 0.10)	0.12
Spo_2 on PACU arrival, %	97 (90–100)	95 (72–100)	2 (1 to 3)	<0.0001
No. with Spo_2 90–93% on arrival in PACU	5 (5.6%)	22 (24.4%)	−18.8% (−32.9 to −5.5%)	<0.001
No. with Spo_2 < 90% on arrival in PACU	0 (0%)	9 (10.0%)	−10.0% (−21.1 to −2.7%)	0.003
No. with episodes of Spo_2 90–93% in PACU	6 (6.7%)	39 (43.3%)	−36.6% (−51.2 to −21.1%)	<0.0001
No. of Spo_2 90–93% episodes in PACU	0 (0–4)	0 (0–12)	0 (−1 to 0)	<0.0001
No. with episodes of Spo_2 < 90% in PACU	0 (0%)	19 (21.1%)	−21.1% (−34.0 to −12.2%)	<0.0001
No. of Spo_2 < 90% episodes in PACU	0 (0–0)	0 (0–6)	0 (0 to 0)	<0.0001
Lowest Spo_2 in PACU, %	96 (90–100)	93.5 (80–100)	3 (2 to 4)	<0.0001
No. requiring airway maneuver in PACU	0 (0%)	4 (4.4%)	−4.4% (−13.8 to 2.7%)	0.12
No. requiring stimulation to maintain Spo_2 in PACU	0 (0%)	7 (7.8%)	−7.8% (−18.3 to −0.5%)	0.014



RCT,185 patients
Intraoperative acceleromyography Vs. Conventional TOF

Anesthesiology 2008; 109:389–98

RESEARCH ARTICLE Open Access

Usefulness of intra-operative neuromuscular blockade monitoring and reversal agents for postoperative residual neuromuscular blockade: a retrospective observational study

Gonzalo Domenech[1*], Matías A. Kampel[1], María E. García Guzzo[1], Delfina Sánchez Novas[1], Sergio A. Terrasa[2] and Gustavo Garcia Fornari[1]

Table 4 Multivariable logistic regression analysis for the association between residual neuromuscular blockade and potentially related factors

	OR	95% CI	*P* value
Intra-operative NMB monitoring	0.043	0.004 to 0.400	0.006
Sugammadex	0.182	0.045 to 0.727	0.016
Neostigmine	0.798	0.124 to 5.099	0.812
Duration of surgery	1.002	0.995 to 1.009	0.522
Time from last NMBD dose	0.986	0.977 to 0.995	0.002
Rocuronium	0.861	0.174 to 4.247	0.855
Atracurium	1.846	0.349 to 9.751	0.470

- Retrospective cohort study
- Tertiary referral hospital, Argentina
- 240 patients underwent elective surgery requiring NMBAs
- Residual NMB (TOF < 0.9) at PACU
- 1.6% (quantitative NMB monitoring) Vs. 32% (not monitored) of residual NMB (P < 0.01)

BMC Anesthesiology (2019) 19:143

Current guidelines for the use of NMB monitoring

Society guidelines

- No published guidelines from the American Society of Anesthesiologists (ASA) and the European Society of Anaesthesiology (ESA)
- The ASA standard of intraoperative monitoring (2015) *does not* include NMB monitoring[1]
- The ASA Practice Guidelines for Postanesthetic Care (2013)[2]
  - *"assessment of neuromuscular function primarily includes physical examination and, on occasion, may include NMB monitoring"*

1. https://www.asahq.org/standards-and-guidelines/standards-for-basic-anesthetic-monitoring
2. Anesthesiology 2013 Feb;118(2):291-307.

Consensus Statement on Perioperative Use of Neuromuscular Monitoring

Mohamed Naguib, MB BCh, MSc, FCARCSI, MD,* Sorin J. Brull, MD, FCARCSI (Hon),†
Aaron F. Kopman, MD,‡ Jennifer M. Hunter, MBE, MB ChB, PhD, FRCA, FCARCSI (Hon),§
Béla Fülesdi, MD, PhD, DSci,‖ Hal R. Arkes, BA, PhD,¶ Arthur Elstein, PhD,#
Michael M. Todd, MD,** and Ken B. Johnson, MD††

