Jan P Mulier

Sint jan Brugge, Belgium

2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

Why is measuring NMT essential in obese patient to optimize muscle relaxation?

az sint-jan
brugge - oostende av

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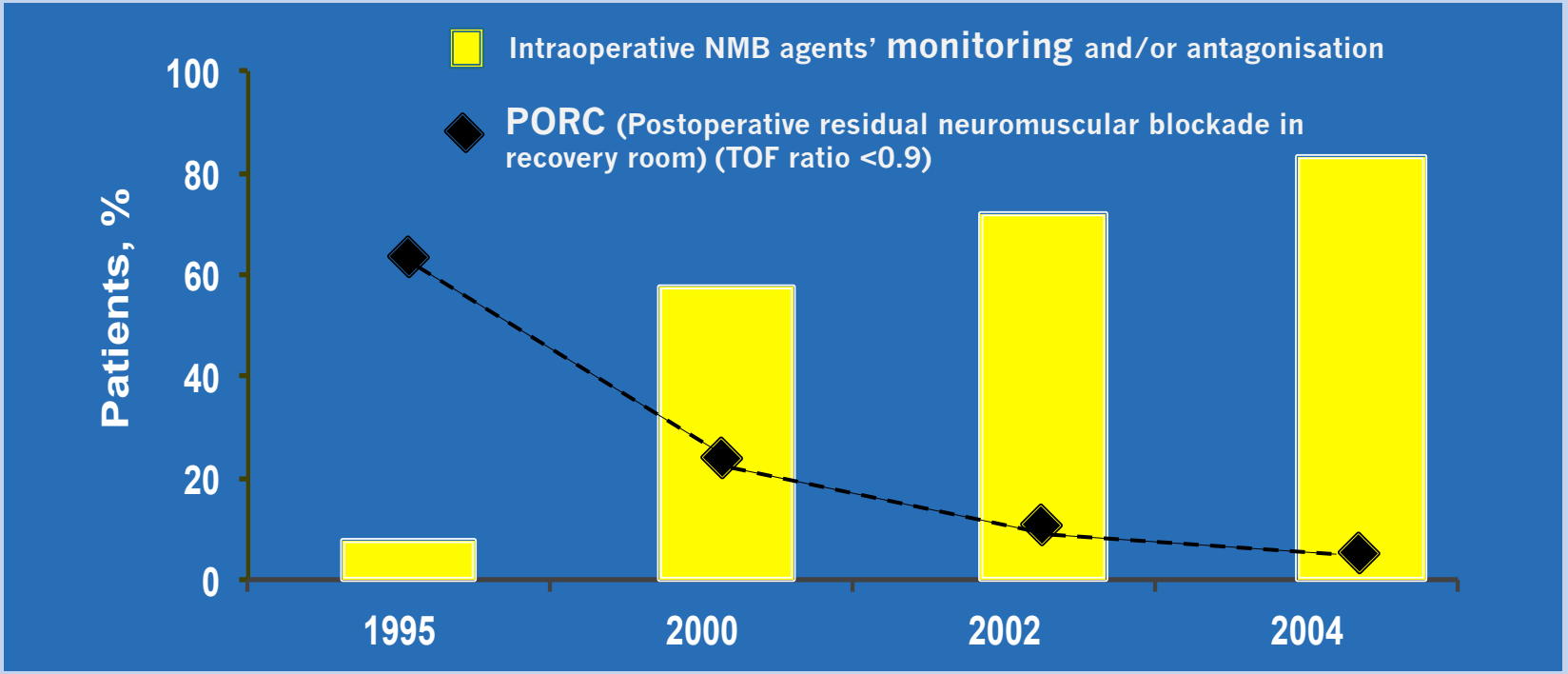
The Clinical Benefits of Routine Monitoring and Reversal[1]



NMB=neuromuscular blockade; TOF=train of four.

1. Baillard C et al. *Br J Anaesth.* 2005;95:622–626.

Economics, Education, and Policy

Section Editor: Franklin Dexter

What Rules of Thumb Do Clinicians Use to Decide Whether to Antagonize Nondepolarizing Neuromuscular Blocking Drugs?

Rogerio L. R. Videira, MD, PhD, and Joaquim E. Vieira, MD, PhD

Table 1. Heuristics (Rules of Thumb) Most Frequently Chosen and the Percentage of Clinicians Who Chose Them (Simple Rank), in Comparison with Other Surveys

Heuristics	Brazil Videira and Viera[a]	Europe Naguib et al[6]	USA Naguib et al[6]	France Duvaldestin et al[23]	UK Grayling & Sweer
Time since last NMBD dose	73 (1st)	71 (1st)	69 (1st)	30 (2nd)	—
Breathing pattern	71 (2nd)	—	—	—	36 (2nd)
Muscular strength	56 (3rd)	44 (3rd)	53 (3rd)	—	26 (3rd)
Type of NMBD	56 (4th)	20 (6th)	21 (5th)	—	—
Ventilometry results	47 (5th)	—	—	10 (3rd)	11 (4th)
Total NMBD dose	46 (6th)	43 (4th)	47 (4th)	—	—
TOF value (quantitative)	44 (7th)	46 (2nd)	12 (6th)	—	—
Head lift maintenance	40 (8th)	—	—	60 (1st)	42 (1st)
TOF fade (qualitative)	—	28 (5th)	56 (2nd)	—	—

NMBD = neuromuscular blocking drug; TOF = train-of-four ratio; US = United States; UN = United Kingdom.

[a] Results as presented in this study.

Time since last NMB dose

PORC impossible if 60 min ago?

No monitor needed, no reversal needed?

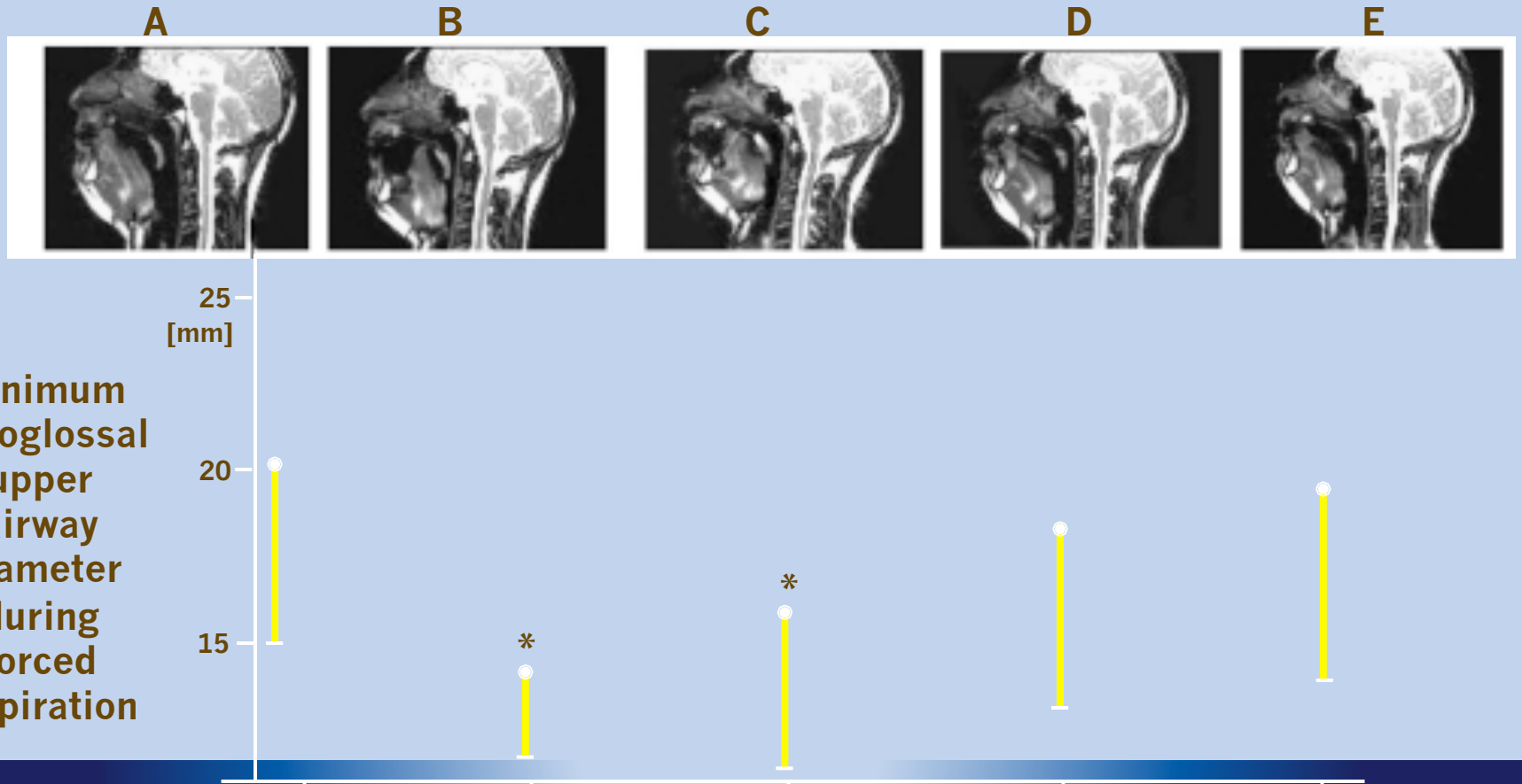
Breathing pattern clinical sufficient

PORC impossible? No monitor needed, no reversal needed

Anesth Analg 2011;113:1192–6

Why do we need TOF > 90% before extubation?

Importance of Achieving TOF ≥0.9



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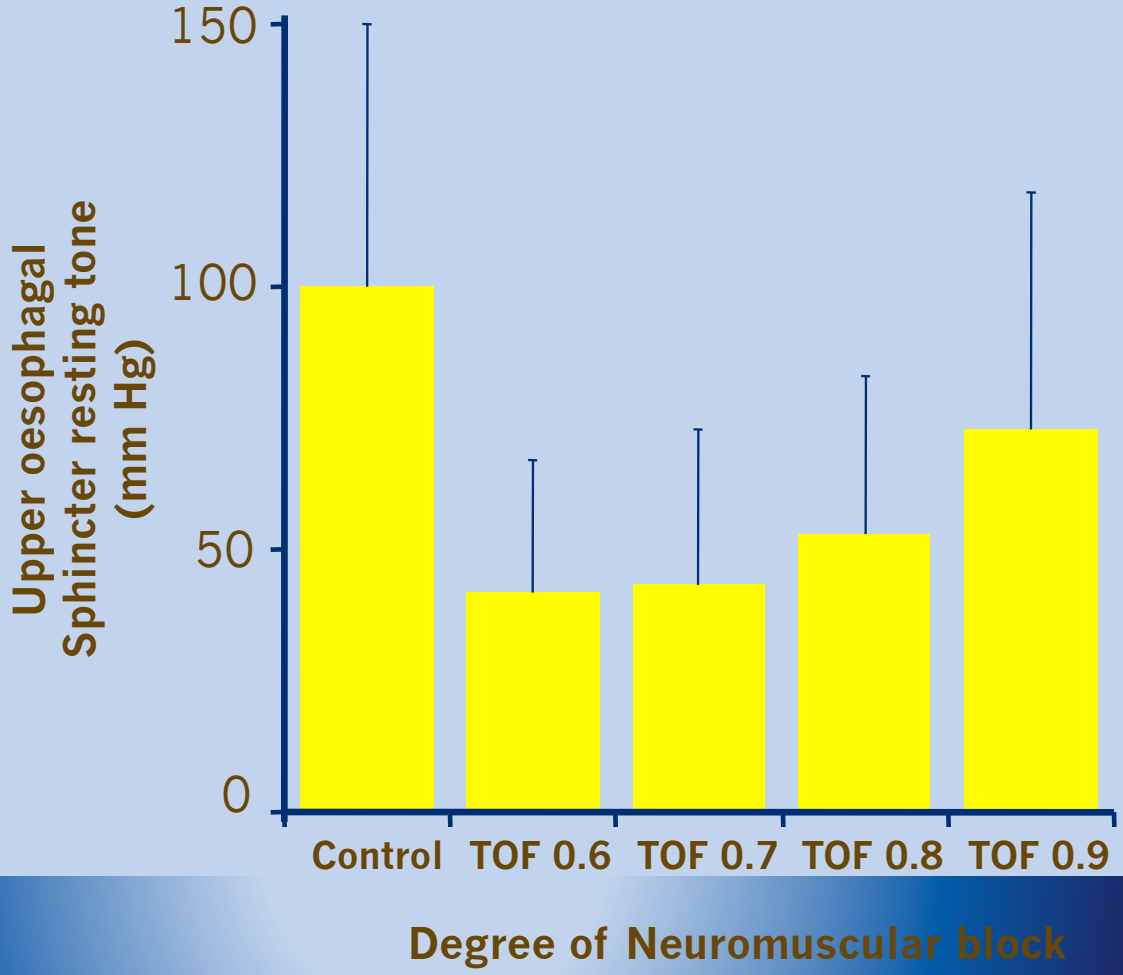
Eikermann, et al. *Am J Respir Crit Care Med.* 2007;175:9-15.

* *P*<0.05 versus baseline

Obstructive breathing post op if TOF < 90%

Pharynx Dysfunction Increases the Aspiration Risk after extubation

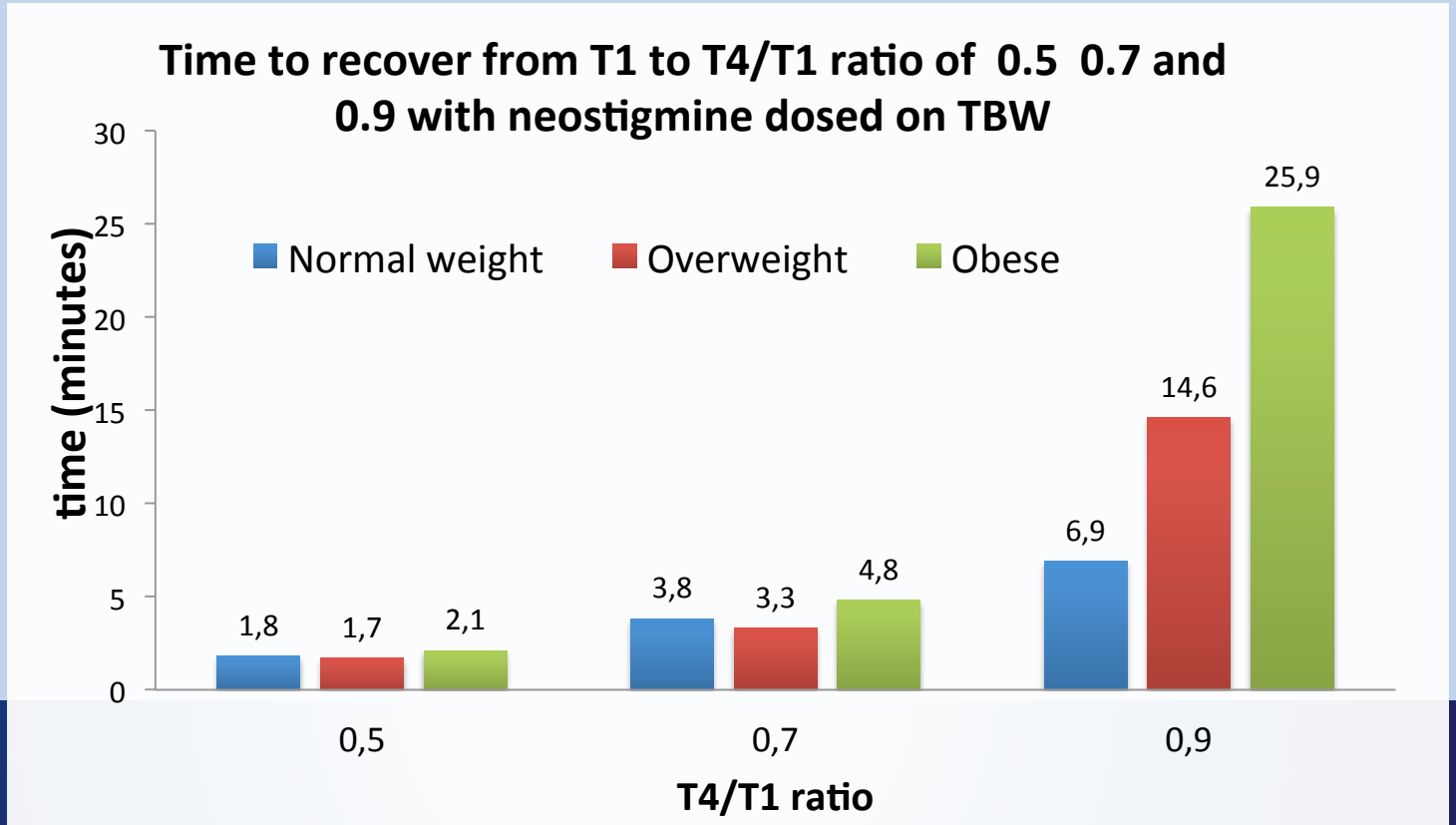
Human volunteers
Partially paralyzed



Mulier ESA 2015
Eriksson LI, et al. *Anesthesiology*. 1997;87:1035

Neostigmine is Less Effective in Obese Patients

- **Obese patients are more difficult to reverse with neostigmine.**



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

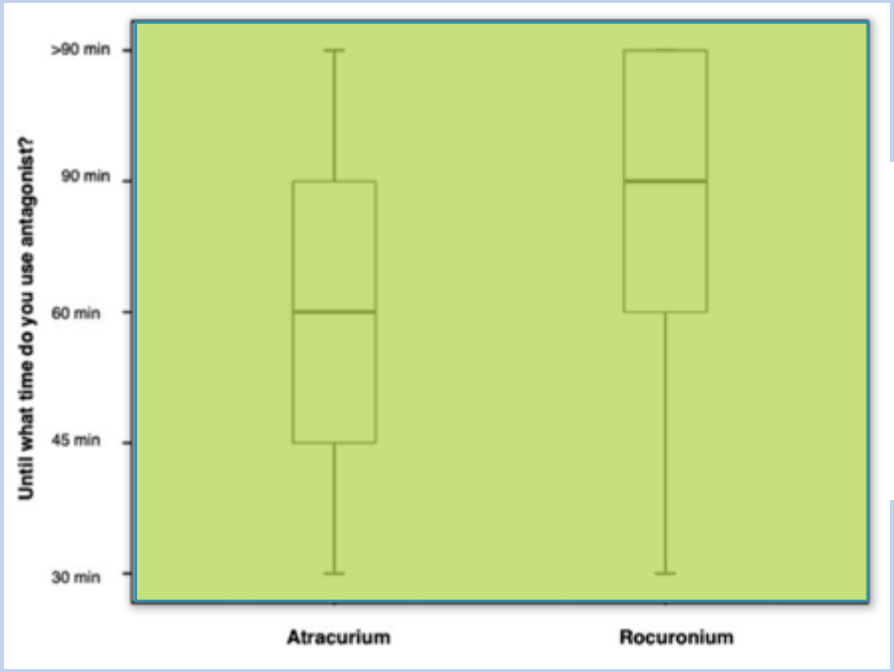
After a single dose, how long do you wait to extubate the patient's trachea without reversal?

