

NEUROMUSCULAR BLOCKADE: TIMES ARE CHANGING

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"Time changes everything"

That's what people say, it's not true.

Doing things changes things.

Not doing things leaves things
exactly as they were.

House

**CONFLICTS OF INTEREST:
NONE**





Briefly review the History of NMBs, Reversal and Monitoring



Review current practice techniques and how we got here



Discuss why our current approach is wrong



Evaluate new reversal and monitoring techniques



Provide some examples of sustainability



Discuss current and upcoming practice recommendations

GOALS

CURARE

- 1516 "THE FLYING DEATH" FIRST WRITTEN ABOUT IN 1516 BY PETER MARTYR D'ANGHERA
- 1594 MENTIONED AGAIN IN SIR WALTER RALIEGHS BOOK
 - OURARI
 - OURARA, URALI, URARE, WOORARI, WOURALI AND EVENTUALLY CURARE
- SUBSEQUENT 200 YEARS, WRITTEN ABOUT AND OCCASIONALLY STUDIED IN SMALL SAMPLES.
- 1846 CLAUDE BERNARD PUBLISHED EXPERIMENTS ON FROGS DEMONSTRATING THE EFFECTS OF THE "WOURALI" AND PREVENTING MUSCLE CONTRACTION
- 1900 VIENNA SCIENTIST PAL USING CURARE TO PARALYZE DOGS, NOTED THAT PHYSOSTIMINE SEAMED TO REVERSE IT EFFECTS.

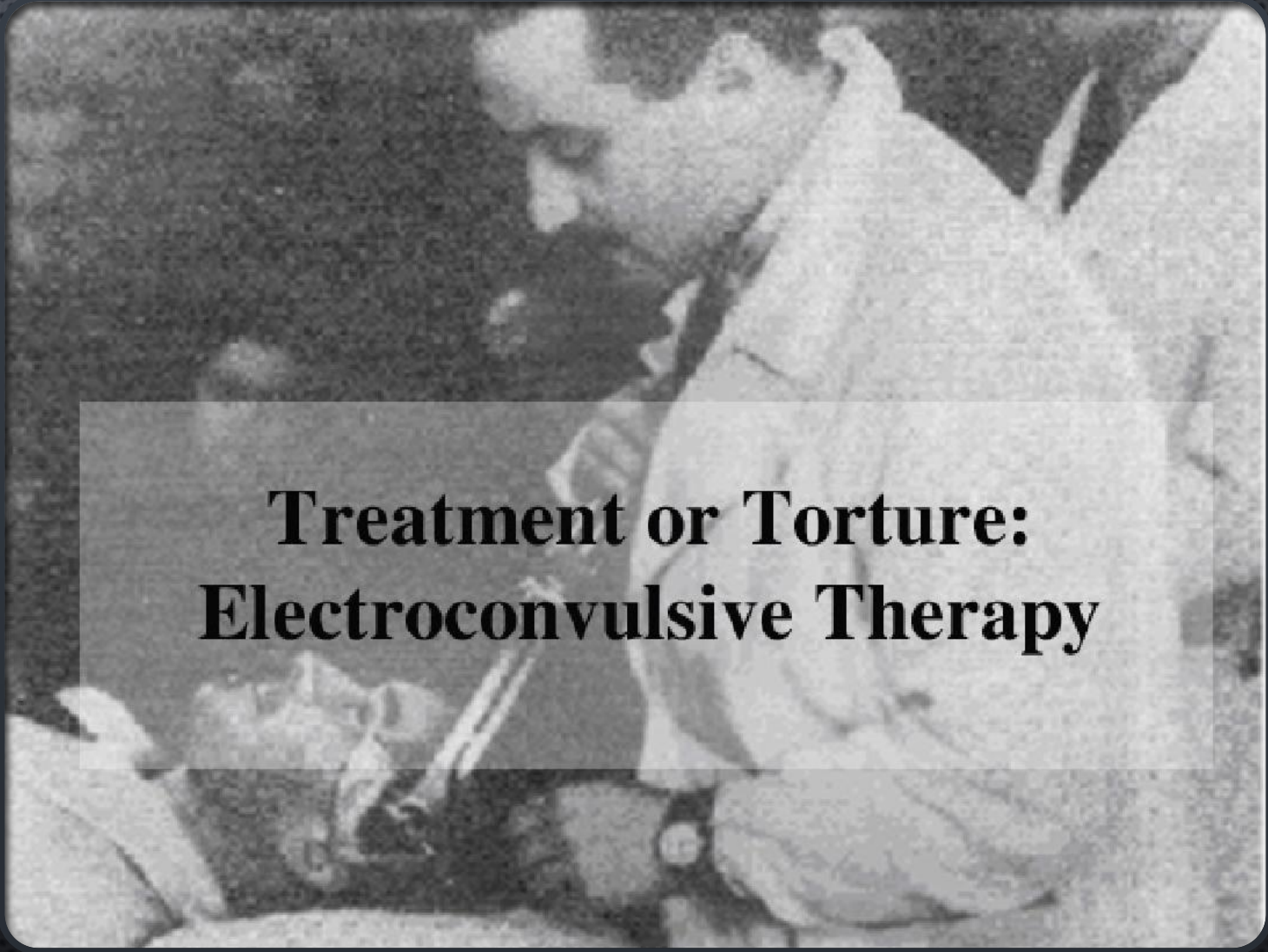


1938: RICHARD GILL EXPLORER AND BOTANIST



FIRST USES IN ANESTHESIA

1940 AE BENNETT PSYCHIATRIST,
ABOUT TO ABANDON ECT DUE TO
SPINAL FRACTURES. READS OF
CURARE, UTILIZES IT AND THEN
PRESENTS A FILM AT THE 91ST AMA
ANNUAL SESSION



Treatment or Torture: Electroconvulsive Therapy

MORE TO LEARN



EA Rovenstine at NYU gives it to one of his residents and tells him to “Experiment with it”

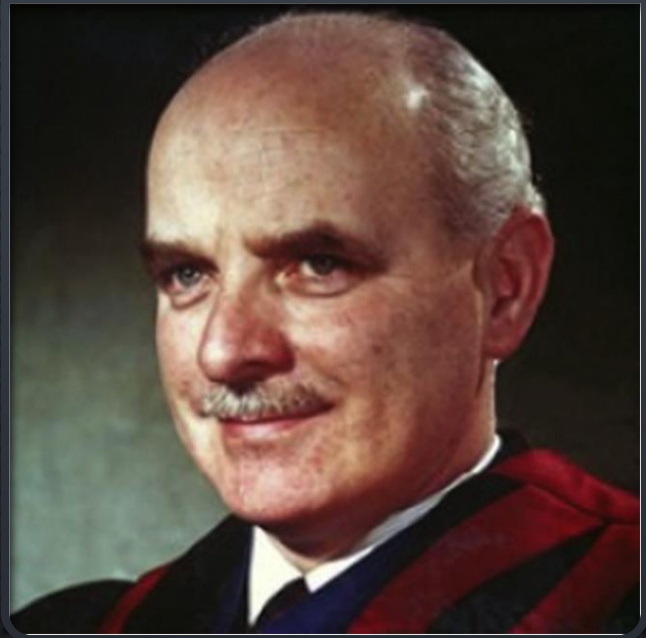


1942: Griffith and Johnson first started using Curare in General Anesthesia in Montreal