- International panel of experts, published 2017
- *"Quantitative (objective) NMB monitoring should be used whenever non-depolarizing NMBAs are administered"*
- Subjective monitoring and clinical evaluation of muscle strength should be abandoned
- Education & time in order to change
- Professional organizations should develop practice standards and guidelines detailing how best to monitor and manage perioperative administration of NMBDs

Anesth Analg 2018;127:71–80

No recommendations from RCAT

Country	Year	Recommendations
Great Britain & Ireland[1]	2015	a peripheral nerve stimulator is mandatory for all patients receiving NMBAs Apply and use from induction until recovery *Quantitative monitor is required*
Norwegian[2]	2016	Monitoring of NM function when NMBAs and reversal are used
Australian & New Zealand[3]	2017	Neuromuscular function monitoring, *preferably quantitative*, must be available for every patient in whom NMBAs has been induced Should be used whenever the anaesthetists consider extubation
Danish[4]	2017	Nerve stimulator should be used if a non-depolarizing NMBAs are administered Quantitative measure not mentioned
Japanese[5]	2018	Monitoring of NM function when NMBAs and reversal are used
Dutch[6]	2019	Peripheral nerve stimulator as minimal monitoring standard when NMBAs are administered

1. Anaesthesia. 2016;71(1):85–93
2. https://www.nafweb.com/dokumenter/norsk-standard-for-anestesi-2016.pdf.
3. http://www.anzca.edu.au/documents/ps18-2015-guidelines-on-monitoring-during-anaesthe.pdf.
4. http://www.dasaim.dk/wp-content/uploads/2019/05/Rekommandation-for-an%C3%A6stesi-2017.pdf.
5. https://anesth.or.jp/files/pdf/monitor3_20190509.pdf.
6. https://www.anesthesiologie.nl/uploads/files/KD_Leidraad_Anesthesiologische_perioperatieve_zorg_11032019.pdf..

Changes of Guidelines

- The 2016 Finnish guideline[1] abandoned clinical testing which had been part of the previous (1999) guidelines
- Canadian guidelines
  - 2016 - a nerve stimulator only needed to be “exclusively available for each patient”[2]
  - 2018 - NM should be utilized when non-depolarizing NMBAs are administered[3]
  - 2020 - NM is mandatory when NMBAs are used, Nerve stimulator is “required”, Objective monitoring is superior to subjective monitoring[4]

1. https://www.say.fi/application/files/6314/5392/9236/1suomen_anestesiologiyhdistyksen_suositukset_vuodelta_1999.
2. Can J Anaesth. 2016;63(1):86–112.
3. Can J Anaesth. 2018;65(1):76–104.
4. Can J Anaesth. 2019;67(1):64–99.

ELSEVIER

SFAR
Société Française d'Anesthésie et de Réanimation

Guidelines

Guidelines on muscle relaxants and reversal in anaesthesia☆,☆☆

Benoît Plaud [a,*,1], Christophe Baillard [b,1], Jean-Louis Bourgain [c], Gaëlle Bouroche [d], Laetitia Desplanque [e], Jean-Michel Devys [f], Dominique Fletcher [g,2], Thomas Fuchs-Buder [h], Gilles Lebuffe [i], Claude Meistelman [h], Cyrus Motamed [c], Julien Raft [j], Frédérique Servin [e], Didier Sirieix [k], Karem Slim [l], Lionel Velly [m,2], Franck Verdonk [n], Bertrand Debaene [o,1]

- Monitoring of NMB intraoperatively is recommended; (GRADE 1+) strong agreement
- TOF stimulation of the ulnar nerve at the adductor pollicis; (GRADE 2+) strong agreement
- Quantitative adductor pollicis monitoring of the neuromuscular blockade for diagnosing a residual NMB and obtaining a TOF ratio of 0.9 to eliminate the possibility of diagnosing a residual NMB; (GRADE 2+) strong agreement
- Pursue quantitative monitoring of neuromuscular blockade after administration of neostigmine until a TOF ratio of 0.9 has been obtained (GRADE 1+) strong agreement

Anaesth Crit Care Pain Med 39 (2020) 125–142

Take home messages

- Residual NMB increases risks for postoperative pulmonary complications
- Clinical evaluate of recovery of NM function is difficult and unreliable
- Tactile (Subjective) responses to TOF stimulation DOES NOT exclude residual NMB
- Evidence-based practice mandates clinician to use objective monitoring
- To avoid significant residual NMB, TOF ratio measured must be ≥ 0.9 before extubation