Economics, Education, and Policy

Section Editor: Franklin Dexter

What Rules of Thumb Do Clinicians Use to Decide Whether to Antagonize Nondepolarizing Neuromuscular Blocking Drugs?

Rogerio L. R. Videira, MD, PhD, and Joaquim E. Vieira, MD, PhD



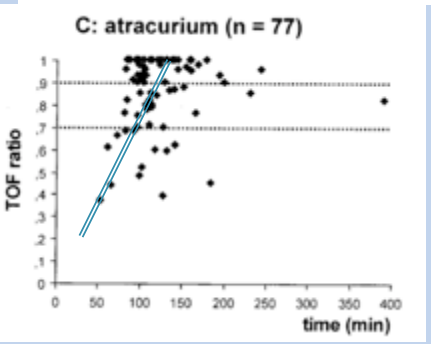
- Statistically significant difference between neuromuscular blocking drugs for 60 minutes.

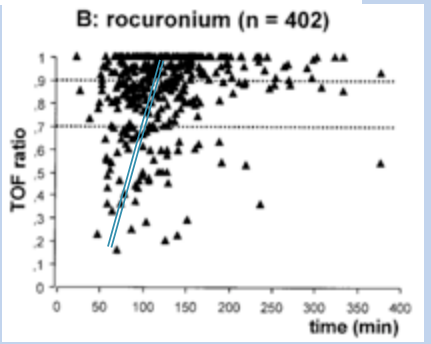
CLINICAL INVESTIGATIONS

Anesthesiology 2003; 98:1042–8

Residual Paralysis in the PACU after a Single Intubating Dose of Nondepolarizing Muscle Relaxant with an Intermediate Duration of Action

Bertrand Debaene, M.D.,* Benoît Plaud, M.D.,† Marie-Pierre Dilly, M.D.,‡ François Donati, Ph.D., M.D., F.R.C.P.C.§





- Waiting 120 min is needed to have only 50 % spont reversal
- 100 % do not wait for atracurium
- 90 % do not wait for rocuronium

Anesth Analg 2011;113:1192–6

- NMT monitoring is the key to adequate NMB management.
- Neostigmine is best administered after re-emergence of the 3rd or 4th train-of-four (TOF) response.
- If obese this might take longer.

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(*Acta Anaesth. Belg., 2013, 64, 49-60*)

A review of the interest of sugammadex for deep neuromuscular blockade management in Belgium

Ph. E. Dubois (*) and J. P. Mulier (**)

Abstract : Oro-tracheal intubation and selected surgical conditions are facilitated by a deep neuromuscular block (NMB), but patient's security can be jeopardized by its residual effects at the time of tracheal extubation. Although neostigmine remains the reference reversal agent in many situations, the limitations of its efficacy must be well understood (ceiling effect, delay of action, side effects). It is best administered after re-emergence of the 3rd or 4th train-of-four (TOF) response. Sugammadex causes more predictable and more rapid recoveries from much deeper rocuronium-induced NMB. Therefore, maintaining deep NMB during surgery is no longer incompatible with rapid recovery and safe extubation. In Belgium, the use of sugammadex and its reimbursement depend on specific conditions. The excellent clinical tolerance of sugammadex benefits to patients at risk of developing complications related to residual NMB or to the undesirable effects of neostigmine. In all cases, neuromuscular transmission monitoring is the key to adequate NMB management.

Key words : Neuromuscular block ; residual neuromuscular block ; rocuronium ; neostigmine ; sugammadex ; neuromuscular transmission monitoring.

In Belgium, sugammadex has been available for clinical practice since March 1st, 2009. The patients, who pay for the drug, benefit from specific reimbursement conditions by the 'Institut national d'assurance maladie-invalidité / Rijksinstituut voor Ziekte en Invaliditeitsverzekering - INAMI/RIZIV' (National Health and Disability Insurance Institute), which became effective on July 1st, 2010. This new drug has several clinical benefits, either for the patient or for the clinician, and practitioners did not wait for the establishment of the INAMI/RIZIV reimbursement program before using the drug. Unfortunately, sugammadex has a relatively high cost, which remains a barrier to its routine clinical use in Belgium, even with its own reimbursement program. Undoubtedly, the cost of the drug impacts on the decisions of most clinicians as to use of the new drug instead of neostigmine, the historically classic reversal agent.

Currently, only a limited number of anesthesiologists have changed their practice of neuromuscular block (NMB) management and reversal. Most of them have changed their protocols for a limited number of procedures. As a result, the use of specific relaxants and their antagonists varies among hospitals, and even between anesthesiologists within the same team.

Considering the wide variability in daily clinical practices, the authors of this review aimed at listing the reasons for inducing and reversing neuromuscular blockades (NMBs) in 2013. We here propose an algorithm for proper NMB management and reversal, based on the technical and pharmacological options available in Belgium. We also suggest specific modifications to the current state of clinical practice. In particular, we propose a specific role for sugammadex as a reversal agent within the context of Belgian anesthesia practice.

Definitions and scope

The authors will describe the management modalities for non-depolarizing NMBs. The depolarizing block induced by succinylcholine is generally short in length and cannot be reversed by the pharmacologic agents discussed here.

After the induction of NMB, spontaneous recovery is defined as the progressive recovery of neuromuscular transmission and muscular contractile strength. The progressive return to normal function of the nicotinic receptors is related to the

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Reversal according to NMB level

Block level	NMT monitoring (Adductor pollicis)		Reversal agent	Comment
	Objective - Quantitative	Subjective - Qualitative		
Full recovery				There is no monitoring able to confirm full recovery
Safe extubation	TOF ratio > 0.9 (MMG) (≥ 1.0 with AMG?)	No fade to tetanus 100 Hz	Not needed	Up to 70% of nicotinic receptors are still occupied by NMBA! The patient is at risk of NMB recurrence
Recovery in process	TOF ratio 0.5 - 0.9	No TOF or DBS fade	Neostigmine low dose 0.02 mg/kg	Pay attention to the delay and variability of neostigmine reversal!
Moderate NMB	TOF count 3-4	DBS or TOF count 4 with fade	Neostigmine standard dose 0.05 mg/kg	Reversal threshold for neostigmine Maximal dose 0.07 mg/kg, ceiling effect! Sugammadex 2 mg/kg is not reimbursed, but could help to spare time and improve safety in selected patients
	TOF count 1-2		Sugammadex 2 mg/kg	Sugammadex is suitable only for steroidal NMBA! Sugammadex is reimbursed according to specific INAMI/ RIZIV conditions
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 Manual TOF count at corrugator supercilii could be an alternative to PTC at adductor pollicis
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

Effects Of Rocuronium on Morbidly Obese Patients

Rocuronium 0.6 mg/kg:

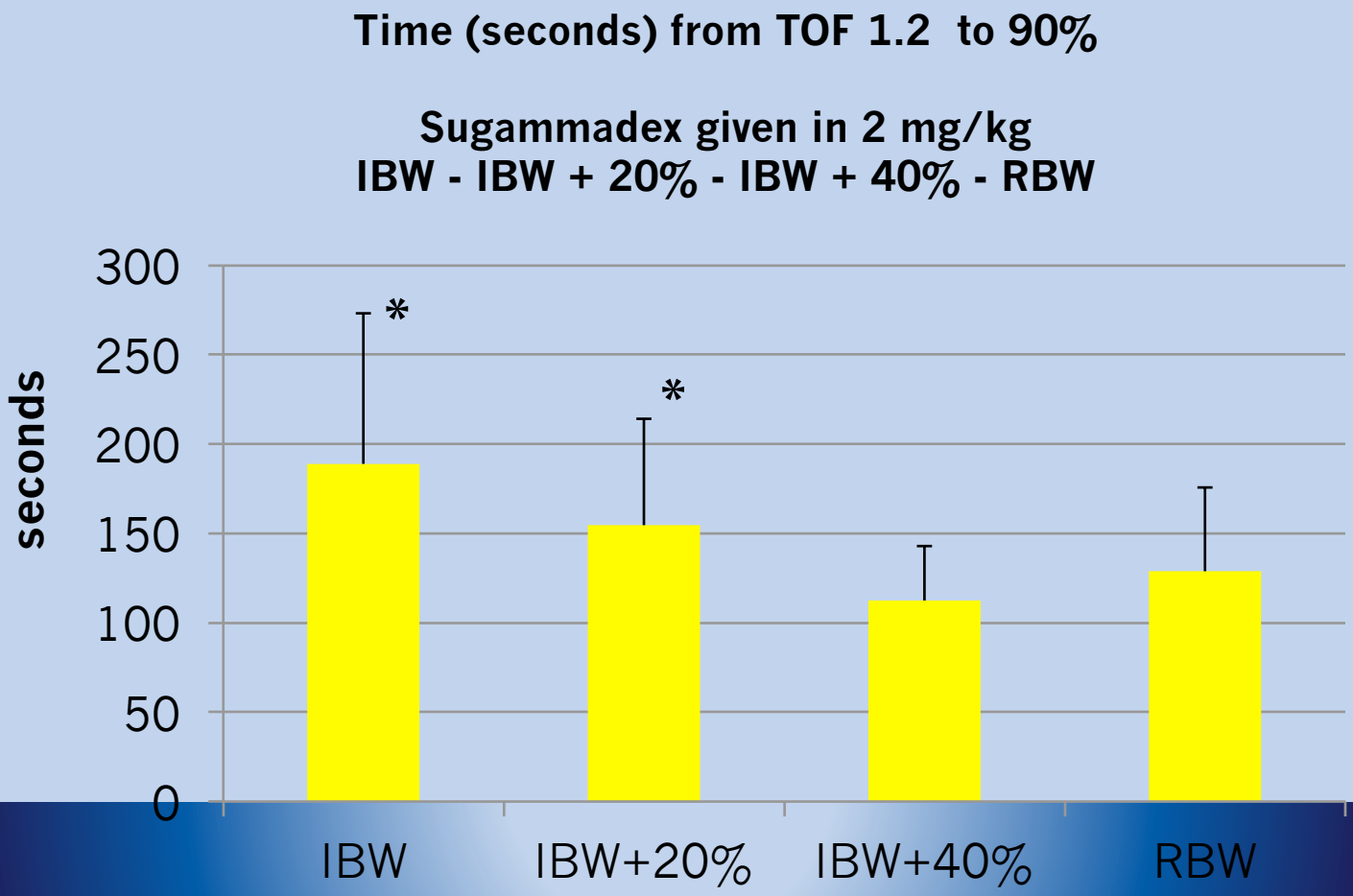
- RBW: Real body weight (BMI>40)
- IBW: ideal body weight (BMI>40)
- NBW: RBW in non obese patients (BMI < 25)

Group	BMI	Weight (kg)	Onset (sec)	Duration 25% (min)
RBW (*n*=6)	43.8 ± 2.1	111 ± 13	77.0 (37-92)	**55.5** (43.6-60.1)
IBW (*n*=6)	43.3 ± 5.8	114 ± 21	87.5 (54-99)	**22.3*** (21.1-24.9)
NBW (*n*=6)	22.1 ± 1.8	62 ± 8	66.5 (50-85)	**25.4*** (18.4-31.1)

* *P*<0.001 vs Real Body Weight

Leykin Y et al. *Anesthesia Analgesia*. 2004;99:1086-1089.

Ideal vs Corrected Body Weight for Dosage of Sugammadex in Morbidly Obese Patients



IBW=ideal body weight; RBW: real body weight

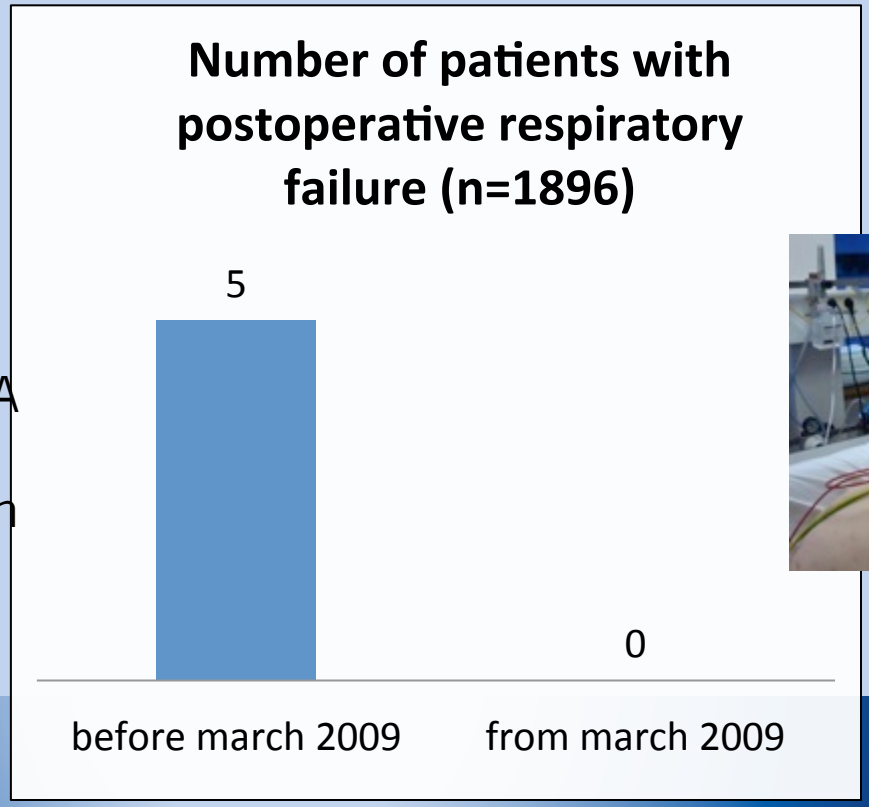
Mulier. ESA 2015

Van Lancker T, et al. *Anaesthesia*. 2011;66(8):721-725.

*P<0.001 versus RBW

Perfect reversal in morbidly obese patients prevents pulmonary complications

- **Retrospective analysis of 948 consecutive morbid obese patients before vs. 948 consecutive morbid obese patients after availability of sugammadex.**
- **1st march 2009: sugammadex available**
- **Mulier JP, ESA 2011**



- Respiratory failure
- Re intubation
- CPAP different from OSA
- Hypercapnia post op
- Intensive care admission

Do you measure NMT routinely when NMB are given?

- If you ask it here you might get 50 %
- Reality 10%
- Most centers do not have one NMT monitor in each OR room
- Some have only one monitor
  - With no Battery
  - Cables defect
  - Not aware how to use it properly

Acta Anaesthesiol Scand 2010; **54**: 307–312
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ACTA ANAESTHESIOLOGICA SCANDINAVICA
doi: 10.1111/j.1399-6576.2009.02131.x

Knowledge of residual curarization: an Italian survey

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[1]*Department of Anesthesia and Intensive Care Medicine, University of Rome 'La Sapienza', Rome, Italy and* [2]*Department of Anesthesia and Intensive Care Medicine, University of Udine, Azienda Ospedaliera Universitaria, Udine, Italy*

Table 1

Clinical tests used to assess adequacy of reversal from neuromuscular blockade (parametric analysis).