Successful use in 43 abdominal surgeries

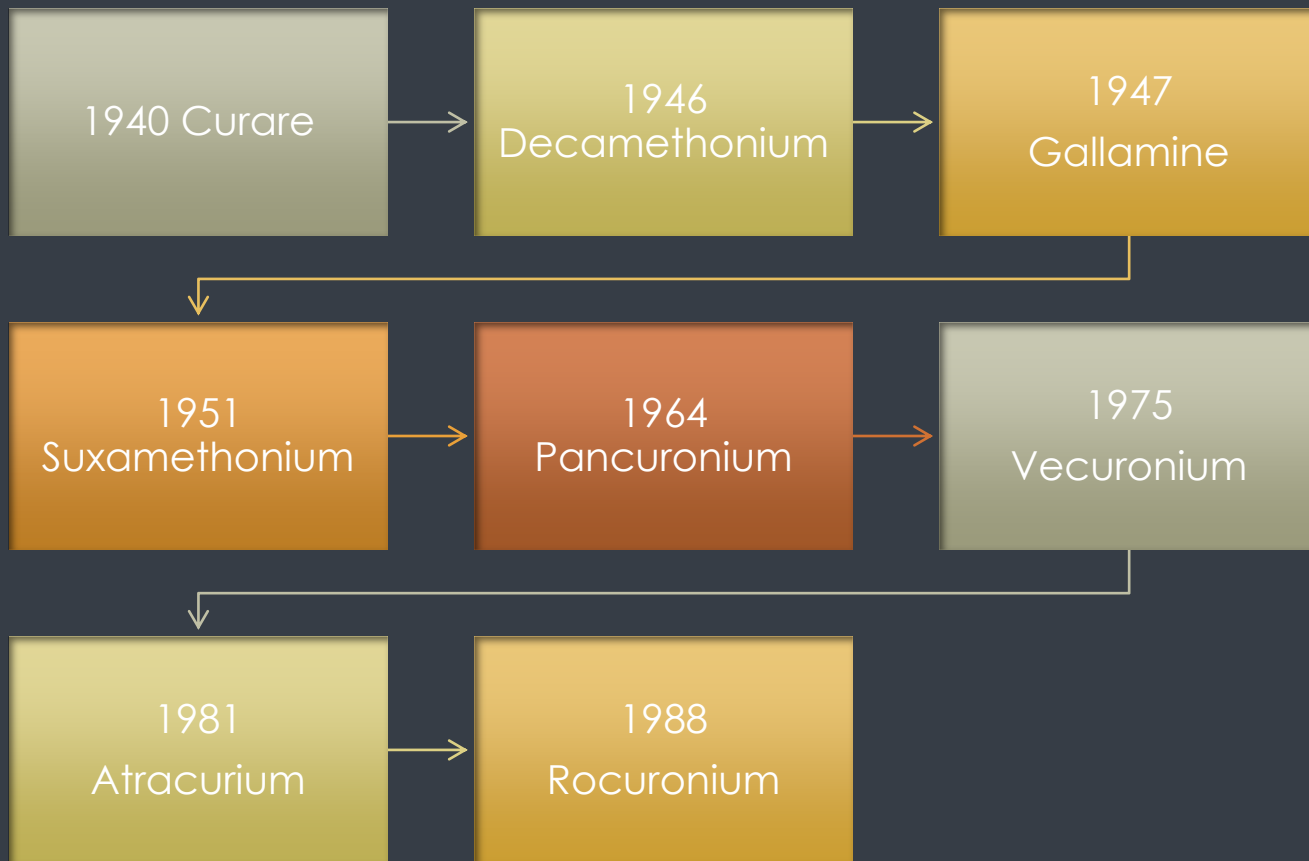


WAR BRINGS MEDICAL INNOVATION: THE LIVERPOOL ANESTHETIC



- A MILESTONE IN ANAESTHESIA? D-TURBOCURARINE CHLORIDE

GRAY TC, HALTON J PRC R SOC. MED 1946
MAY; 36(7):400-10



NEUROMUSCULAR AGENTS

MONITORING AND REVERSAL

EVERY 20 YEARS

1939

- Neostigmine FDA Approval

1940

- D-Turbocurarine

1958

- Peripheral Nerve Stimulator

1980s

- POC TOFr

2008

- Sugammadex sought FDA

2015

- Sugammadex approved

REVERSAL: NEOSTIGMINE

“PHARMACOLOGICAL REVERSAL OF NMBAs BEGINS WITH THE CARBAMATE GROUP, ACETYLCHOLINESTERASE INHIBITOR ‘NEOSTIGMINE’ FOR ALL PRACTICAL PURPOSES AND **SINCE TIME IMMEMORIAL** (FIRST CLINICAL USE 1931; FDA APPROVAL 1939), DESPITE DRAWBACKS.”

Neostigmine Available since the 1950s.

Anticholinesterase-

- Prevents the degradation of ACh, - Puts it on the winning side of the Race to the receptor between NMDRs and ACh.
- Advantages: Cheap and previously one of the only options
- Wide safety margin and few examples of allergic reactions
- Disadvantages: Requires anticholinergic
- Not recommended for reversal of moderate to deep blocks (<2 twitch)
- Ceiling effect 70mcg/kg
- May allow recurarization when long acting NMDRs outlast the Neostigmine

THE “MORE”
COMMON
REVERSAL
TECHNIQUE

NEOSTIGMINE

Advantages:

- Cheap and previously one of the only options
- Wide safety margin and few examples of allergic reactions
- Can be used with ANY non depolarizing neuromuscular blocking agent

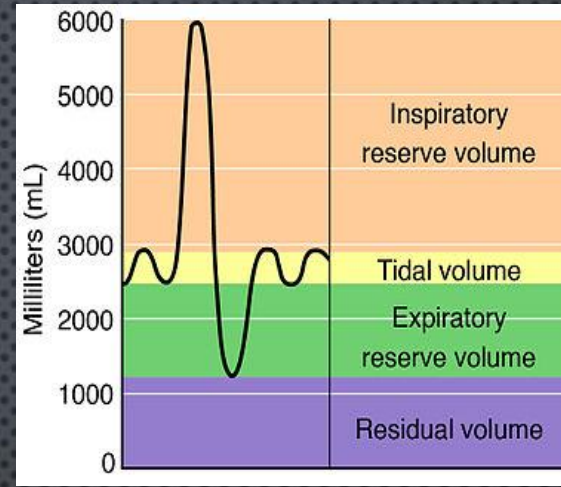
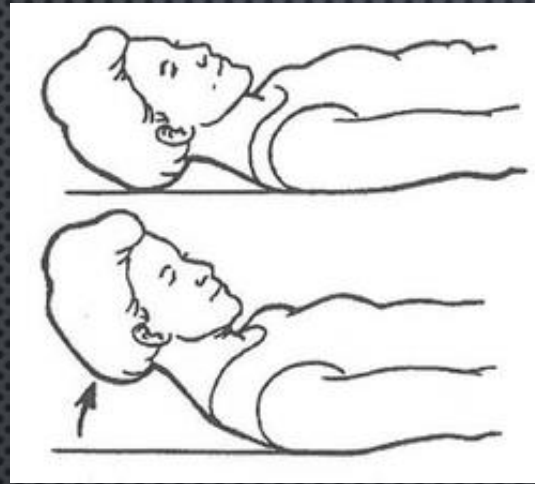
Disadvantages:

- Requires anticholinergic
- Not recommended for reversal of moderate to deep blocks (<2 twitches)
- Ceiling effect 70mcg/kg or 5mg
- May allow recurarization when long acting NMDRs outlast the Neostigmine
- Requires 8min at minimum to work
- May create a depolarizing block if given in excess

TIME TO EXTUBATE?