	Total		Procedures/year			Age group (years)		
	%	Number	0–3000%	3001–5000%	Over 5000%	30–40%	41–50%	Over 50%
Sustained head lift (5 s)	67	505	69	64	68	70	63	64
Tongue protrusion	64	482	61	66	63	71*	52*	55†
Eye opening	47	354	47	44	49	51	48	39†
Hand grip	39	294	40	42	37	42	35	37
Normal pattern of respiration	24	180	19	24	28	25	24	23
Normal oxygen saturation	24	180	25	26	19	18†	27	33*
Normal vital capacity	19	143	0	24†	14†	16	22	22
Eyelid clenching	11	82	10	12	11	10	13	12
Tongue depressor test	8	60	10	7	7	8	10	6
Maximum inspiratory effort = 25 cmH_2O	7	52	6	8	7	6	9	7
Maximum inspiratory effort = 50 cmH_2O	3	22	1	5	3	3	3	2
Others	3	22	4	2	4	1	3	4

The sum of frequency exceeds 100% because multiple tests could be selected by a respondent.
On average, each respondent gave three answers. Five percent did not answer the question.
*$P<0.01$ vs. Total.
†$P<0.05$ vs. Total.

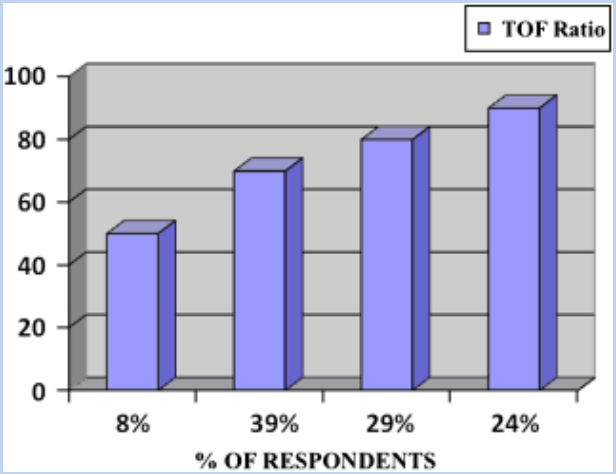
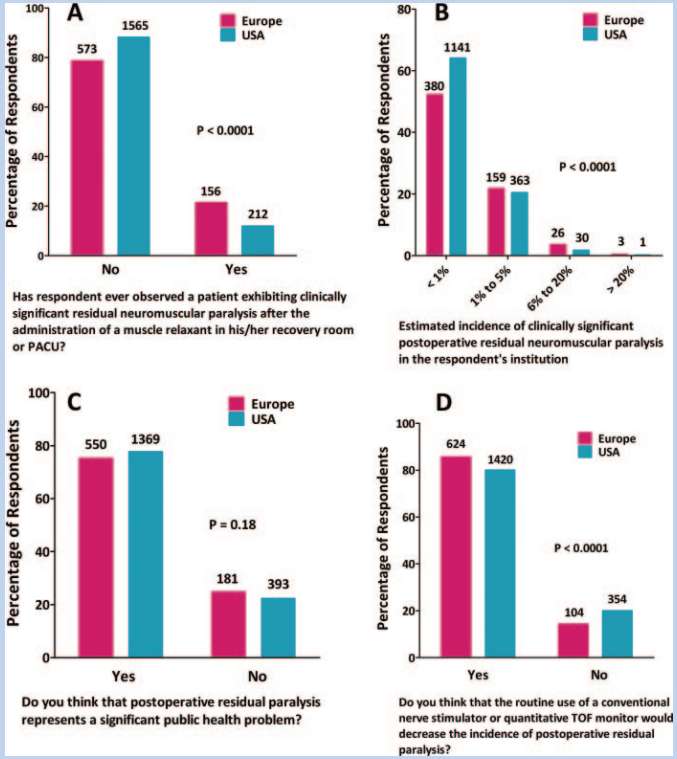


Fig. 1. Respondent opinion about the train-of-four (TOF) ratio considered safe for extubation (18% did not answer the question).

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‖

BACKGROUND: Postoperative residual neuromuscular block is a frequent occurrence. Recent surveys of clinical practice in Europe suggest that neuromuscular blocking drugs are often administered without appropriate monitoring. No comparable survey has been undertaken in the United States (US). From this survey, we compared current clinical neuromuscular practice and attitudes between anesthesia practitioners in the US and Europe.
METHODS: We conducted an Internet-based survey among anesthesia practitioners in the US and Europe. The Anesthesia Patient Safety Foundation and the European Society of Anaesthesiology e-mailed all of their active members, inviting them to anonymously answer a series of questions on a dedicated Internet Protocol address–sensitive website. The survey was available online for 60 days. The χ^2 test and Fisher's exact test were used to compare clinical survey items between the 2 cohorts.
RESULTS: A total of 2636 completed surveys were received. Most respondents from the US (64.1%) and Europe (52.2%) estimated the incidence of clinically significant postoperative residual neuromuscular weakness to be <1% ($P < 0.0001$). Routine pharmacologic reversal was less common in Europe than in the US (18% vs 34.2%, respectively; $P < 0.0001$), and quantitative monitors were available to fewer clinicians in the US (22.7%) than in Europe (70.2%) ($P < 0.0001$). However, 19.3% of Europeans and 9.4% of Americans never use neuromuscular monitors. Most respondents reported that neither conventional nerve stimulators nor quantitative train-of-four monitors should be part of minimum monitoring standards.
CONCLUSIONS: Our results suggest a lack of agreement among anesthesia providers about the best way to monitor neuromuscular function. Efforts to improve awareness by developing formal training programs and/or publishing official guidelines on best practices to reduce the incidence of postoperative neuromuscular weakness and patient morbidity are warranted. (Anesth Analg 2010;111:110–9)



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

Table 2. Availability and Use of Neuromuscular Monitoring

Question	No. (%) European respondents	No. (%) United States respondents	P
	N = 728	N = 1774	
Are quantitative TOF monitors available in your department?			
Yes	511 (70.2)	402 (22.7)	<0.0001
No	217 (29.8)	1372 (77.3)	
	N = 511	N = 402	
If yes, which units are available?[a]			
TOF Guard	205 (40.1)	51 (12.7)	
TOF Watch	230 (45.0)	51 (12.7)	
Datex NMT	193 (37.8)	151 (37.6)	
Other	92 (18.0)	180 (44.8)	
	N = 546	N = 668	
If quantitative TOF monitors are available, how are they distributed?			
1 per operating room	243 (44.5)	477 (71.4)	<0.0001
1 per 2 operating rooms	81 (14.8)	27 (4)	
1 per 3 or more operating rooms	222 (40.7)	164 (24.6)	
	N = 725	N = 1775	
Are conventional nerve stimulators available in your department?			
Yes	549 (75.7)	1726 (97.2)	<0.0001
No	176 (24.3)	49 (2.8)	
	N = 543	N = 1713	
If conventional nerve stimulators are available, how are they distributed?			
1 per operating room	206 (37.9)	1577 (92.1)	<0.0001
1 per 2 operating rooms	81 (14.9)	58 (3.4)	
1 per 3 or more operating rooms	256 (47.1)	78 (4.6)	
	N = 544	N = 1723	
Does each conventional nerve stimulator unit display the delivered current?			
Yes	421 (77.4)	955 (55.4)	<0.0001
No	123 (22.6)	768 (44.6)	
	N = 498	N = 692	
If you have both quantitative TOF monitors and conventional nerve stimulators available, which unit do you use routinely?			
Quantitative TOF monitor	265 (53.2)	130 (18.8)	<0.0001
Conventional nerve stimulator	85 (17.1)	437 (63.2)	
Both	52 (10.4)	60 (8.7)	
None	96 (19.3)	65 (9.4)	

TOF = train-of-four.
[a] The participant may answer >1 option presented in the second column.

Table 3. Availability and Use of Different Neuromuscular Blocking and Reversal Drugs

Question	No. (%) European respondents	No. (%) United States respondents	P
	N = 739	N = 1792	
Which of the following drugs are available in your operating room? Choose all those that apply[a]			
Succinylcholine	713 (96.5)	1780 (99.3)	
Mivacurium	472 (63.9)	200 (11.2)	
Rocuronium	651 (88.1)	1747 (97.5)	
Vecuronium	362 (49)	1554 (86.7)	
Cisatracurium	384 (52)	1235 (68.9)	
Atracurium	457 (61.8)	455 (25.4)	
Pancuronium	225 (30.5)	1167 (65.1)	
d-Tubocurarine	5 (0.7)	22 (1.2)	
	N = 739	N = 1792	
Which of the following neuromuscular blockers do you use to facilitate tracheal intubation? Choose all those that apply[a]			
Succinylcholine	634 (85.8)	1662 (92.8)	
Mivacurium	272 (36.8)	429 (2.3)	
Rocuronium	560 (75.8)	1650 (92.1)	
Vecuronium	227 (30.7)	904 (50.5)	
Cisatracurium	288 (39)	721 (40.2)	
Atracurium	363 (49.1)	196 (10.9)	
Pancuronium	81 (11)	321 (17.9)	
d-Tubocurarine	1 (0.1)	2 (0.1)	
None	0 (0.00)	31 (1.7)	
	N = 739	N = 1792	
Which of the following neuromuscular blockers do you commonly use to provide surgical relaxation? Estimate the percentage for each (should total 100%)[a]			
Succinylcholine	351 (47.5)	379 (21.2)	
Mivacurium	261 (35.3)	33 (1.8)	
Rocuronium	539 (72.9)	1605 (89.6)	
Vecuronium	242 (32.8)	1132 (63.2)	
Cisatracurium	296 (40.1)	854 (47.7)	
Atracurium	371 (50.2)	210 (11.7)	
Pancuronium	101 (13.7)	503 (28.1)	
d-Tubocurarine	6 (0.8)	6 (0.3)	
	N = 728	N = 1776	
When a nondepolarizing relaxant has been given, do you always administer an anticholinesterase at the end of surgery?			
Yes	131 (18)	607 (34.2)	<0.0001
No	597 (82)	1169 (65.8)	
	N = 592	N = 1165	
If answer to the above question was "No," in what percentage of cases do you omit a reversal drug?			
1%–25%	227 (38.3)	670 (57.5)	<0.0001
26%–50%	107 (18.1)	245 (21.0)	
51%–75%	115 (19.4)	158 (13.6)	
76%–100%	143 (24.2)	92 (7.9)	
	N = 739	N = 1792	
If you elect not to administer a reversal drug at the end of surgery, which of the following factors helps in making that decision? Choose all that apply[a]			
a) Total dose of nondepolarizing relaxant	316 (42.8)	836 (46.7)	
b) Timing of last dose of nondepolarizing relaxant	527 (71.3)	1229 (68.6)	
c) Absence of fade when using a conventional nerve stimulator	208 (28.2)	995 (55.5)	
d) Measurement of TOF ratio by using a quantitative TOF monitor	337 (45.6)	215 (12.0)	
e) No evidence of clinical weakness	323 (43.7)	945 (52.7)	
f) Use of a specific nondepolarizing relaxant	149 (20.2)	384 (21.4)	
g) None of the above	20 (2.7)	74 (4.1)	

TOF = train-of-four.
[a] The participant may answer >1 option presented in the second column.

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

Table 4. Attitudes Regarding the Criteria for Adequate Antagonism of Residual Neuromuscular Blockade and Safe Tracheal Extubation

Question	No. (%) European respondents	No. (%) United States respondents	*P*
	N = 727	*N* = 1769	
Do you think that the clinical signs (such as the ability to sustain a 5-s head lift) are reliable indicators of the adequacy of neuromuscular recovery?			
Yes	316 (43.5)	1207 (68.2)	<0.0001
No	411 (56.5)	562 (31.8)	
	N = 677	*N* = 1763	
Do you think that a sustained response to a 50-Hz tetanic stimulation excludes the presence of residual curarization?			
Yes	151 (22.3)	379 (21.5)	0.67
No	526 (77.7)	1384 (78.5)	
	N = 710	*N* = 1761	
How much time do you allow from time of administration of neostigmine to extubation?			
2 min or less	44 (6.2)	48 (2.7)	<0.0001
3–5 min	383 (53.9)	683 (38.8)	
6–10 min	244 (34.4)	808 (45.9)	
>10 min	39 (5.5)	222 (12.6)	
	N = 574	*N* = 1396	
In your views, at what TOF count would neostigmine produce reliable and rapid reversal?			
a) 0	4 (0.7)	4 (0.3)	<0.0001
b) 1	27 (4.7)	346 (24.8)	
c) 2	134 (23.3)	425 (30.4)	
d) 3	194 (33.8)	284 (20.3)	
e) 4	215 (37.5)	337 (24.1)	
f) Any response to neuromuscular stimulation[a]	17	67	
g) It depends on the muscle relaxant used[a]	96	302	
h) I don't use reversal drugs in my practice[a]	19	4	
	N = 702	*N* = 1753	
When administering neostigmine, what is the dose you usually administer?			
a) A 2.5-mg dose	424 (60.4)	251 (14.3)	<0.0001
b) <0.05 mg/kg	131 (18.7)	315 (18)	
c) 0.05 mg/kg	129 (18.4)	859 (49)	
d) >0.05 mg/kg	18 (2.6)	328 (18.7)	
	N = 676	*N* = 1731	
Do you have any concerns regarding the adverse effects associated with the administration of anticholinesterase/antimuscarinic drugs?			
Yes	566 (83.7)	1492 (86.2)	0.12
No	110 (16.3)	239 (13.8)	
	N = 566	*N* = 1492	
If yes to preceding question, what are they?[b]			
a) Hemodynamic effects	251 (44.3)	960 (64.3)	
b) Respiratory effects	162 (28.6)	246 (16.5)	
c) Increased nausea and vomiting	268 (47.3)	1240 (83.1)	
d) Inadequate recovery of neuromuscular function	99 (17.5)	554 (37.1)	
e) Other	0 (0)	99 (6.6)	
	N = 643	*N* = 1580	
Prior to tracheal extubation, the TOF ratio should be			
a) <50%–60%	15 (2.3)	24 (1.5)	<0.0001
b) 61%–70%	9 (1.4)	19 (1.2)	
c) 71%–80%	77 (12)	97 (6.1)	
d) 81%–90%	175 (27.2)	194 (12.3)	
e) 91%–100%	367 (57.1)	1246 (78.9)	

(*Continued*)

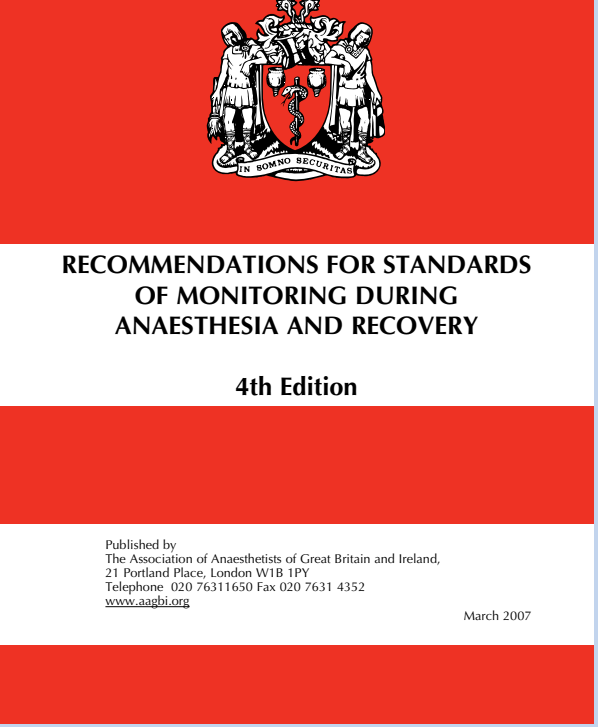
Table 4. Continued

Question	No. (%) European respondents	No. (%) United States respondents	*P*
	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)	

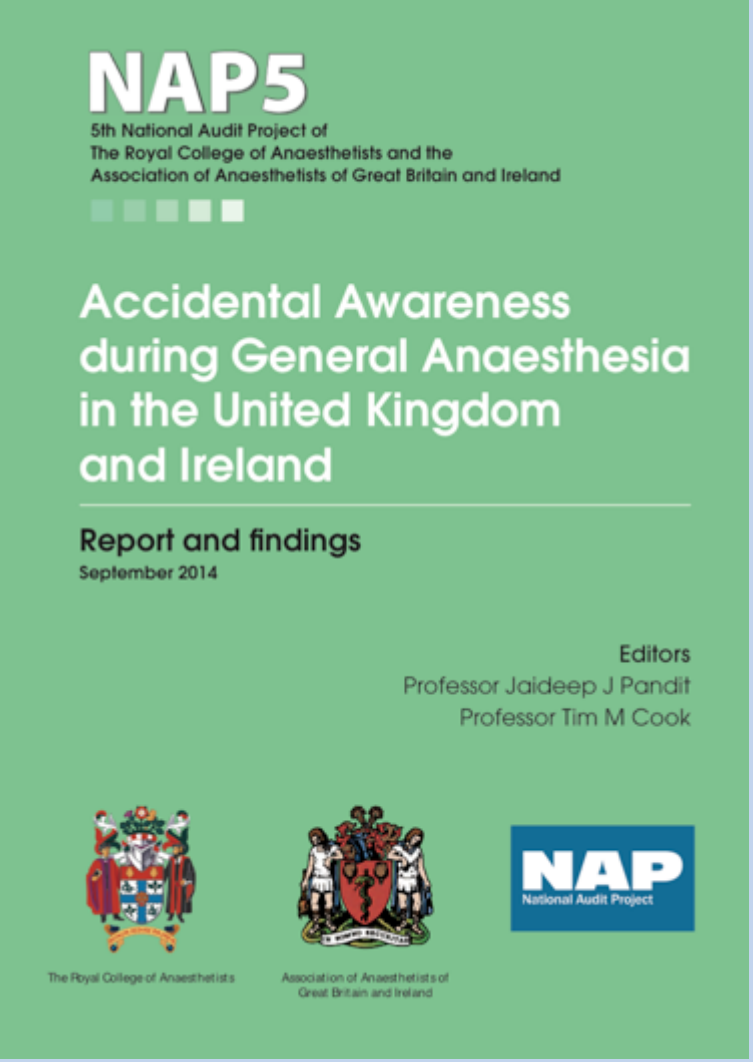
TOF = train-of-four.

[a] Answers that were not included in the analysis.

[b] The participant may answer >1 option presented in the second column.



- Association of Anaesthetists of Great Britain and Ireland. Recommendations for standards of monitoring during anaesthesia and recovery. London: Association of Anaesthetists of Great Britain and Ireland, 2007.
  - Available at: http://www.aagbi.org
- The following **must also be available**
  - A nerve stimulator whenever a muscle relaxant is used



NAP5 recommendation 2

- … consider including **nerve stimulators as 'essential' in monitoring** guidelines whenever **neuromuscular blocking drugs are used**.

ASA - ESA guidelines ?

STANDARDS FOR BASIC ANESTHETIC MONITORING

Committee of Origin: Standards and Practice Parameters

(Approved by the ASA House of Delegates on October 21, 1986, and last amended on October 20, 2010 with an effective date of July 1, 2011)

These standards apply to all anesthesia care although, in emergency circumstances, appropriate life support measures take precedence. These standards may be exceeded at any time based on the judgment of the responsible anesthesiologist. They are intended to encourage quality patient care, but observing them cannot guarantee any specific patient outcome. They are subject to revision from time to time, as warranted by the evolution of technology and practice. They apply to all general anesthetics, regional anesthetics and monitored anesthesia care. This set of standards addresses only the issue of basic anesthetic monitoring, which is one component of

2.1.5. Obesity

1. Pre-operative assessment of obese patients includes at least clinical evaluation, Berlin or STOP questionnaire, ECG, polysomnography and/or oximetry. (grade of recommendation: **D**)

2. Laboratory examination is indicated in obese patients in order to detect pathological glucose/HbA_{1C} concentrations and anaemia. (grade of recommendation: **D**)

3. Neck circumferences ≥ 43 cm as well as a high Mallampati score are predictors for a difficult intubation in obese patients. (grade of recommendation: **D**)

4. Use of CPAP peri-operatively may reduce hypoxic events in obese patients. (grade of recommendation: **D**)

- Some countries have a guideline stating

  You should have a NMT monitor available

  But

- No request on having it in every anesthesie room
- No request on using it

Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland
Anaesthesia, 2009, **64** (Suppl. 1), pages 82–89

Monitoring neuromuscular block: an update

T. Fuchs-Buder,[1] J.-U. Schreiber[2] and C. Meistelman[3]

1 Staff, Department of Anaesthesia and Critical Care, Centre Hospitalier Universitaire, Nancy Brabois, France
2 Staff, Department of Anaesthesia, Maastrich UMC, The Netherlands
3 Chairman, Department of Anaesthesia and Critical Care, Centre Hospitalier Universitaire, Nancy Brabois, France

Can we learn how to use it?

Table 1 Recommendations for the use of different stimulation patterns for the assessment of neuromuscular blockade in various clinical situations.

Stimulation pattern	Onset of block	Deep block (TOF = 0)	Moderate block (TOF > 0)	Recovery
Train-of-four (TOF)	Adequate	Not adequate	Adequate	Intermediate (a) Adequate (b)
Double-burst stimulation	Intermediate	Not adequate	Not adequate	Intermediate
Post-tetanic count	Not adequate	Adequate	Not adequate	Not adequate
Tetanus (50/100 Hz)	Not adequate	Not adequate	Not adequate	Intermediate

(a), tactile estimation; (b), quantitative estimation.

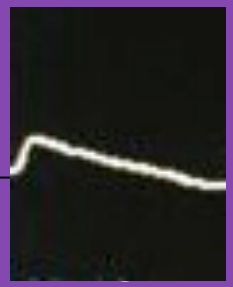
Table 2 Negative predictive values of different acceleromyographic (accelerомyography) train-of-four (TOF) ratios. Adapted from reference [23].

	Negative predictive value; median [range]		
Acceleromyography TOF ratio	Calibrated data	Uncalibrated data, not normalised	Uncalibrated but normalised data
0.9	37 [20–56]%	40 [23–59]%	89 [70–98]%
0.95	70 [51–85]%	60 [41–77]%	92 [75–99]%
1.0	97 [83–100]%	77 (58–90)%	96 [80–100]%

Monitoring acceleration, bending (force) or EMG

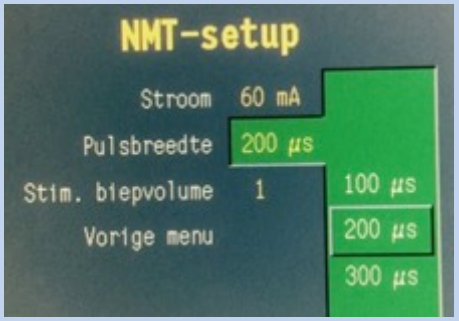
Supra maximal Stimulus:

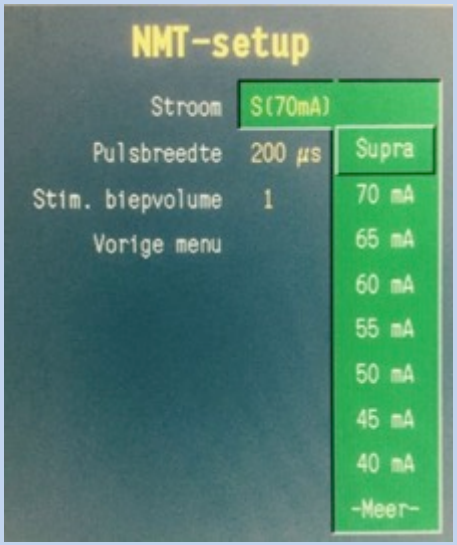
Force, acceleration, bending or pressure Muscle contraction

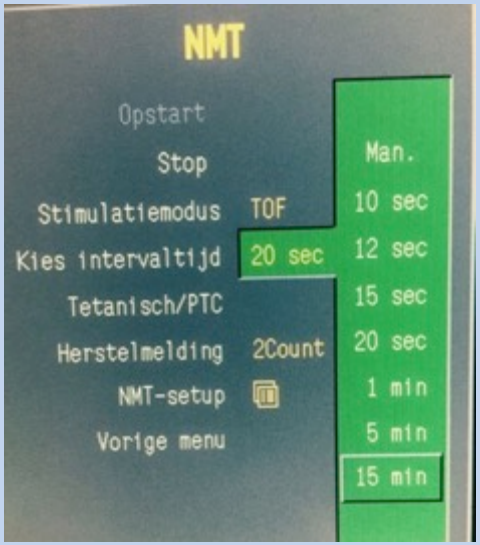


Electric activity

Settings to choose

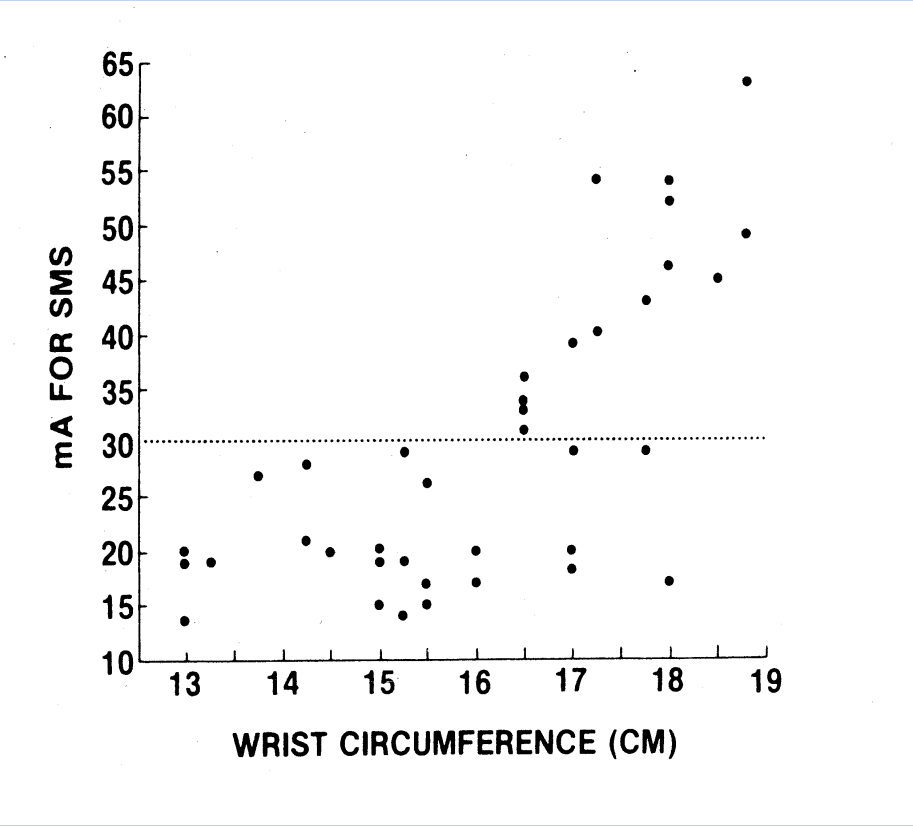






1. Choose mode: ST: Single twitch, TOF: train of four, PTC: post tetanic count
2. Period from 100 usec to 300 usec
3. Current from 10 mA to 75 mA 25% higher than max answer: supra maximal
4. Repeat from every 10 sec till every 15 min

stimulation current and wrist circumference

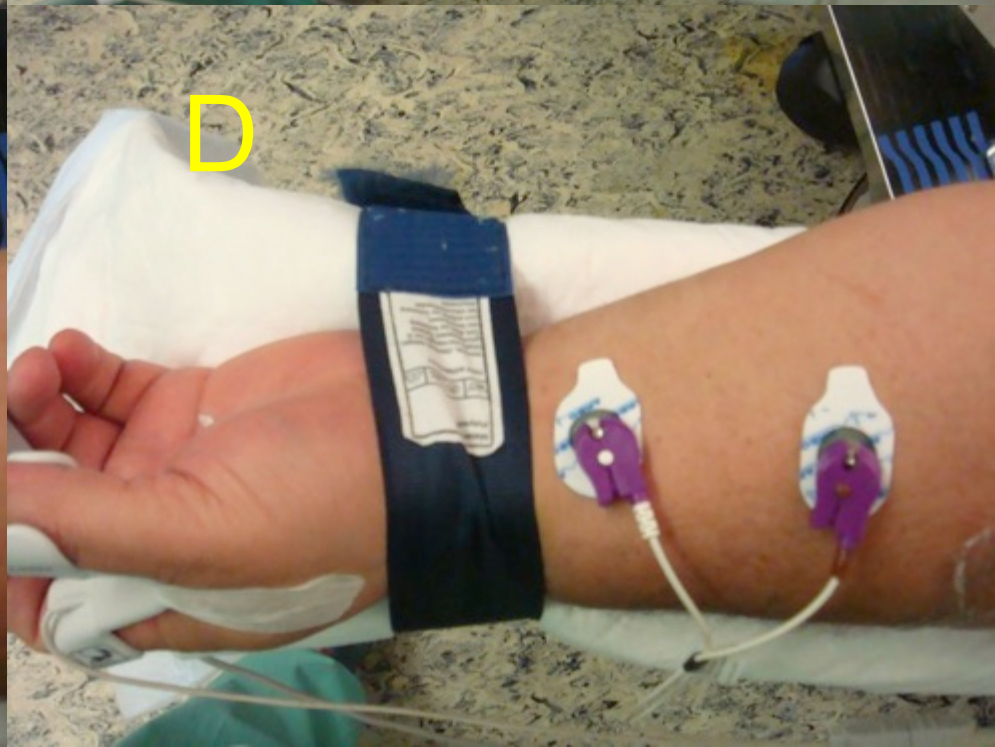


Obese patients need higher current

Calibration before NMB
allows to find minimum current

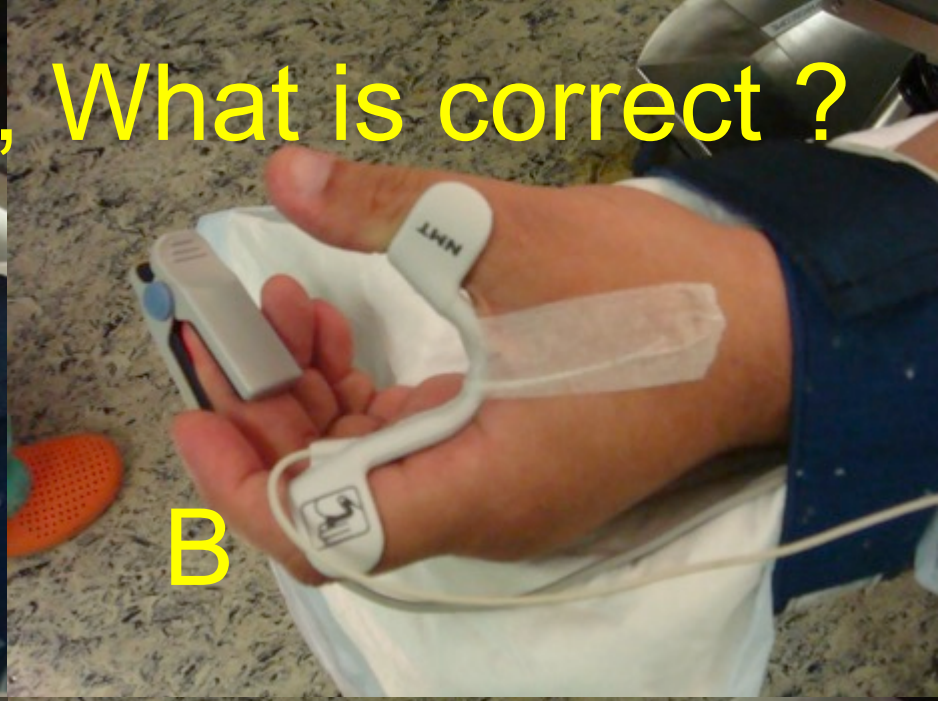
Kopman A.F.,Anesthesiology, 1984;61:83-5

What is wrong, What is correct ?



What is wrong, What is correct ?

A

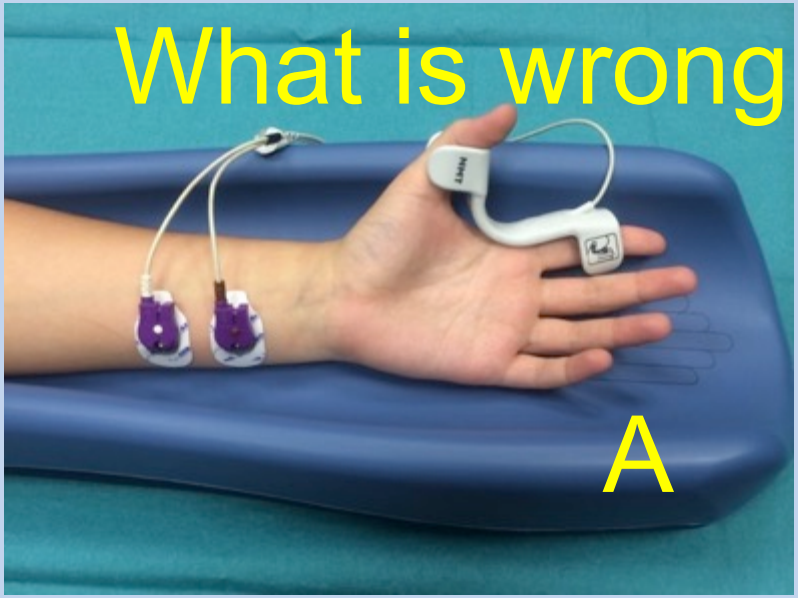


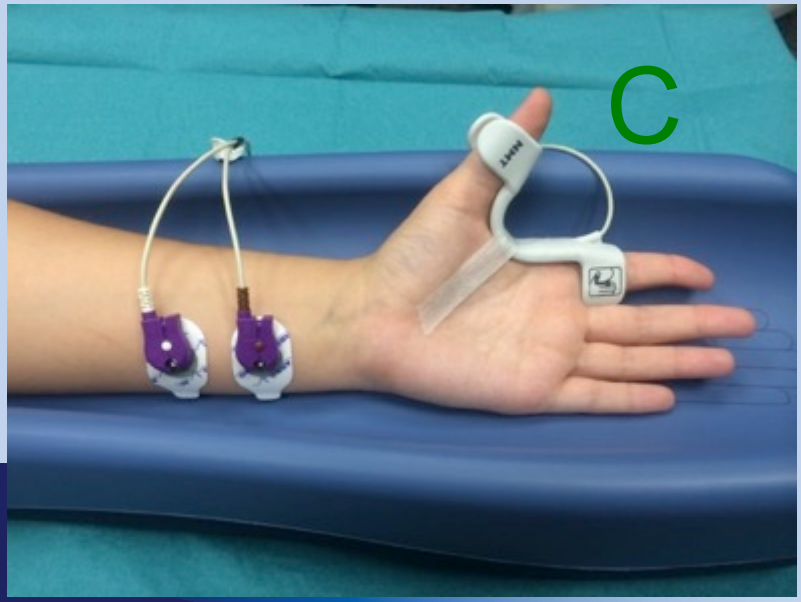
B

C

D

What is wrong, What is correct ?