IS IT TIME YET?



Occupancy		
Monitoring Technique	Receptor Occupancy, %	Comment
TOF 4/4 twitches	70-75	...
TOF 0/4 twitches	> 90	...
Sustained 5-s head lift (TOF, 0.6)	50	Must be performed unaided with patient supine
Hand grip (TOF, 0.7)	50	Sustained at a level qualitative similar to preinduction baseline
Sustained bite (TOF, approximately 0.85)	50	Sustain jaw clench on tongue blade

TOF = train-of-four. (Sources: Naguib and Lien³ and Lee.⁶⁰)

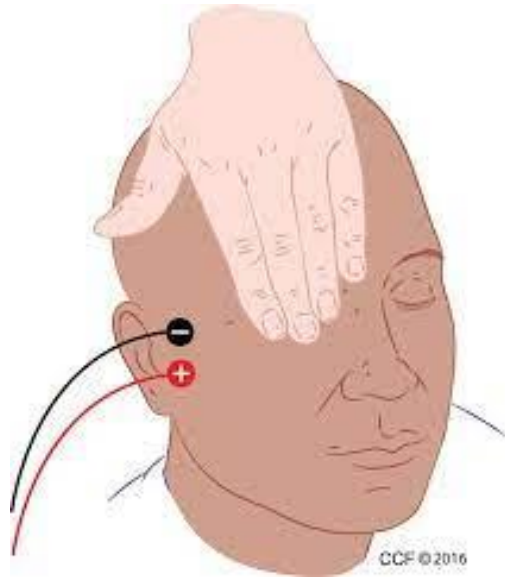
QUALITATIVE PERIPHERAL NERVE MONITORING

1958

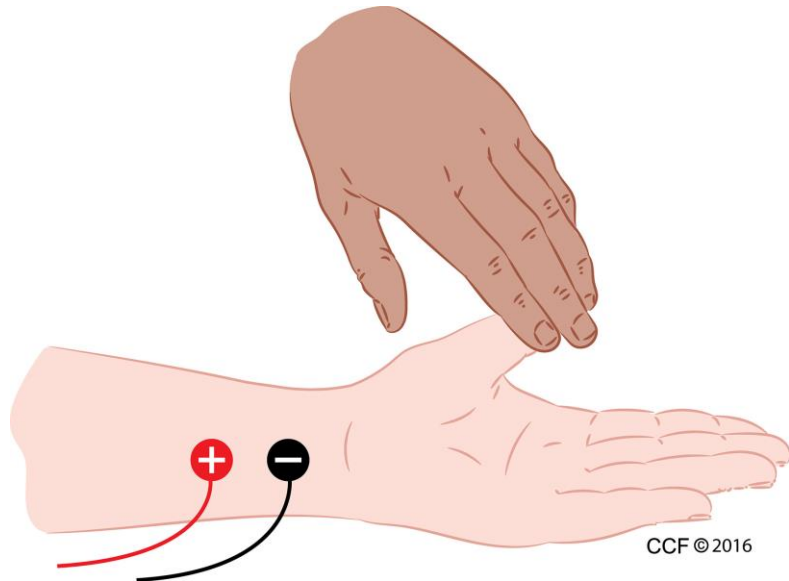


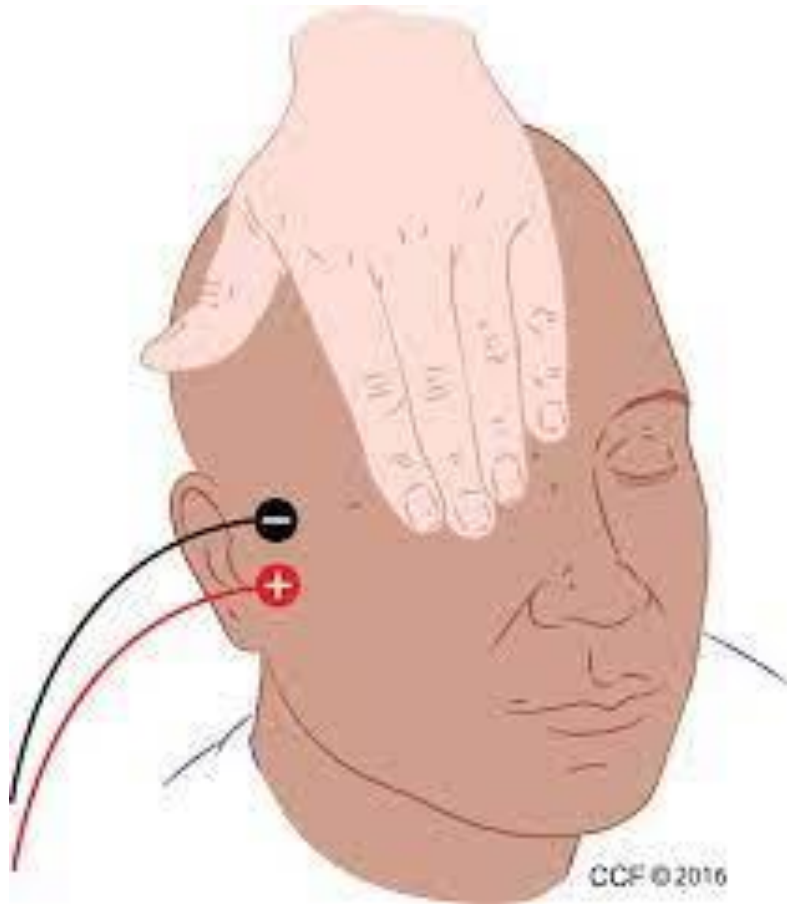
NOW





PNS SITES FOR MONITORING





FACIAL NERVE = NO-GO

- LESS ACCURATE BUT MAY BE NECESSARY DUE TO POSITIONING.
 - 150 PTS RECEIVED NMBAS ASSESSED FOR RNMB
 - 52% HAD RESIDUAL NMB COMPARED TO 22% WITH ULNAR MONITORING
- NOT SAFE TO MONITOR FOR DEGREE OF RECOVERY FOR EXTUBATION.