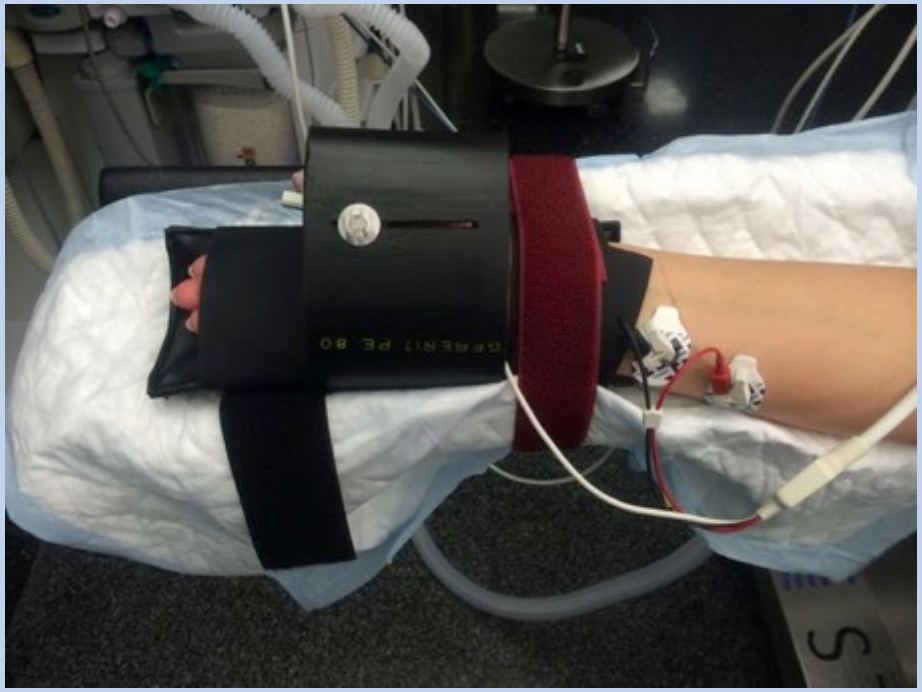




Acta Anaesthesiol Belg. 2002;53(1):33-8.

TOF-tube, a new protection for acceleromyography, compared with the TOF-Guard/TOF-Watch arm board.

Dubois PE1, Broka SM, Jamart J, Joucken KL.



Technical problems

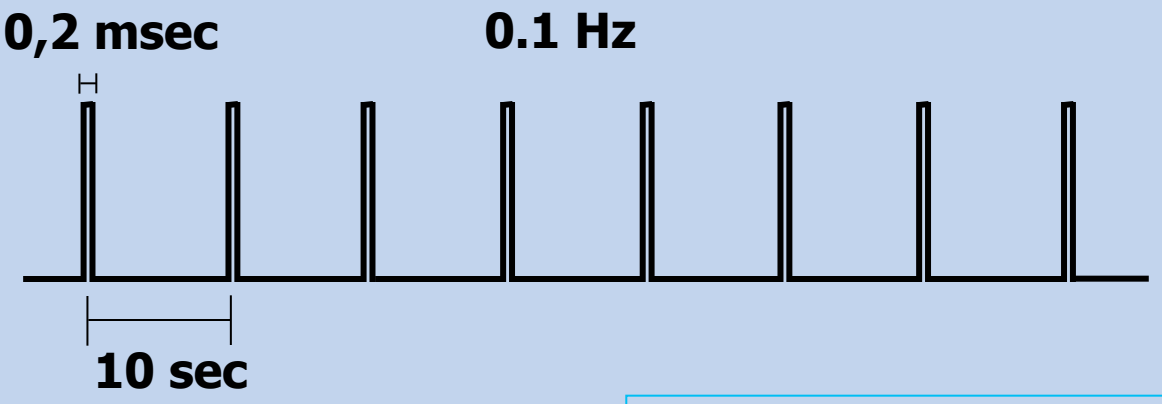
- Direct muscle stimulation
  - Reverse electrodes
  - Move electrodes away from thumb
  - Reduce outlet power
- Surgeon touching thumb or moving table

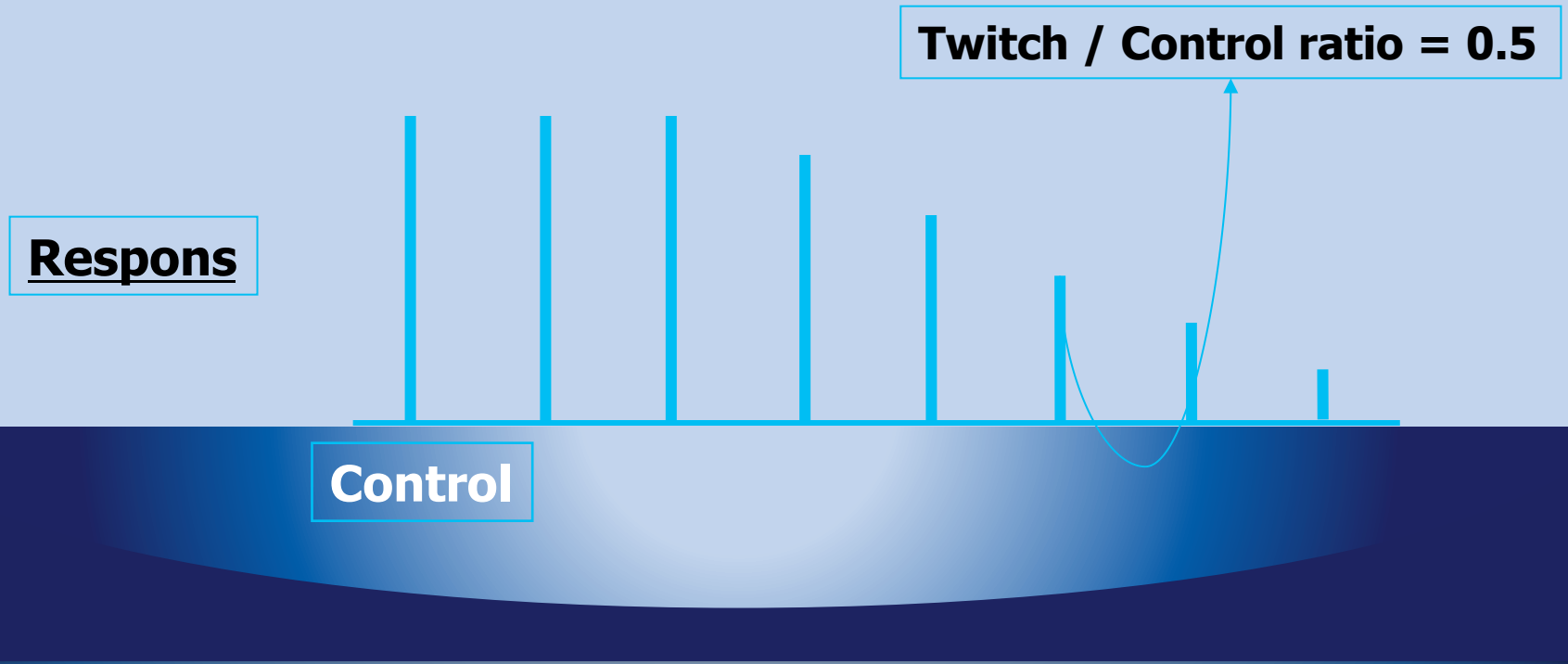
- Thumb not free to move
- Electrode in wrong place
- Current running superficial and not through nerve

Conditions for correct NMT

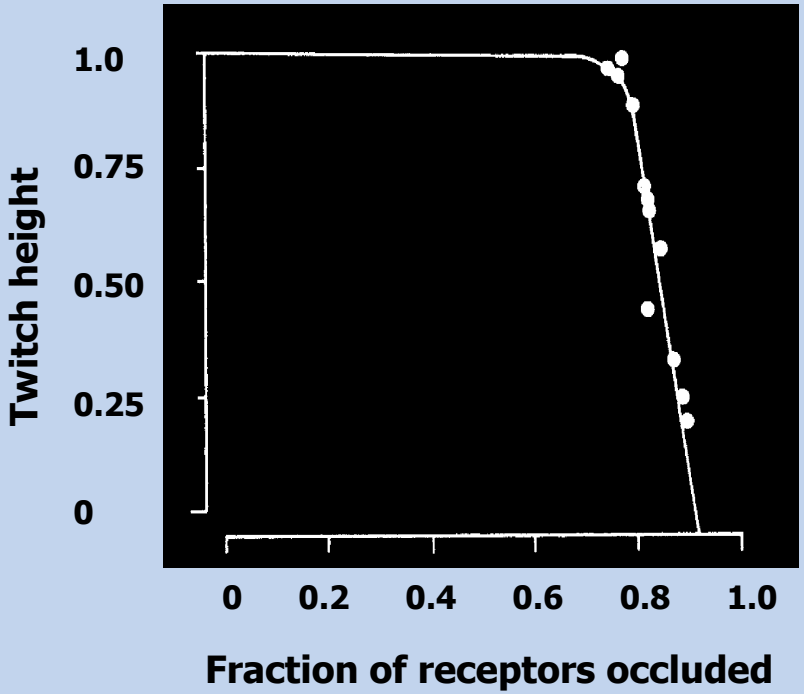
- No low peripheral or central temperature
- Sufficient high current (supramaximal)
- Avoid direct muscle stimulation (no fading)
- Electrodes far enough to reach the nerve under the fat
- Thumb free moving against an elastic resistance

Single twitch





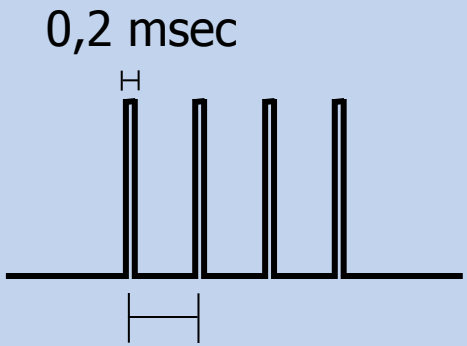
Receptor occupation and twich response



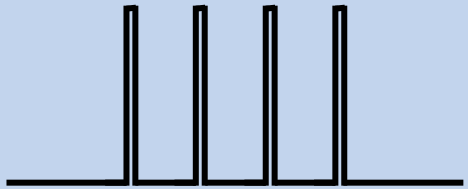
From Stoelting: Pharmacology & physiology in anesthetic practice

Train - of - four

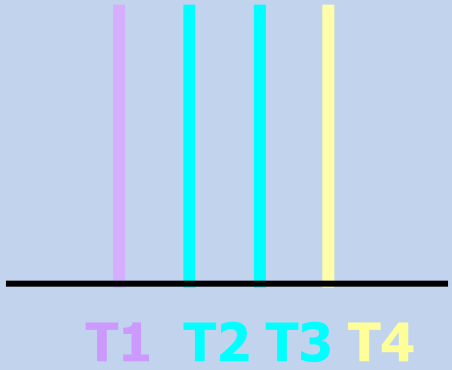
Stimulus

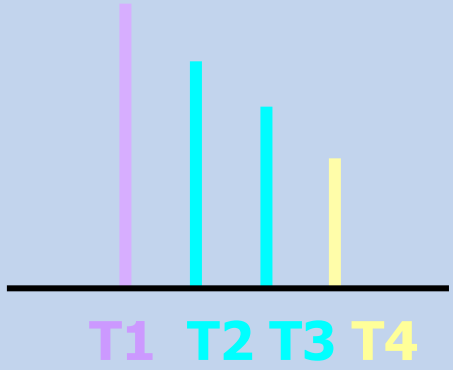


Fade



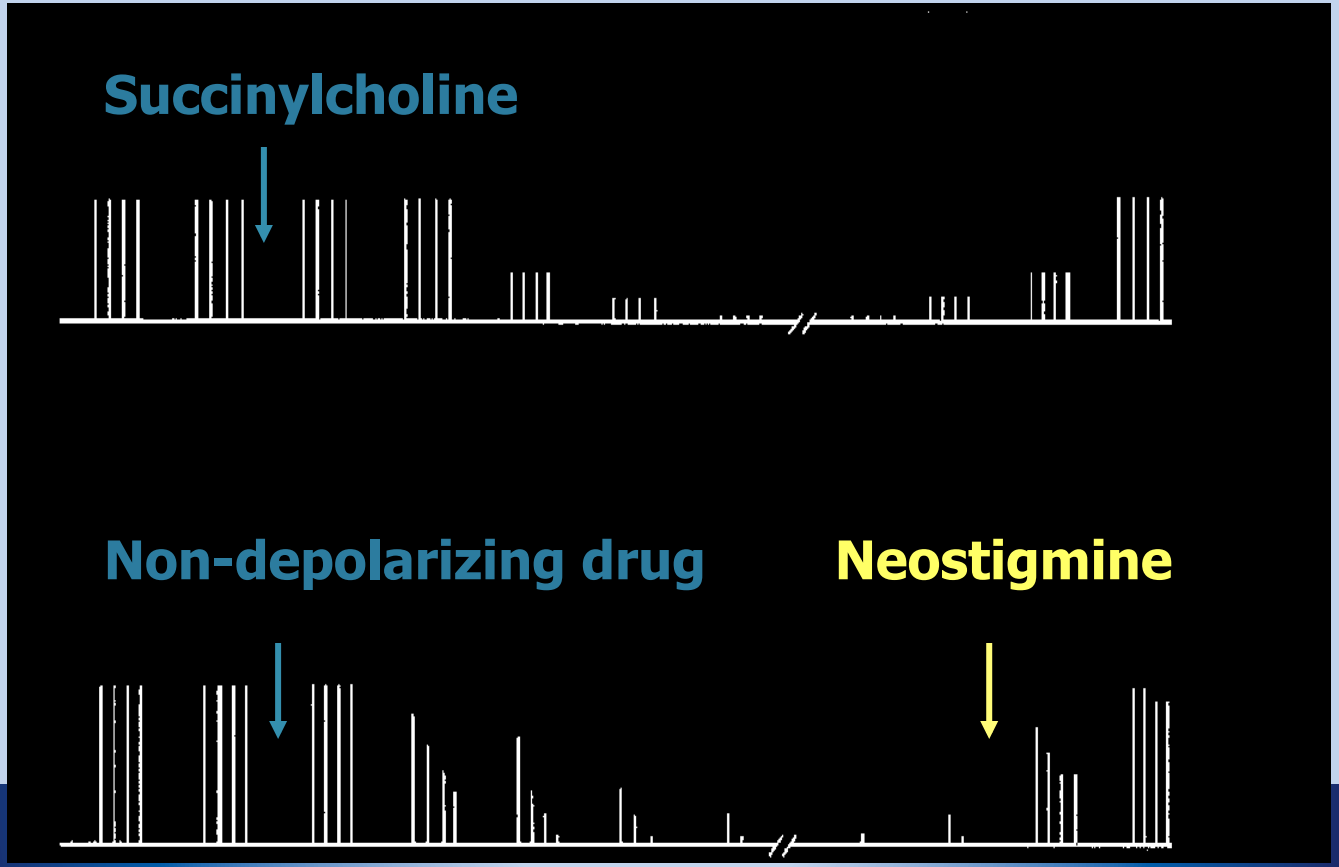
Respons





TOF - count = 4 **TOF - ratio = T4/T1 = 1.0**	**TOF - count = 4** **TOF - ratio = T4/T1 = 0.5**

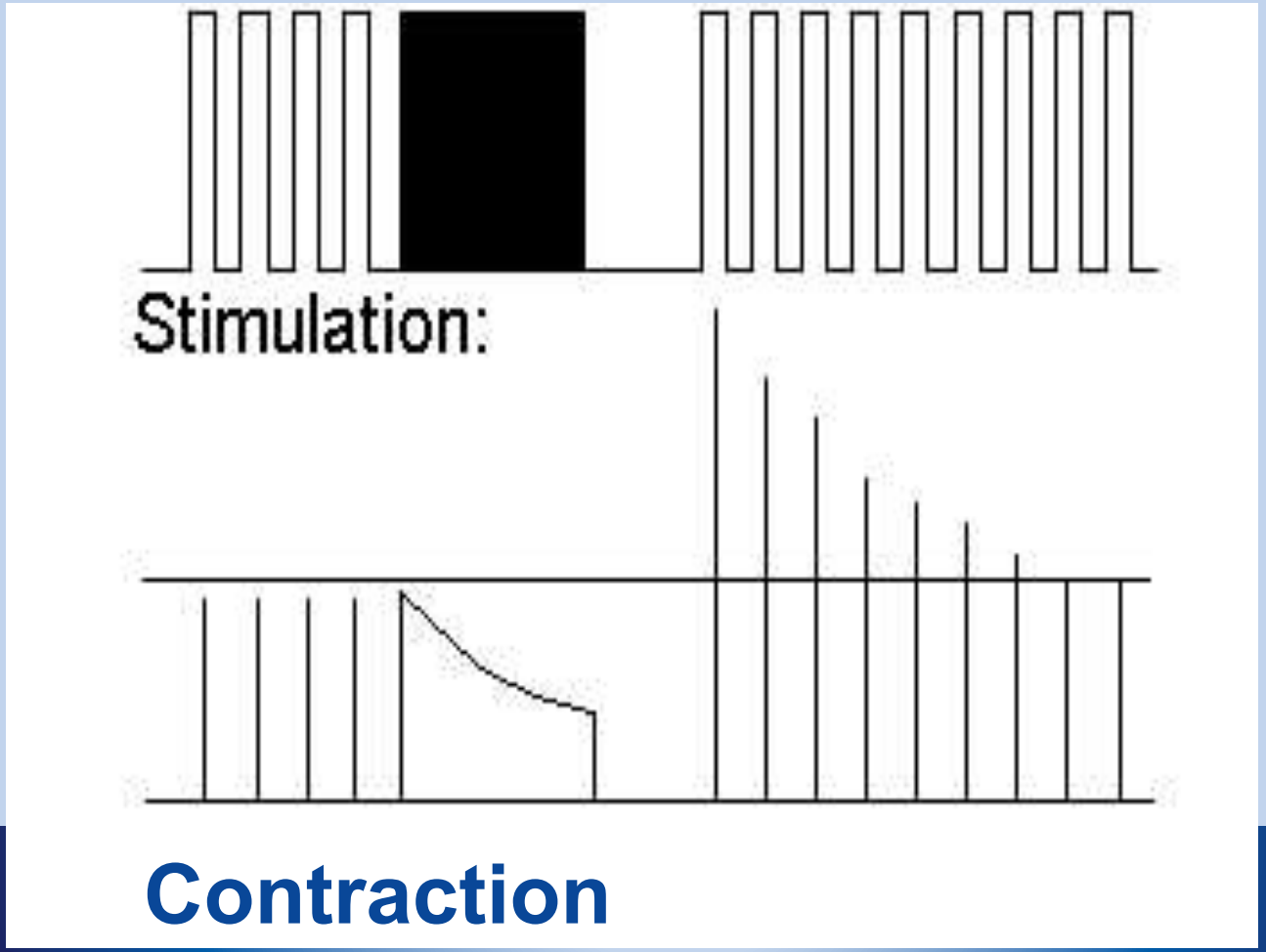
TOF: depol no fade – non-depol fade (diff 1 - 4 stimulus)



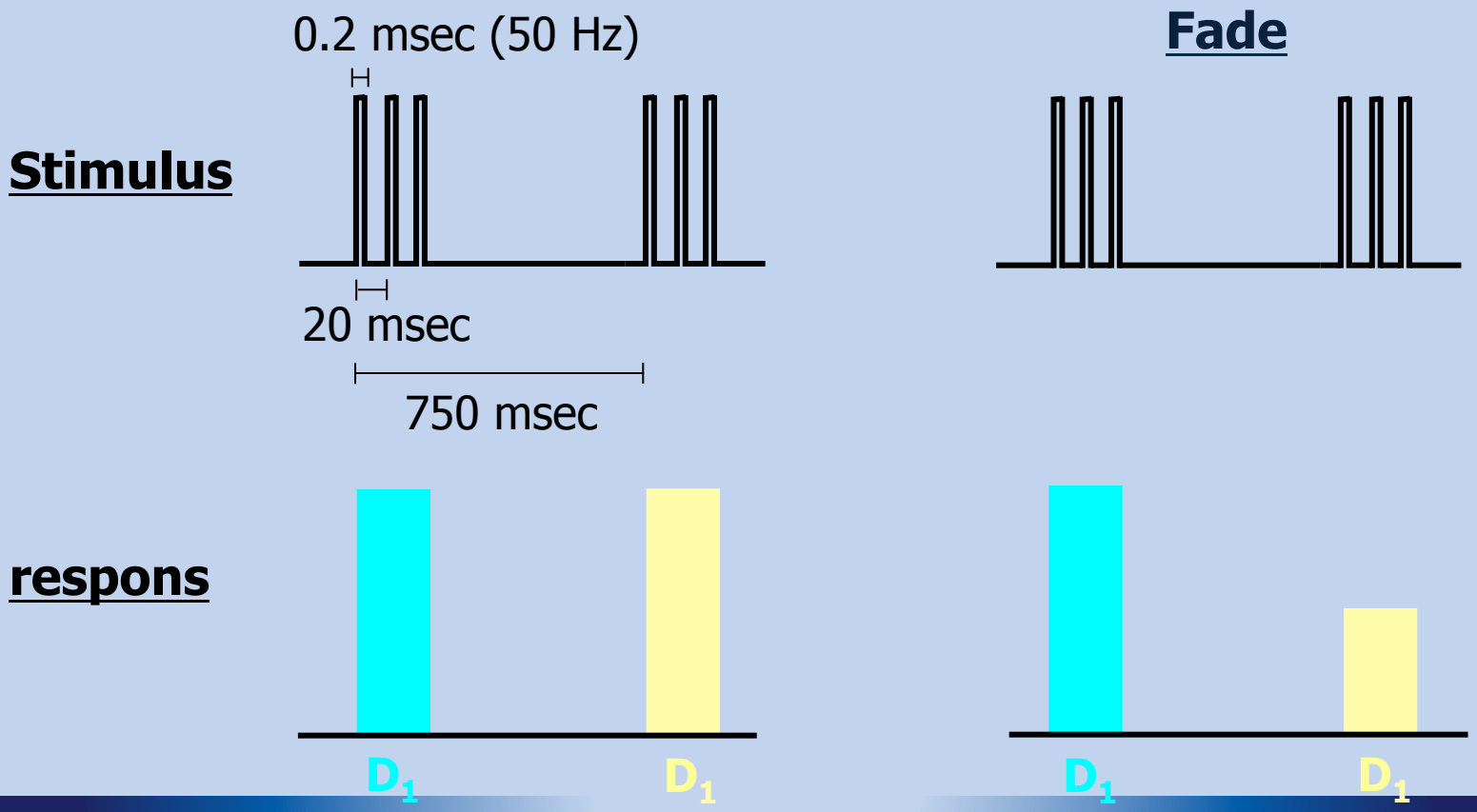
Controle

Hunter, N Engl J Med 1996, 332

Post - tetanic count (PTC)

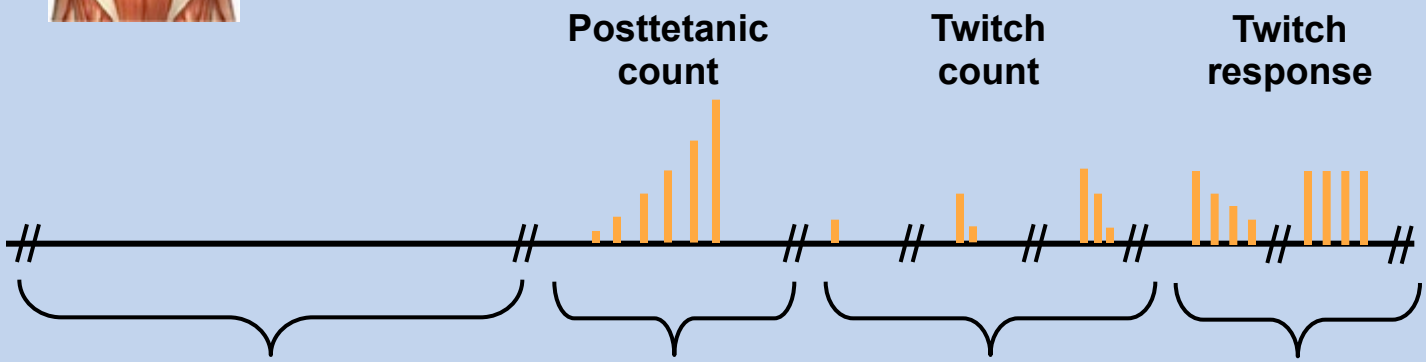


Double burst stimulation (DBS)



Depth of NMB monitoring TOF and PTC





Level of block	Intense block	Deep block	Moderate block	Superficial block
Response to TOF	TOF count 0	TOF count 0	TOF count 1-3	TOF count 4
Response to PTC	PTC 0	PTC ≥1	PTC ≥20	T4 / T1 %

- Intense blockade: no response to either TOF or PTC stimulation
- Deep blockade: response to PTC but not to TOF stimulation
- Moderate blockade: reappearance of response to TOF stimulation
- Superficial blockade: T4 response divided by T1 response

PTC, posttetanic count; TOF, train-of-four.

Fuchs-Buder T, et al. *Acta Anaesthesiol Scand*. 2007;51:789-808.

Acta Anaesthesiol Scand 1991: 35: 387–392

The effect of peripheral hypothermia on a vecuronium-induced neuromuscular block

L. I. Eriksson, J. Viby-Mogensen and C. Lennmarken

Department of Anaesthesia and Intensive Care, Faculty of Health Sciences, University Hospital, Linköping, Sweden and Department of Anaesthesia, Rigshospitalet, University of Copenhagen, Copenhagen, Denmark

One arm hypothermic 27°C the other arm normothermic

- Vecuronium bolus given
- Onset of block
  - 180 sec versus 140 sec
- Duration of block:
  - 26.4min versus 16.5 min
- Recovery of block
  - 265 min versus 130 min
- PTC is not reliable during hypothermia to assess depth of block

ANESTHESIOLOGY
The Journal of the American Society of Anesthesiologists, Inc.

From: Impact of Hypothermia on the Response to Neuromuscular Blocking Drugs
Anesthesiology. 2006;104(5):1070-1080.

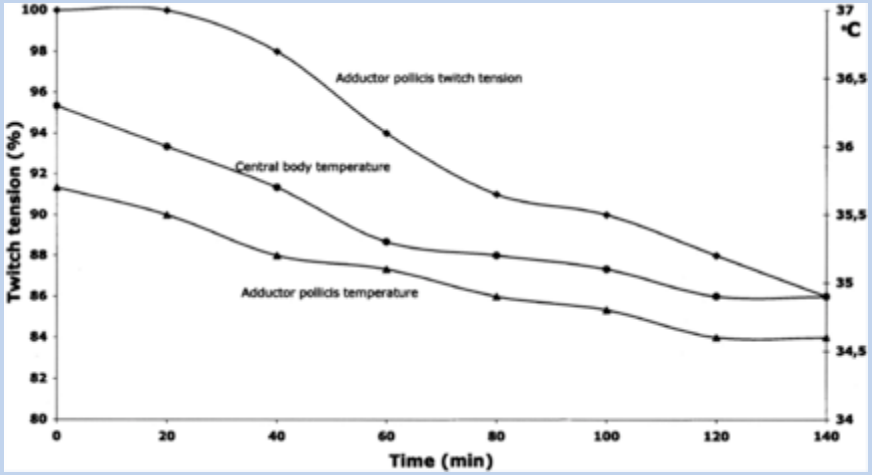


Fig. 1. Simultaneous recording of the changes in central body and adductor pollicis muscle temperatures, and adductor pollicis twitch tension during central body cooling of a patient anesthetized with nitrous oxide–isoflurane in the absence of neuromuscular blocking agents. From Heier et al. 36; used with permission.

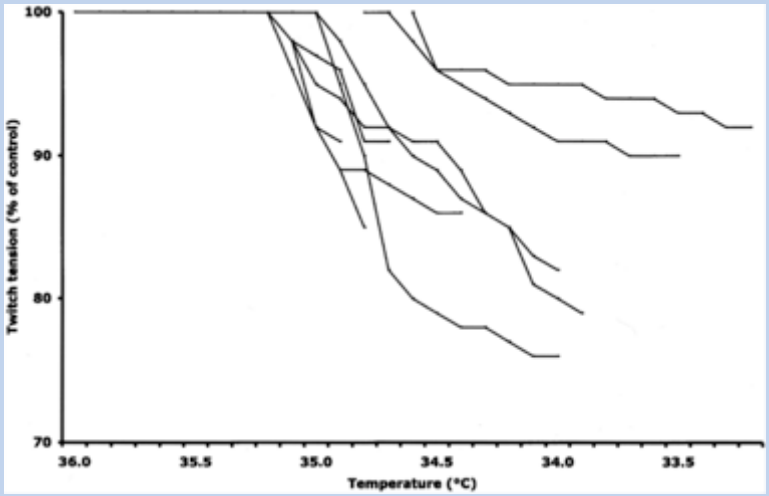
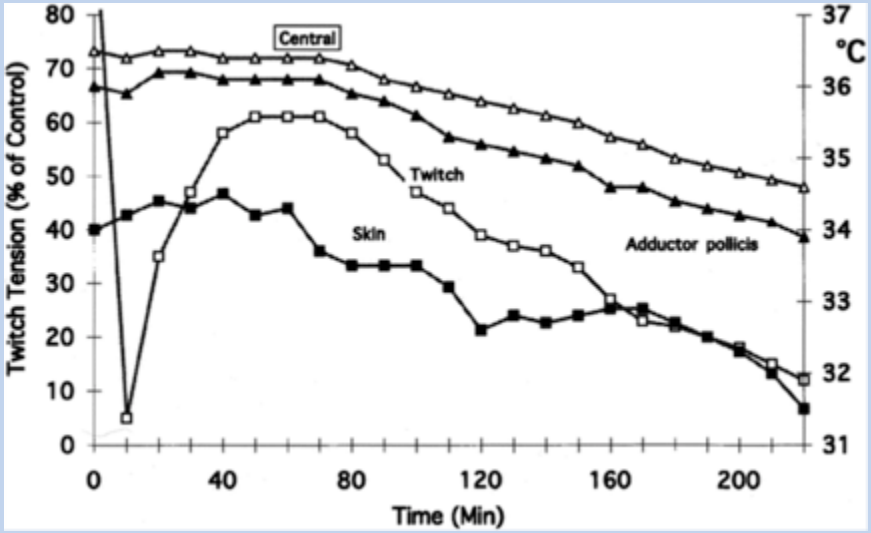


Fig. 2. Recording of the changes in adductor pollicis muscle temperature and twitch tension in 10 patients during nitrous oxide–isoflurane anesthesia in the absence of neuromuscular blocking drugs. A temperature threshold (35.2°C) was detected. From Heier T et al. 37; used with permission.

ANESTHESIOLOGY
The Journal of the American Society of Anesthesiologists, Inc.

From: Impact of Hypothermia on the Response to Neuromuscular Blocking Drugs
Anesthesiology. 2006;104(5):1070-1080.



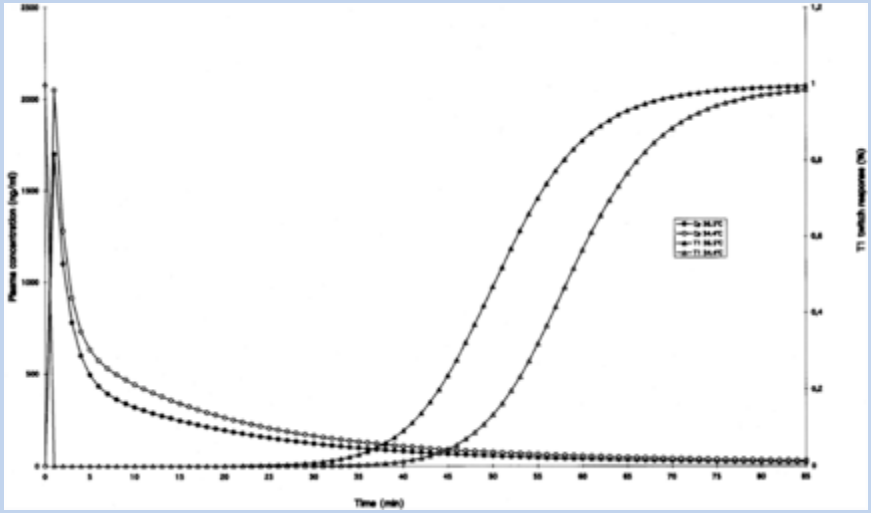


Fig. 3. Simultaneous recording of the changes in central body, adductor pollicis muscle and thenar skin temperatures, and adducto pollicis twitch tension during a constant-rate infusion of vecuronium in a patient anesthetized with nitrous oxide–isoflurane. Adducto pollicis twitch tension decreased 20%/°C reduction in central body and adductor pollicis temperatures.