TRAIN OF FOUR

- TOFC 1 =>95% OF NICOTINIC ACHRS BLOCKED
- TOFC 2= 85-90%
- TOFC 3= 80-85%
- TOFC 4=70-75% BLOCKED

Patterns of nerve stimulation

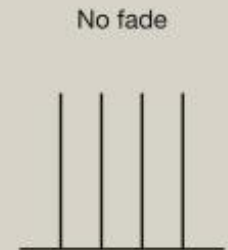
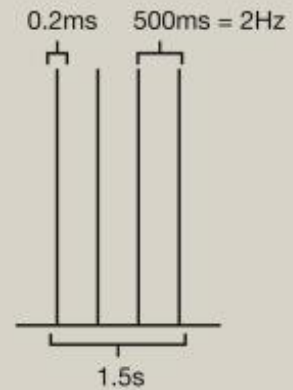
Pattern of nerve stimulation

Control/no block

Partial non-depolarizing blockade

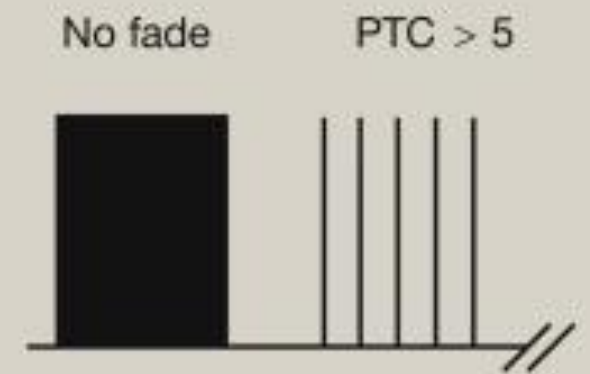
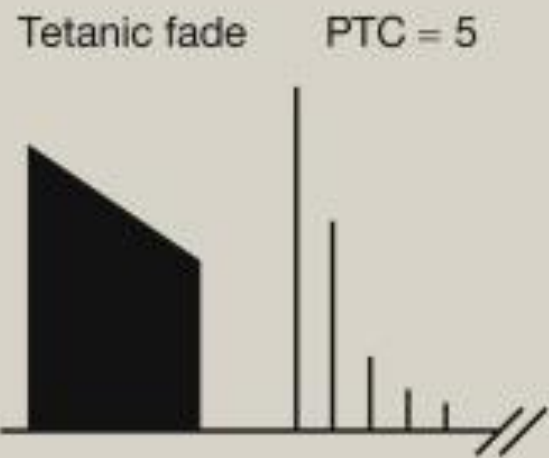
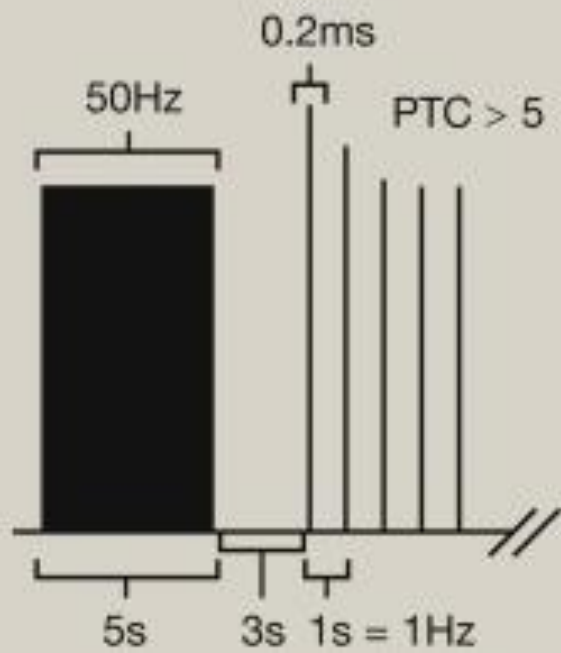
Partial depolarizing blockade

Train-of-four (TOF)



TETANY

Tetanic stimulation

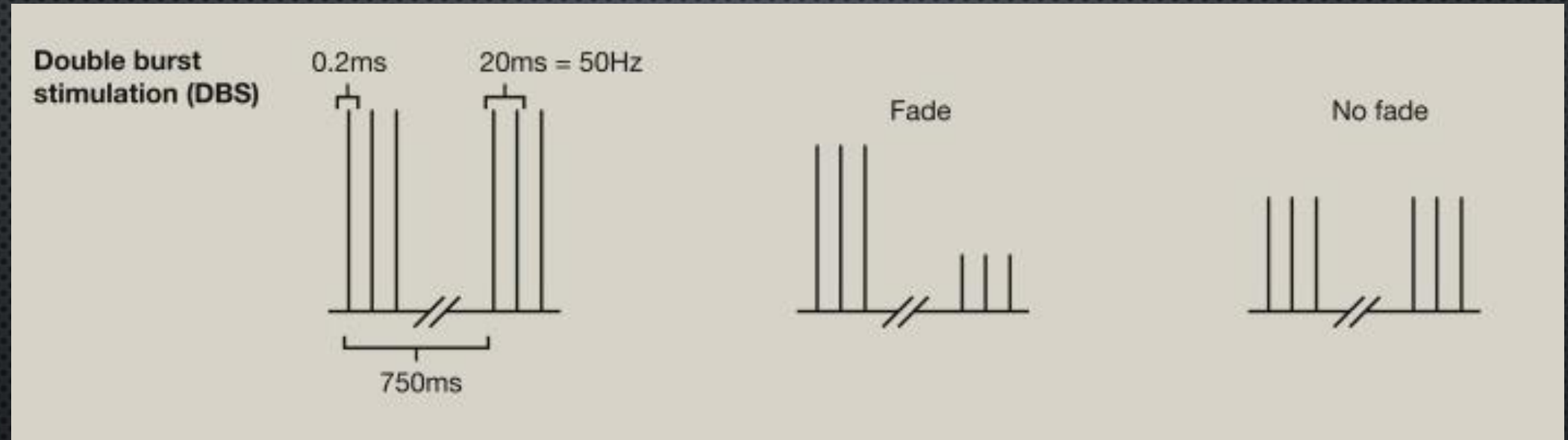




POST TETANIC POTENTIATION (PTC)

- 5 SECOND TETANY FOLLOWED BY A SERIES OF STIMULATION AT 1HZ FOR 20SEC.
- TETANY TRANSIENTLY MOBILIZES THE AVAILABLE ACH INTO THE NMJ
- A WAY OF QUANTIFYING “ZERO”
- MUST BE 3-5 MIN GAP BETWEEN PTC MONITORING

DOUBLE BURST



HELPS TO OVERCOME THE PROVIDERS INABILITY TO DETERMINE FADE IN TOF

SOMETHING'S NOT RIGHT



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Journal of Clinical Anesthesia

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Original Contribution

Incidence, risk factors, and consequences of residual neuromuscular block in the United States: The prospective, observational, multicenter RECITE-US study

Leif Saager^{a,*,1}, Eric M. Maiese^{b,2}, Lori D. Bash^b, Tricia A. Meyer^c, Harold Minkowitz^d, Scott Groudine^e, Beverly K. Philip^f, Pedro Tanaka^g, Tong Joo Gan^{h,3}, Yiliam Rodriguez-Blancoⁱ, Roy Soto^j, Olaf Heisel^k

RECITE- US
STUDY

Table 1

Patient characteristics among those subjects overall, with or without residual neuromuscular block.