Fig. 4. Simulation of plasma concentration (Cp) and adductor pollicis twitch tension (T1) after a bolus injection of vecuronium 0.1 mg/kg during isoflurane anesthesia in a 75-kg healthy volunteer. The figure shows the difference in effect of vecuronium when administered either at central body temperature 36.5°C or 34.4°C. The plasma concentration of vecuronium declines more slowly and the duration of vecuronium block is prolonged at 34.4°C.

NMT response is determined by the central body temp (t°)

- Without NMB, the AP response decreases 10%/°C.
- With NMB the AP response decreases 20%/°C.
- Between 34°–37°C, the adductor pollicis (AP) muscle temperature (t°) is determined by the t° of the blood perfusing the muscle (= 1°C less then central temperature)
- Complete restoration of muscle strength possible only when body t° > 36°C.
- The duration of action and recovery time of NMB are increased by hypothermia during anesthesia, (because of reduced elimination rate.)
- Duration of action increases with 100% when temp drops 2°C. Peripheral nerve stimulation is mandatory in hypothermic patients.

Obesity Surgery, **11**, 570-575

Evaluation of Core Temperature during Laparoscopic and Open Gastric Bypass

Ninh T. Nguyen, MD[1]; Neal W. Fleming, MD, PhD[2]; Amardeep Singh, BS[1]; Steven J. Lee, MS[1]; Charles D. Goldman, MD[1]; Bruce M. Wolfe, MD[1]

Departments of [1]Surgery and [2]Anesthesiology, University of California, Davis, Medical Center, Sacramento, CA, USA

During active force warming in both groups

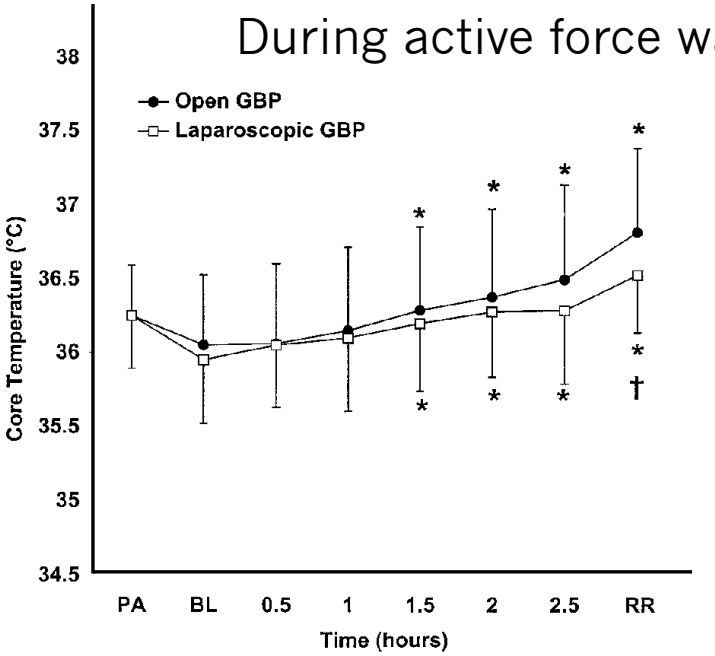


Figure 1. Changes in core temperature (℃) during laparoscopic and open gastric bypass (GBP). *p<0.05 compared with baseline value. †p<0.05 compared with laparoscopic GBP. PA = preanesthesia; BL = after anesthetic induction; RR = recovery room.

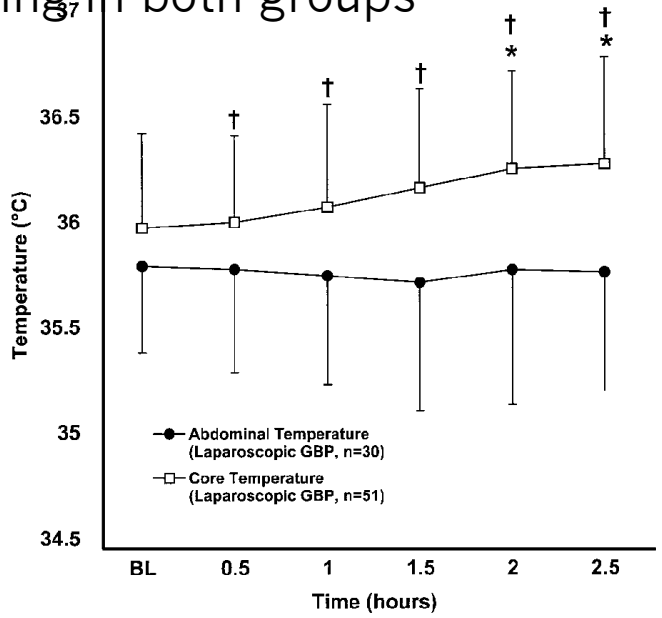


Figure 2. Changes in abdominal (n=30) and core temperature (n=51) during laparoscopic GBP. *p<0.05 compared with baseline value. †p<0.05 compared with abdominal temperature. BL= after anesthetic induction.

Anaesthesia 2012, 67, 1364–1369 doi:10.1111/anae.12002.x

Original Article

Comparison of peri-operative core temperature in obese and non-obese patients*

L. A. Fernandes,[1] L. G. Braz,[2] F. A. Koga,[3] C. M. Kakuda,[1] N. S. P. Módolo,[4] L. R. de Carvalho,[5] P. T. G. Vianna[4] and J. R. C. Braz[4]

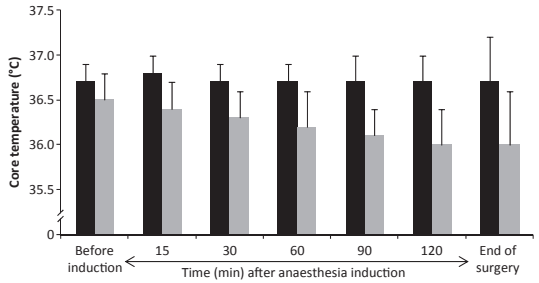


Figure 2 Mean (SD) intra-operative core temperature data in obese (■) and non-obese groups (■). Error bars are SD. The values were significantly different between the groups ($p = 0.008$). Only in the non-obese group there was a significant decrease in the values over time ($p < 0.001$).

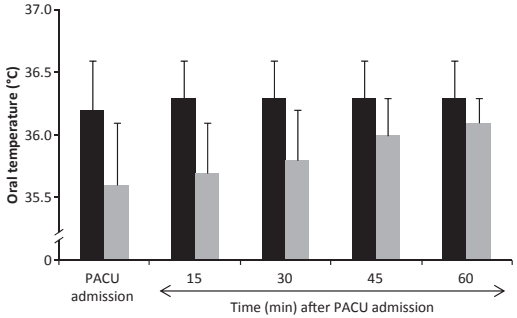


Figure 3 Mean (SD) oral temperature data in obese (■) and non-obese (■) groups in PACU. The values in the obese group were higher than non-obese group ($p < 0.001$). The values increase significantly only in the non-obese group over time ($p < 0.001$).

During active force warming in both groups

British Journal of Anaesthesia 84 (1): 11–15 (2000)

Validity and reliability of a postoperative quality of recovery score: the QoR-40†

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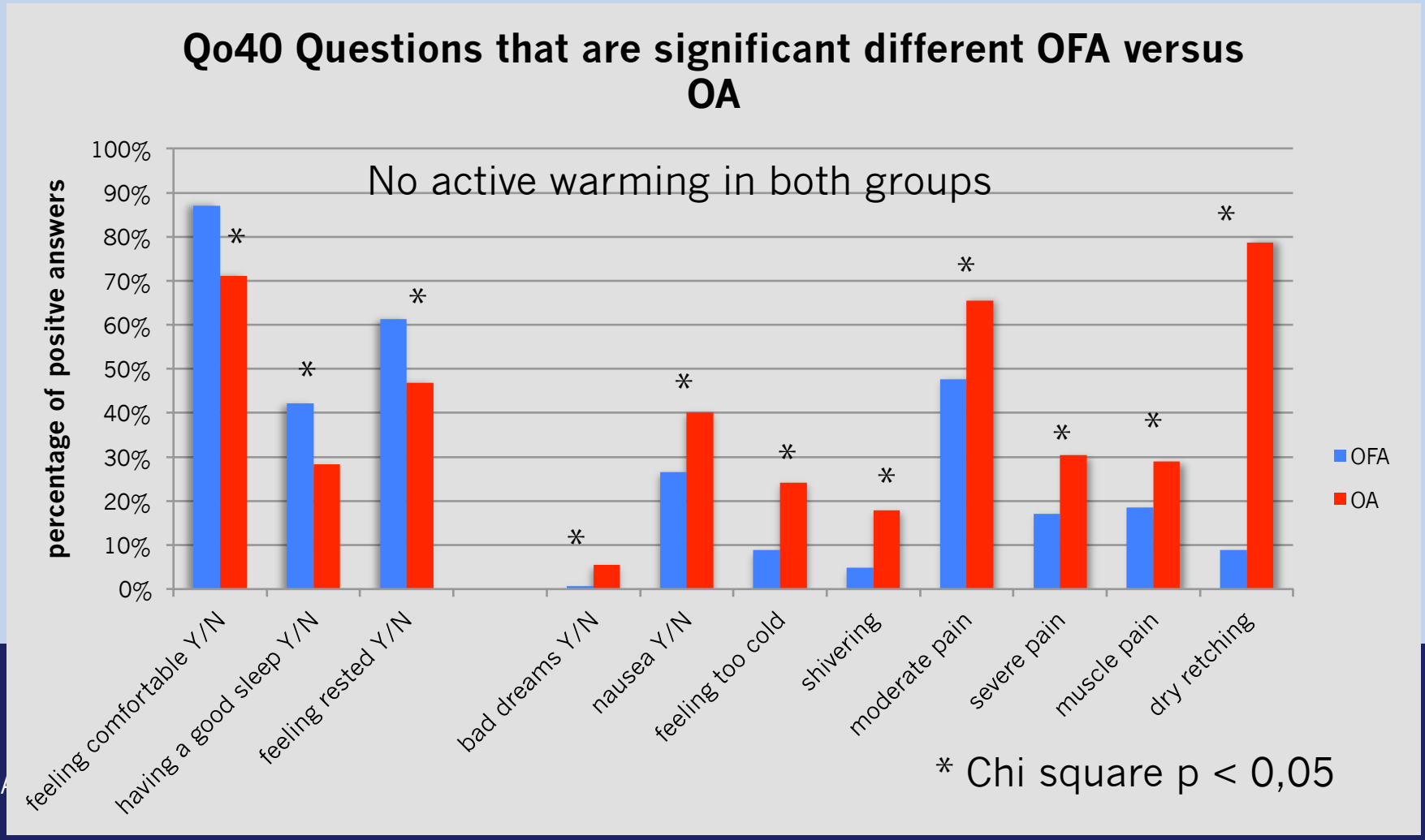
- Observational study in 400 lap RNY patients
  - Patients got OFA or OA per-op and post operative
  - Same post op additive drugs: paracetamol and diclofenac
  - Morphine (or piritramide) as required J Mulier



NMT monitoring needed

- At induction?
  - Most anesthesiologists are not performing this
  - Allows calibration
    - yes for mechano, EMG
    - no for aceleromyography?
- During surgery when muscle relaxation is surgical required
- At end anesthesia to verify (temp sufficient?)
  - Full reversal
  - Decide what reversal drugs and doses are needed
  - To verify full reversal after reversal

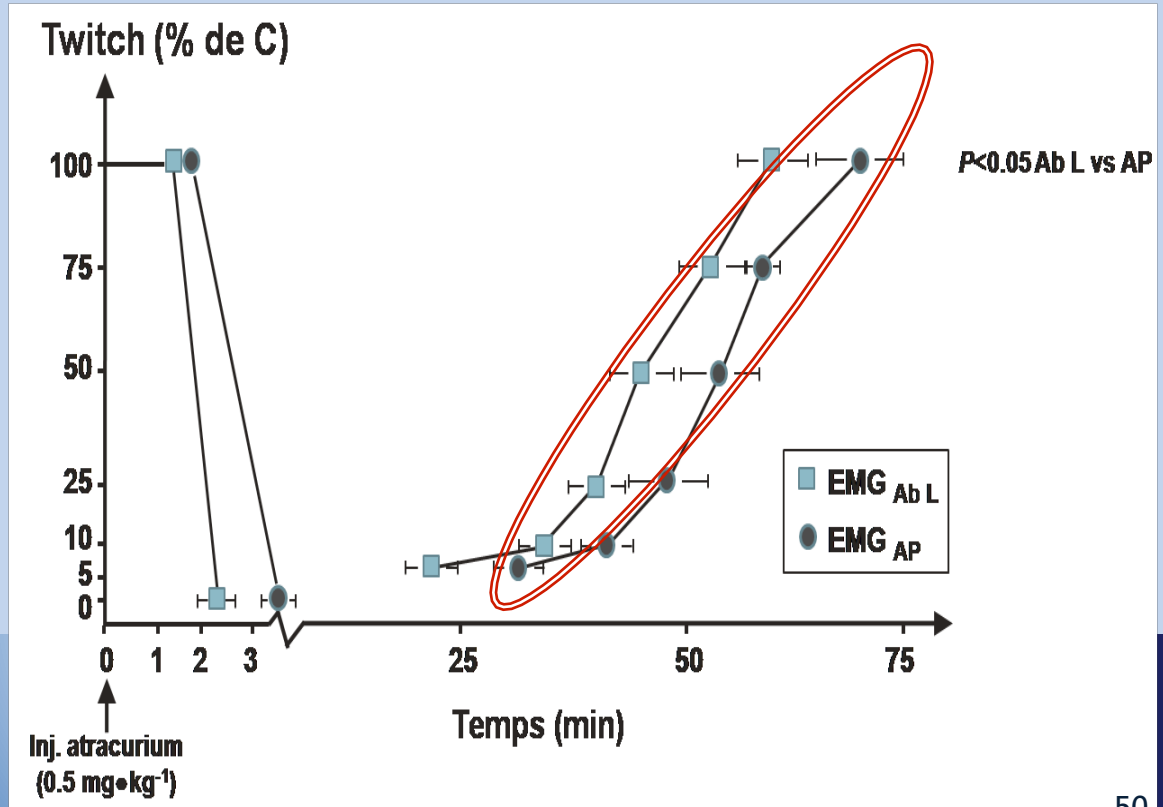
What depth of NMB do we need in obese patients?

Why surgeons are frequently the first once to notice NMB recovery?

Time difference between abdomen – adductor pollicis after bolus NMB is given.

Lateral abdominal muscles blockade have a faster onset and a faster recovery than adductor pollicis

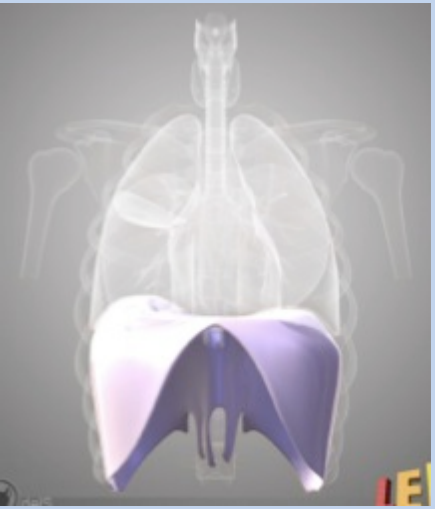
Continuous infusion avoids early abdominal recovery not seen at the adductor pollicis.



Mulier ESA 2015

Kirov K et al. Ann Fr Anesth Reanim. 2000;19:734–738.

Why surgeons are frequently the first once to notice NMB recovery?



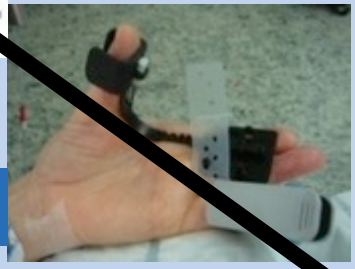
Only deep NMB at the adductor pollicis ensures abdominal muscle relaxation.

- The diaphragm is more resistant than the adductor pollicis to rocuronium.
  - Cantineau JP *Anesthesiology*. 1994;81:585
- Monitoring of the peripheral muscles often overestimates the degree of diaphragmatic relaxation, but is a safe predictor of recovery.
  - Moerer O. *Anasthesiol Intensivmed Notfallmed Schmerzther*. 2005;40:217

What level do you need for each muscle?

Superficial block

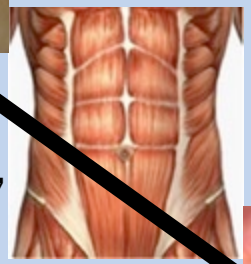
Tongue, throat muscles



Moderate block

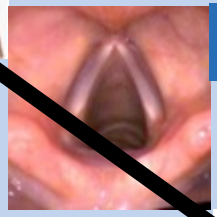
Peripheral mucles, adductor pollicis

Orbicularis oculi
Corrugator supercilii



Deep block

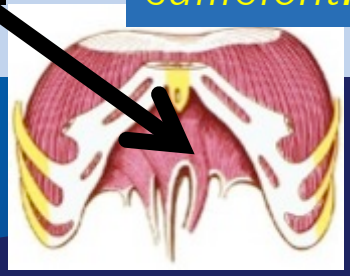
Abdominal mucles,



Deep block

Vocal cords

Deep block sufficient?