Variables	At Baseline	At Tracheal Extubation:		P value
	Overall per protocol population (n = 255)	rNMB	No rNMB	
		TOF ratio < 0.9	TOF ratio ≥ 0.9	
		(n = 165)	(n = 90)	
Age, y (mean ± SD)	50.6 ± 13.6	51.7 ± 14.0	48.5 ± 12.7	0.07
Category (n, %)				
20–40	57 (22.4%)	32 (19.4%)	25 (27.8%)	0.43
41–49	68 (26.7%)	44 (26.7%)	24 (26.7%)	
50–60	66 (25.9%)	44 (26.7%)	22 (24.4%)	
61–100	64 (25.1%)	45 (27.3%)	19 (21.1%)	
Gender (n, %)				
Male	69 (27.1%)	53 (32.1%)	16 (17.8%)	0.018
Female	186 (72.9%)	112 (67.9%)	74 (82.2%)	

RECITE-US

64.7% HAD TOF <.9

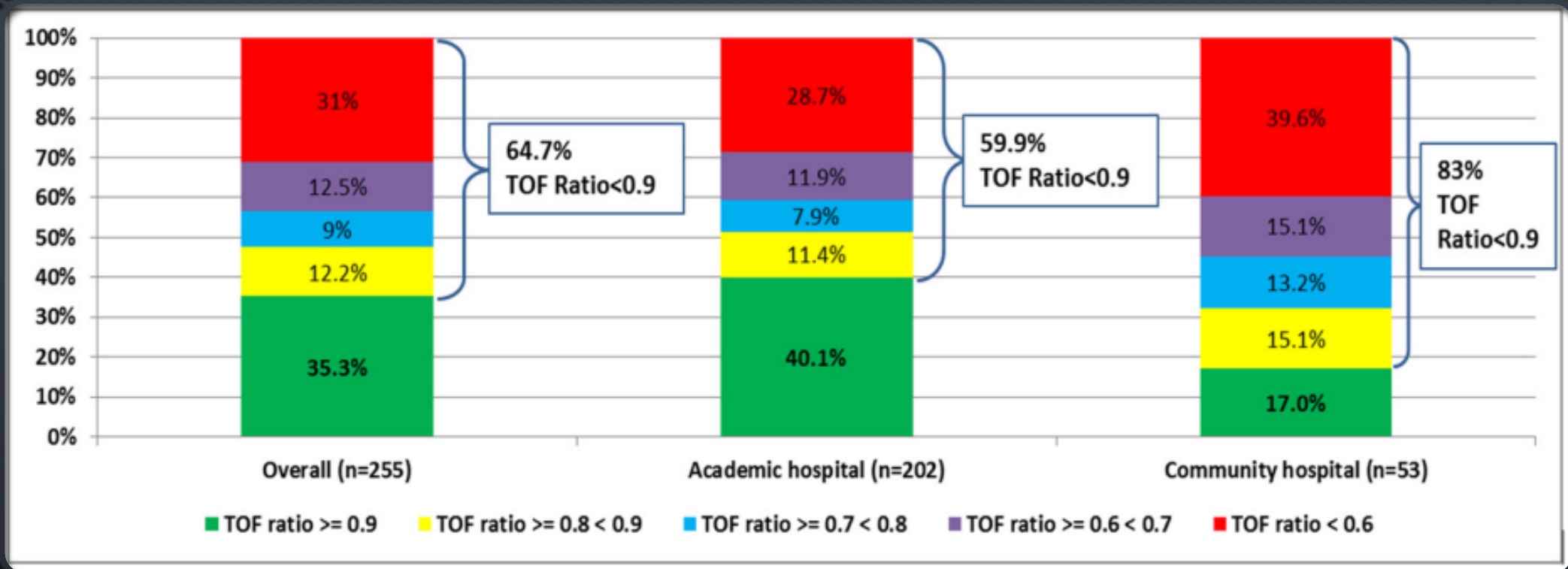
RECITE US OUTCOMES

Table 3

Multivariate analysis of risk factors associated with residual block^a at extubation.

Covariates	Odds Ratio	95% Confidence Internal	P-value
At tracheal extubation			
Female	1.00	References	
Male	2.60	(1.28, 5.27)	0.008
BMI	1.04	(1.00, 1.07)	0.043
ASA PS1	1.00	Reference	
ASA PS2	0.51	(0.21, 1.26)	0.144
ASA PS3	0.98	(0.37, 2.61)	0.976
Time from NMBA admin to TE (min)	0.99	(0.98, 1.00)	0.088
Hospital Type (community vs academic)	3.15	(1.39, 7.15)	0.006
Time from tracheal intubation to extubation (h)	0.67	(0.48, 0.92)	0.014

^a Where residual block is defined as: TOF ratio < 0.9, without residual block: TOF ratio ≥ 0.9. ASA, American Society of Anesthesia; PS, physical status; BMI, body mass index; NMBA, neuromuscular blocking agent; TE, tracheal



RECITE-US - SECONDARY OUTCOME

CONCLUSIONS

- RNMB WITH CURRENT METHODS IS A MUCH BIGGER ISSUE THAN WE THOUGHT
- > 30% OF THESE PATIENTS HAS PROFOUND BLOCK (TOFr<.6)
- THIS STUDY REPORTED A LOWER INCIDENCE THAN OTHERS
 - MURPHY ET AL REPORTED 88%- TARGETED AT-RISK PATIENTS
- MALES
- BMI
- COMMUNITY VS ACADEMIC

ANESTHETIC PHARMACOLOGY: REVIEW ARTICLES

Residual Neuromuscular Block

Lessons Unlearned. Part I

Definitions, Incidence, and Adverse Physiologic Effects of Residual Neuromuscular Block

Murphy, Glenn S. MD^{*}; Brull, Sorin J. MD[†]

[Author Information](#) 

Anesthesia & Analgesia: July 2010 - Volume 111 - Issue 1 - p 120-128

doi: 10.1213/ANE.0b013e3181da832d

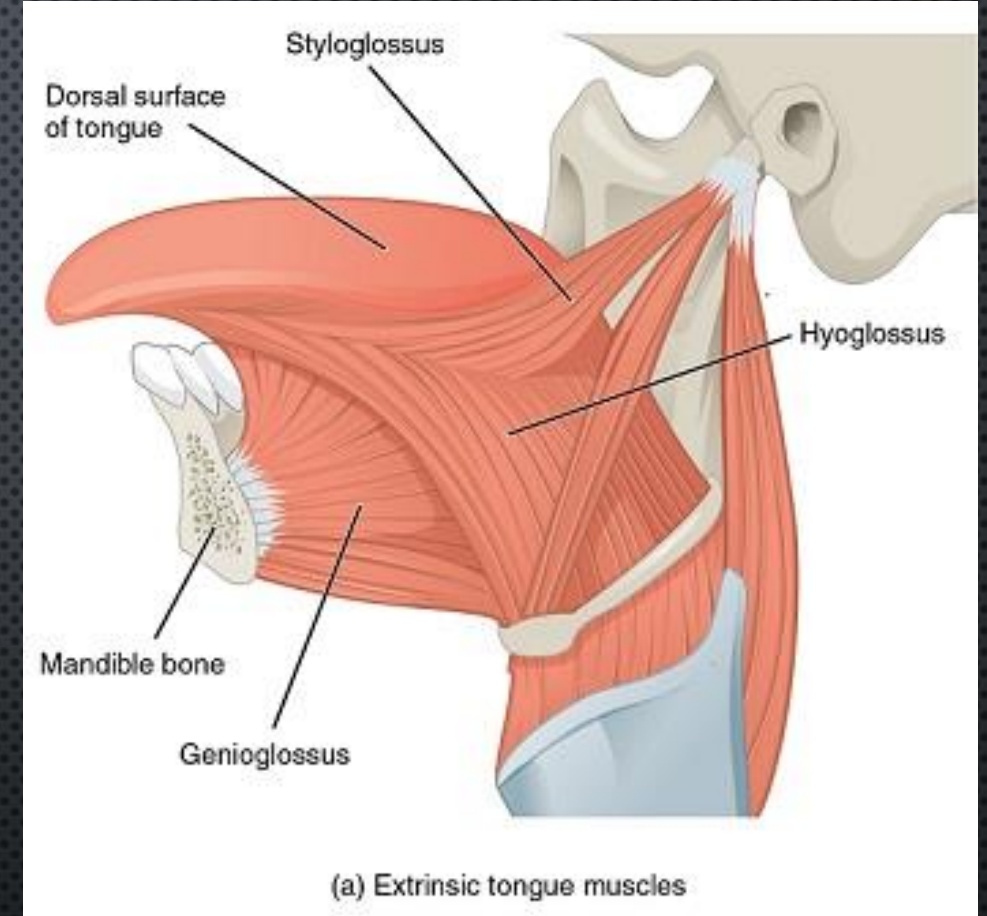
Table 1. Incidence of Residual Neuromuscular Blockade (2000–2008)