Diaphragm

Increasing the workspace from 1 liter to 4 liter

1 liter workspace no NMB pressure 11
Not sufficient workspace
no access to upper abdomen

2 liter workspace no NMB pressure 13
Ceiling is higher but still not enough workspace

3 liter workspace no NMB pressure 15
Sufficient workspace for upper abdomen

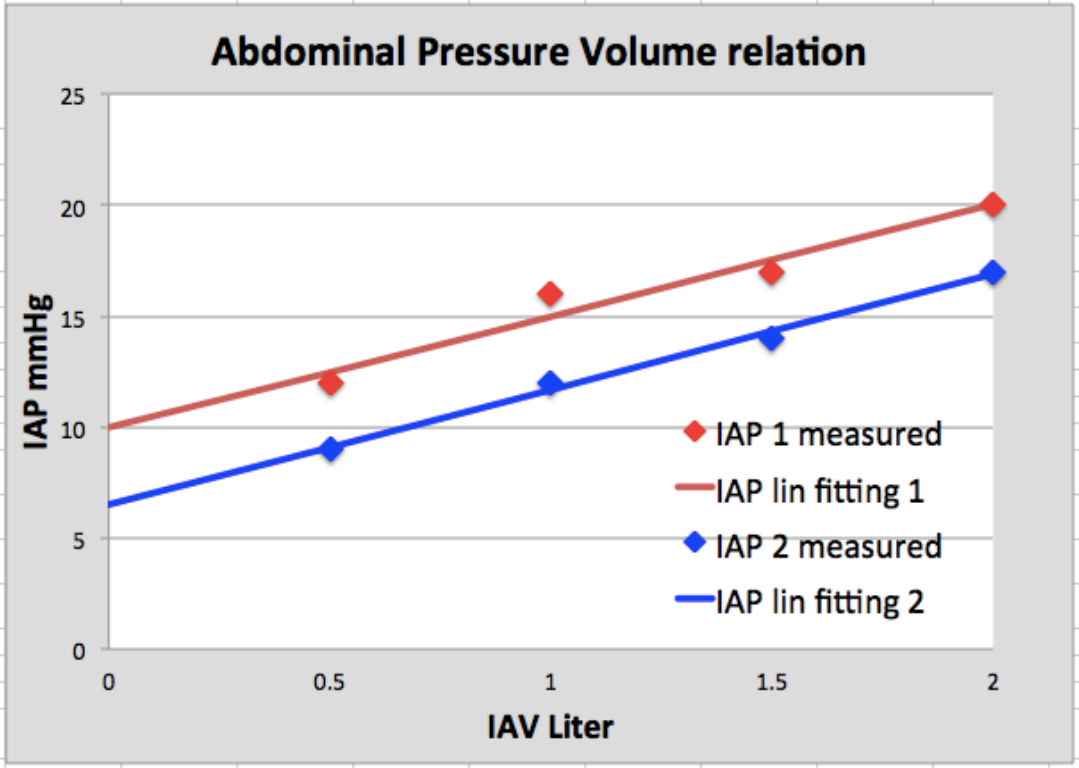
4 liter workspace with NMB pressure 14
Sufficient workspace and easy access.

What are NMB doing?

IAV	IAP 1 measured	IAP lin fitting 1	IAV	IAP 2 measured	IAP lin fitting 2
0		10	0		6,5
0,5	12	12,5	0,5	9	9,1
1	16	15	1	12	11,7
1,5	17	17,5	1,5	14	14,3
2	20	20	2	17	16,9
5	**10**		**5,2**	**6,5**	

PV0	**10**	mmHG	**PV0**	**6,5**	mmHG
E	**5**	mmMHg/L	**E**	**5,2**	mmMHg/L

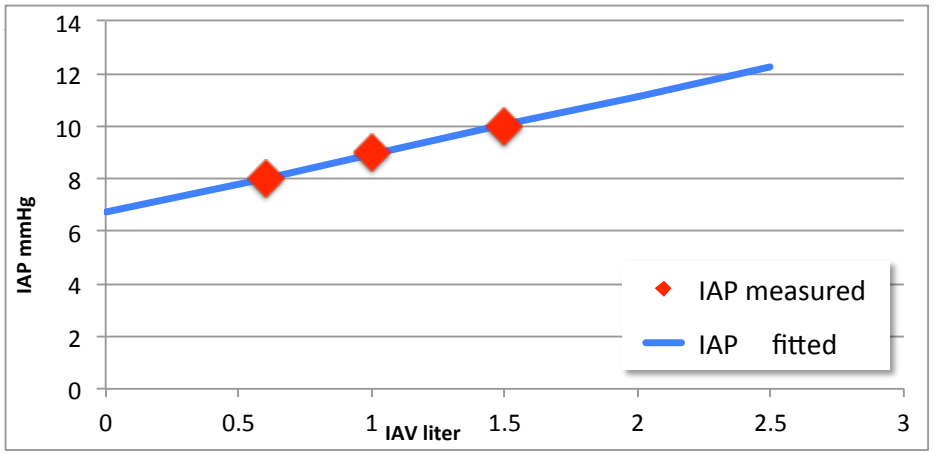
25 mmHg: pressure to reach 3 liter



How to calculate the workspace ?

lap IAP calculator using abd compliance model

IAV measured	IAP measured	IAP fitted
0		6,71
0,6	8	8,04
1	9	8,93
1,5	10	10,03
2		11,14
2,5		12,25



This abdomen size is small

PV0	E
6,71	2,21

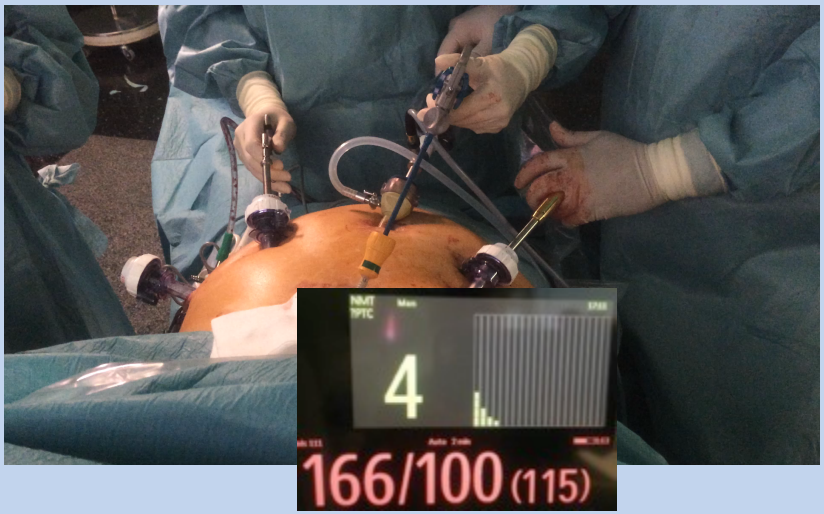
Proposed IAP and IAV 15 mmHg 3,7 L

Pressure needed to reach 3 L 13 mmHg

If measurement was made during moderate NMB (TOF >0) abdomen size will be larger when deep NMB is given.

Case of insufficient deep NMB at PTC = 4

- TOF = 0 PTC = 4
- Rocuronium bolus 0,6 mg/kg at induction
- No continous infusion

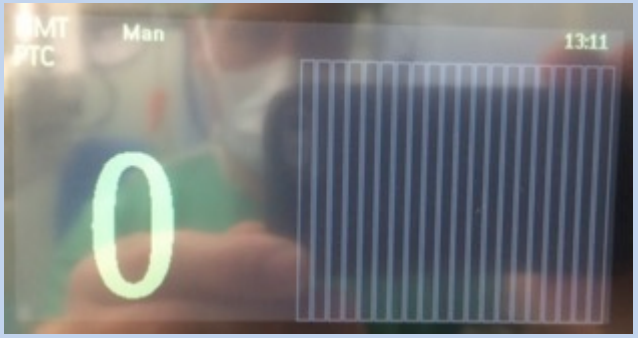


- Patient started to breath against ventilator: abd muscles active

deep NMB (PTC=2) does not paralyze diaphragm totally.

Case with PTC = 0 and diaphragm active

- TOF = 0 PTC = 0
- Rocuronium continous infusio



- Abdominal muscles relaxed, no pressing but diaphragm can trigger pressure support ventilation showing that muscle is not fully blocked.

- Monitoring is not always required (some surgery do not require muscle relaxation), but it is essential to ensure complete recovery from blockade before the return of consciousness.
  - Sufficient breathing is not a sign of full reversal
  - Coughing, hand sqeezing or head elevation is not sign of full reversal
  - If last NMB dose is less than 2 hours, NMT monitor needed
- Continue anaesthesia during attempts to manage an unexpectedly difficult airway.
- an ‘awake’ tracheal extubation primarily requires the patient to be completely reversed from neuromuscular blockade, and only secondarily requires the patient to be ‘awake’.

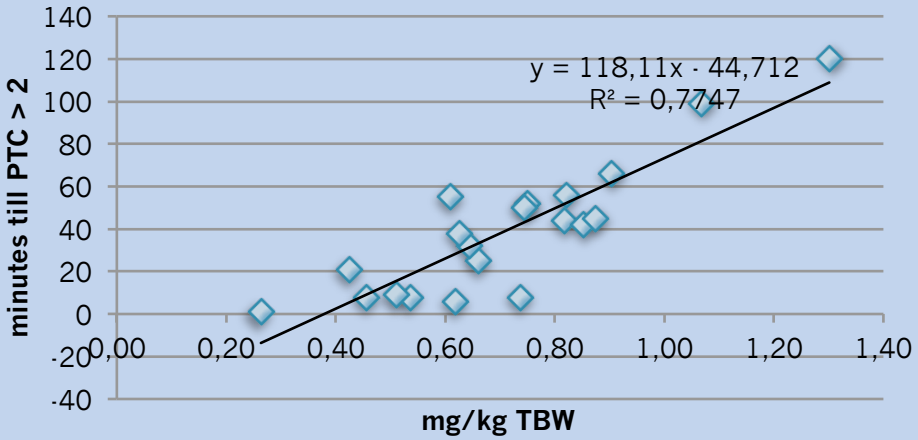
Dosing NMB in morbidly obese patients

- Suxamethonium
  - TBW up to 200 kg, then a little less
- Rocuronium
  - IBW induction and maintenance
- Cis atracurium
  - TBW induction and IBW maintenance
  - IBW probably better LBW
  - But variability is always large what requires NMT monitoring

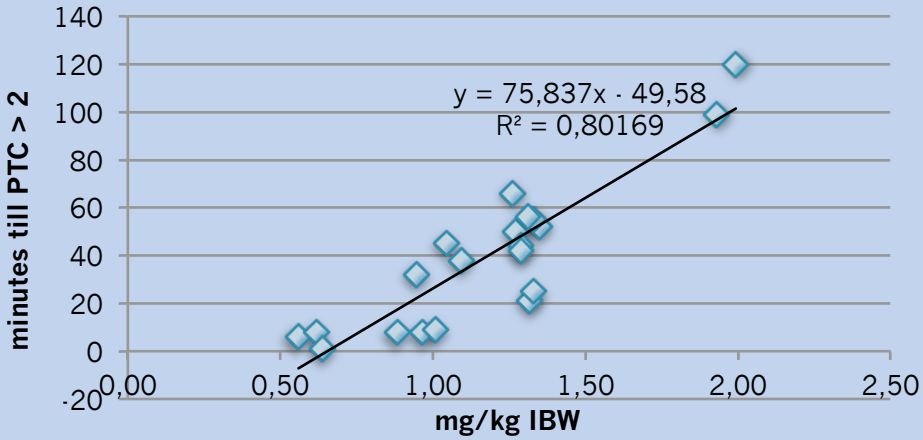
Variability in time on deep NMB according to the model

Clinical Data from L Debaerdemaeker and J Mulier

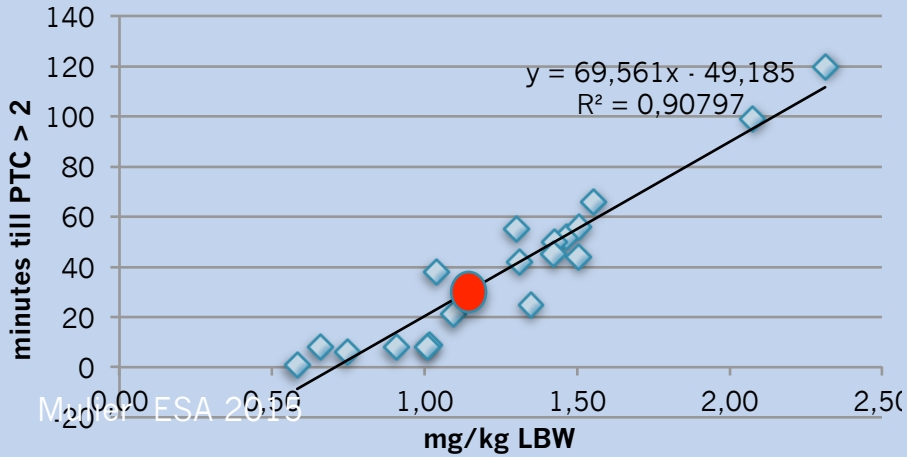
TBW



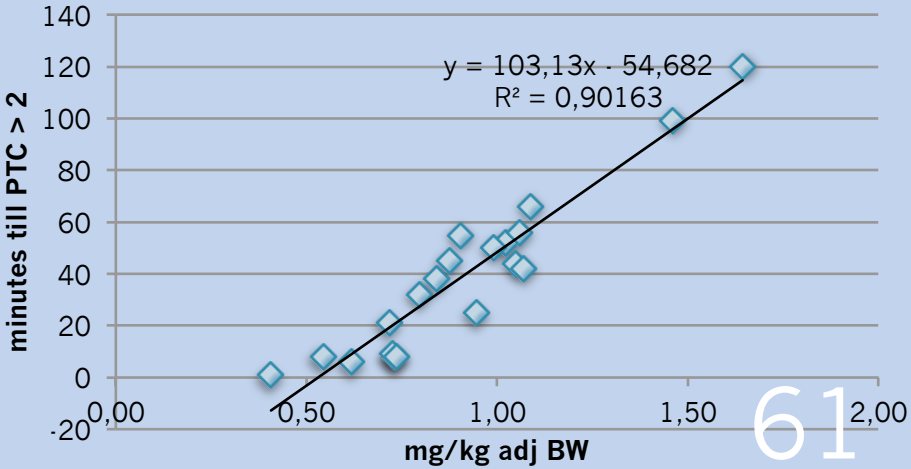
IBW Devine calc



LBM 2005 Janmahasatian



adj BW



Key points to remember

- If you use NMB within the last two hours you have to measure the depth of NMB quantitatively.
  - Breathing, eye opening and head lift are inadequate.
- You have to reach a TOF > 0.9 before extubation.
- Spontaneous or neostigmine reversal is longer and less predictable in obese patients.
- Obese patients need more frequent a deep NMB to facilitate ventilation and abdominal surgery
- It is not the BMI but the intra abdominal fat that increases the risk for metabolic syndrome.

What do we need in the future on NMT

- Automatic running PTC
  - When TOF = zero
  - Next measurement should be PTC
  - When PTC = 20 next measurement should be TOF

  - After PTC, always a long waiting time of 3 minutes.
  - Therefore after last PTC first measure TOF to be sure that TOF is still zero.
- Simple device that is easy to install and reliable

Key points to remember for all patients

- Use NMT monitoring when NMB are used.
  - Look for an objective measure, use thumb instead of orbicularis oris
  - Standardize and keep it simple, keep thumb free or use tof tube (dubois)
  - Learn to use a limited number of modes
    - Single twitch for suxamethonium
    - TOF and PTC for non depolarising drugs like rocuronium, cis atracurium.
    - Limit the number of drugs to have the pharmacokinetics in your fingers
  - Never rely on one measurement, wait for a second to confirm
  - Learn measurement failures and how to resolve them

- Dose sufficient according to length of procedure and required depth or use continuous infusion as reversal is faster in abdominal muscles than in peripheral muscles.

Key points to remember for obese patients

- Obesity requires NMB dosing on LBW and verification of depth by NMT
- Obesity increases the technical failures of NMT monitoring
- Obesity increases the unpredictability of spontaneous recovery and increases reversal time by neostigmine.
- Obese patients with OSAS have more reasons for full reversal to a TOF of 100%
- Reversal by Sugammadex is based on TBW. If BMI > 40 dosing is possible on IBW + 40% but requires NMT verification.

ESPCOP
The European Society for Perioperative Care of the Obese Patient

www.ESPCOP.org

LIVE OPIOID FREE ANAESTHESIA

December 18th 2015

AZ Sint-Jan AV
Ruddershove 10
Bruges, Belgium

ESA Mulier 2015

ESPCOP
The European Society for Perioperative Care of the Obese Patient

6th ESPCOP meeting

December 19th 2015
Crowne Plaza, Burg 10
Bruges, Belgium

Following the advice in using less peri-operative opioids in morbidly obese patients, it has now become time to discuss "from low-opioid to opioid free" anaesthesia (OFA).

Why, how and when do we use low-opioid or opioid free anaesthesia combined with post-operative multimodal analgesia in morbidly obese patients?