Author	Year	Number of patients	NMBD used	NM monitoring used (%)	Reversal used (%)	Site/time RNMB measured	Definition RNMB	Incidence RNMB	Type of anesthesia
Baillard et al. ²⁷	2000	568	Vecuronium	2	0	PACU	<0.7	42% (AMG)	Inhalational
Bissinger et al. ²⁰	2000	83	Pancuronium	NS	100	PACU	<0.7	20% (AMG)	Inhalational and TIVA
Hayes et al. ²²	2001	148	Vecuronium	NS	100	PACU	<0.7	7%	Primarily inhalational
			Vecuronium	41	68	PACU	<0.8	64% (AMG)	
McCaul et al. ²⁸	2002	40	Atracurium	41	68	PACU	<0.8	52%	NS
			Rocuronium	41	68	PACU	<0.8	39%	
			Atracurium	50	100	Extubation	<0.7	65% (MMG)	
Kim et al. ²	2002	602	Vecuronium	0	100	PACU	<0.7	24.7% (AMG)	Inhalational
Gatke et al. ²³	2002	60	Rocuronium	0	100	PACU	<0.7	14.7%	TIVA
			Rocuronium	0	100	Extubation	<0.8	16.7% (MMG)	
Baillard et al. ²¹	2005	101	Rocuronium	45	43	PACU	<0.9	9% (AMG)	Inhalational
			Vecuronium	45	43	PACU	<0.9	9%	Inhalational
			Vecuronium	NS	0	PACU	<0.7	16% (AMG)	Inhalational
Debaene et al. ³	2003	526	Rocuronium	NS	0	PACU	<0.9	45%	Inhalational
			Atracurium	NS	0	PACU	<0.9		
			Vecuronium	60	42	PACU	<0.9	3.5% (AMG)	Inhalational
Baillard et al. ²¹	2005	218	Atracurium	60	42	PACU	<0.9	3.5%	Inhalational
			Cisatracurium	100	100	Transfer to	<0.9	36.7% (MMG)	Inhalational
Kopman et al. ²⁴	2004	60	Rocuronium	100	100	PACU	<0.9	50.0%	Inhalational
			Pancuronium	100	100	PACU	<0.9	83% (AMG)	Inhalational
Murphy et al. ²⁸	2004	70	Pancuronium	100	100	PACU	<0.9	83% (AMG)	Inhalational
Murphy et al. ²⁵	2005	120	Rocuronium	100	100	PACU	<0.9	29%	Inhalational
			Rocuronium	100	100	Extubation	<0.9	88% (AMG)	Inhalational
Cammu et al. ⁴	2006	640	Atracurium	11–12	25–26	PACU	<0.9	38–47% (AMG)	NS
			Mivacurium	11–12	25–26	PACU	<0.9	38–47%	NS
			Rocuronium	11–12	25–26	PACU	<0.9	38–47%	NS
Maybauer et al. ²⁹	2007	338	Cisatracurium	100	0	Extubation	<0.9	57% (AMG)	TIVA
			Rocuronium	100	0	Extubation	<0.9	44%	TIVA
Murphy et al. ⁶	2008	90	Rocuronium	100	100	PACU	<0.9	30% (AMG) (TOF group)	Inhalational

NMBD = neuromuscular blocking drugs; NM monitoring = neuromuscular monitoring; RNMB = residual neuromuscular blockade; TIVA = total intravenous anesthesia; NS = not stated.

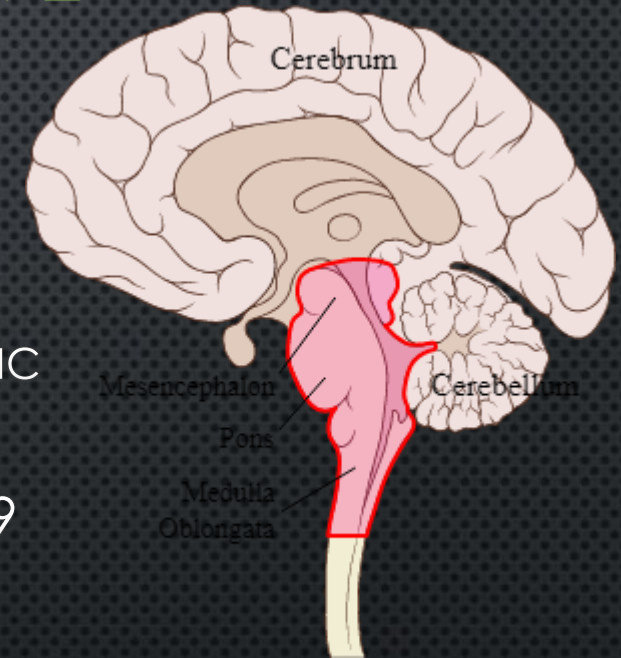
EFFECTS OF RNMB

- AIRWAY MUSCLE FXN
 - HEALTHY ADULTS WITH TOF RATIO OF .5-1.0 SHOWED A FORCE VC OF ACCEPTABLE LEVELS BUT SHOWED SIGNS OF PARTIAL UPPER AIRWAY OBSTRUCTION
 - EIKERMANN ET AL DEMONSTRATED GENIOGLOSSUS MUSCLE IMPAIRMENT AT TOFR OF .8. CONCLUDED PARTIAL OBSTRUCTION DUE TO WEAKNESS UPPER AIRWAY DILATOR MUSCLES



EFFECTS ON HYPOXIC VENTILATORY DRIVE

- RNMB MINIMALLY AFFECTS TIDAL VOLUMES AND RR BUT CAN IMPAIR THE HYPOXIC VENTILATORY RESPONSE ERIKSSON ET AL (1992)
- REDUCED BY AS MUCH AS 30% AND DID NOT RETURN TO NORMAL UNTIL TOF >.9





Awake patients experiencing muscle weakness
TOFr .7-.75

- **Difficulty swallowing**
- Diplopia
- Visual Disturbances
- Decreased grip strength
- Facial weakness
- Difficulty speaking and drinking

TOFr .85-1.0

- Fatigue and visual problems remains in 70% of the patients.
- Diplopia remained for 45-90min after TOFr 1.0

PATIENT EXPERIENCE



**IS THIS
REALLY A
PROBLEM?**

INCIDENCE

- OVERALL INCIDENCE **DEFINITELY** ATTRIBUTED TO RNMB IS <1-3%

HOWEVER.....

- NSQUIP DATABASE SUGGESTS THAT 2.5% OF PATIENTS UNDERGOING GETA WITH NMBS HAVE A 2.5% INCIDENCE OF POST OP PNEUMONIA AND 2.7% INCIDENCE OF POST OP REINTUBATION

40M ANESTHETICS

40% RECEIVE NMBS

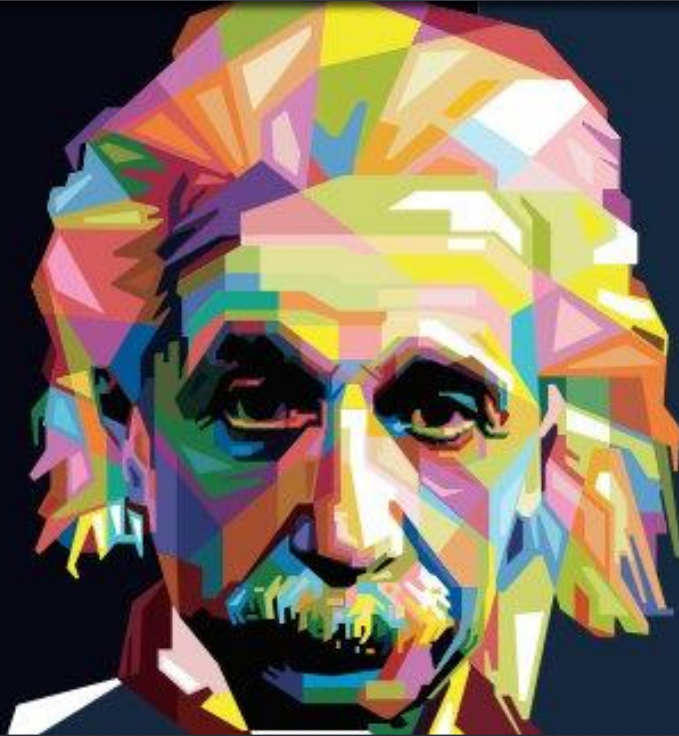
4M AT RISK

5.2% EXPERIENCE POPC

208,000 PTS PER YEAR

**\$38K COST TO
INSTITUTIONS**

**\$7,904,000,000 COST
TO HEALTHCARE**



“The definition of insanity is doing the same thing over and over again—but expecting different results.”

HOW DO WE FIX THIS?
MEDS AND MONITORING

SUGAMMADEX

Direct Reversal
Agent of
AMINOSteroids
NMBs

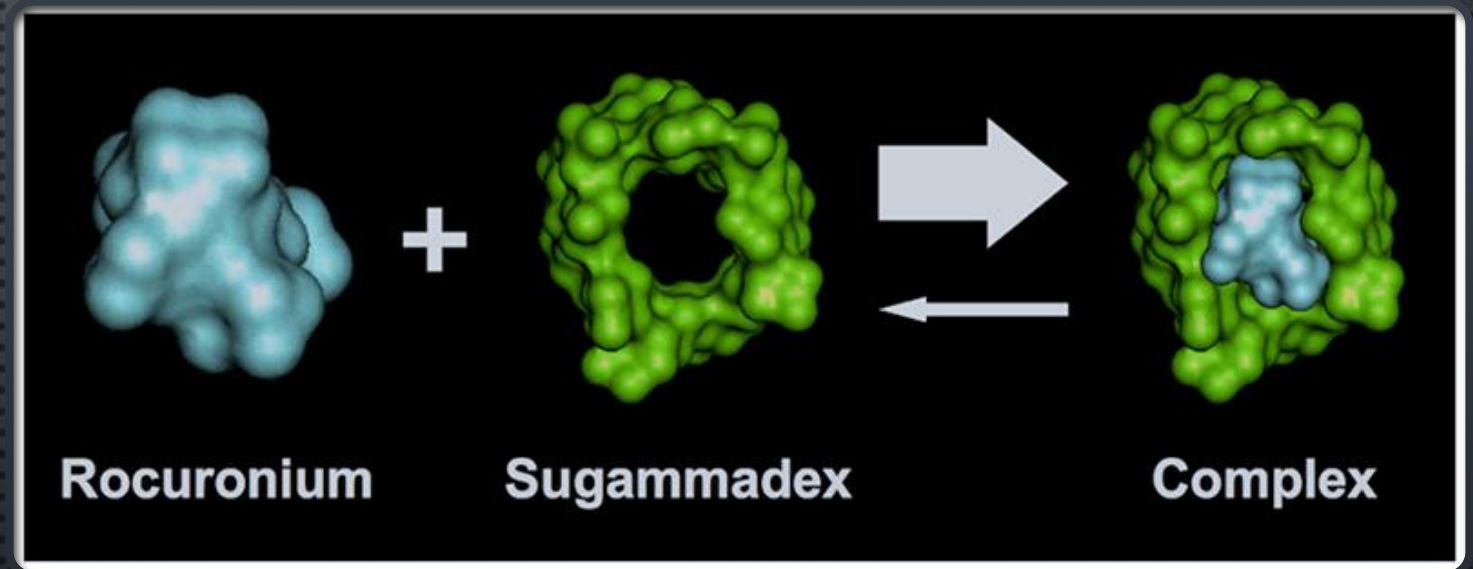
Cyclodextrin with
Hydrophilic exterior
and lipophilic
center

Lipophilic center
has a high affinity
for quat ammonium
complex of the
aminosteriods

1:1 Encapsulation
opf circulating
Aminosteroid NMBs

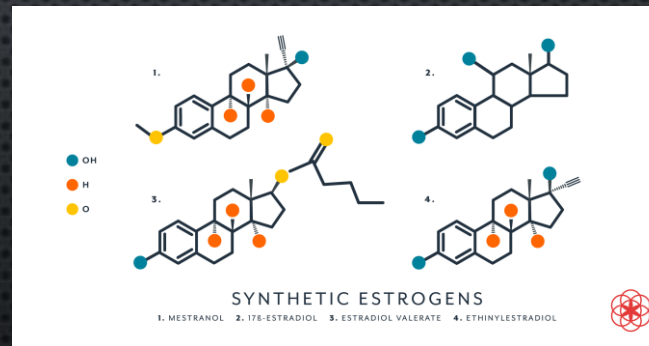
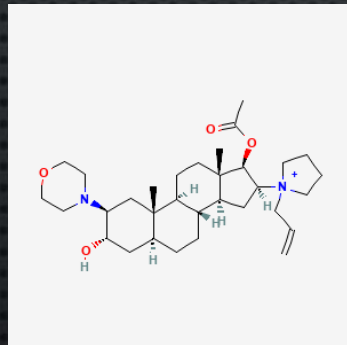
Also promotes
dissociations from
NMJ by creating a
concentrtation
gradient

Not metabolized
and excreted
through the kidneys



SUGAMMADEX CONSIDERATIONS

- RISK FOR ANAPHYLAXIS (.039%)* > NEOSTIGMINE
- **RENAL FAILURE GFR < 30**
- “CAPTURING REACTIONS” – SIMILAR AFFINITY FOR SUGAMMADEX COMPARED TO ROCURONIUM
 - HORMONAL CONTRACEPTIVES



Miyazaki, Yusuke MD; Sunaga, Hiroshi MD*; Kida, Kotaro MD*; Hobo, Shotaro MD†; Inoue, Nobuyoshi MD*; Muto, Masayuki MD*; Uezono, Shoichi MD*
Incidence of Anaphylaxis Associated With Sugammadex, Anesthesia & Analgesia: May 2018 - Volume 126 - Issue 5 - p 1505-1508
doi: 10.1213/ANE.0000000000002562

ADVERSE EFFECTS

- HYPERSENSITIVITY
 - RARE BUT CAN BE SEVERE. PRESENT WITHIN 5 MIN.
- HEADACHE
- FATIGUE
- NV
- URITCARIA
- ABD PAIN
- ELEVATED BIS LEVELS
- PREVIOUS CONCERNS ABOUT QTC PROLONGATION HAS SINCE BEEN DISMISSED.

Type of Block	Dose of Sugammadex	Time to TOF >0.9
Routine – TOF count 2	2mg/kg	2 minutes
Moderate – Post tetanic count 1-2	4mg/kg	3 minutes
Profound – 3-5 minutes post NMBDs	16mg/kg	1.5 minutes

SUGAMMADEX DOSING STRATEGY

COST: SUGAMMADEX

Projected 2021 Volume	46984.5
%Cases Rocuronium	38.70%
Projected case w/ Rocuronium 2021	18183
Cost per vial/ Rocuronium	\$156.00
Projected min cost Rocuronium 2021	\$2,836,548.23
%Cases Neostigmine	100.00%
Cost per neostigmine syringe (5ml)	\$11.00
Cost per glycopyrrolate	\$4.28
Min cost/case	\$15.28
Projected min cost Neo/glyco 2021	\$277,836.26
%cases using Sugamedex 2021	100.00%
Projected 2021 use	12921
Cost per vial	100.53
Projected Cost (min)	\$1,827,937.14

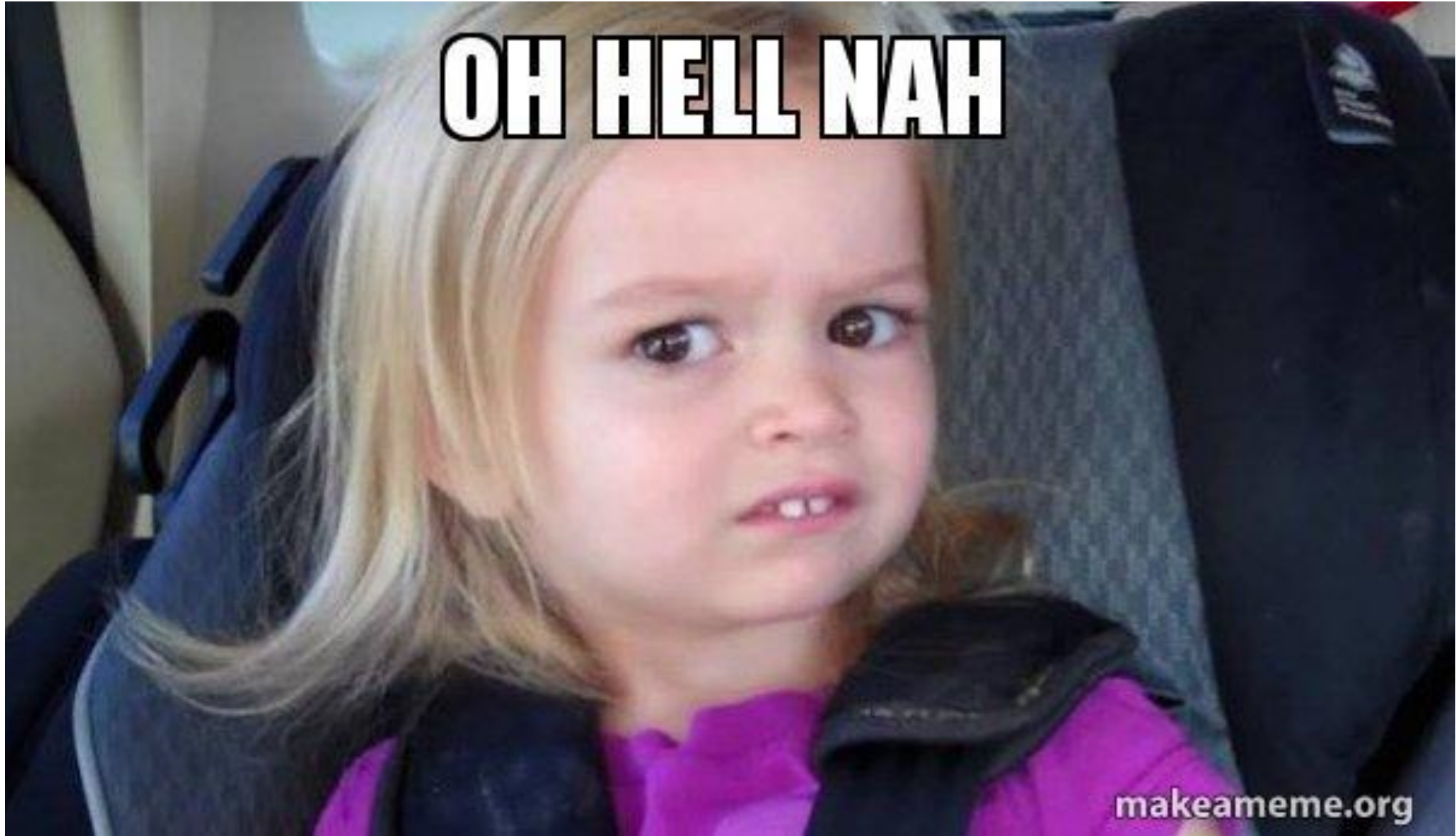
•WVUH 2021

•6.5X >NEOSTIGMINE

BIG MONEY



OH HELL NAH



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**JUST HOLD A MINUTE,
HOLD A MINUTE!**

Universal quantitative neuromuscular blockade monitoring at an academic medical center—A multimodal analysis of the potential impact on clinical outcomes and total cost of care

Lori-Ann Edwards^{a,*}, Nam Ly^a, Jonathan Shinefeld^b, Gordon Morewood^a

^a Department of Anesthesiology, Lewis Katz School of Medicine, Temple University, Philadelphia, PA, United States

^b Performance Excellence, Temple University Hospital, Philadelphia, PA, United States

- QI INITIATIVE: EVALUATED THEIR INCIDENCE OF RNMB (60%)
- CALCULATED NUMBER OF PATIENTS AT RISK DUE TO RNMB (4500)
- BASED ON NSQUIP DATA CALCULATED THE POSSIBLE INCIDENCE OF MAJOR POST OPERATIVE COMPLICATIONS: (189)

Table 2

Complications and variable costs of care from the TUH NSQIP and financial databases.

Service	Neither Complication		Pneumonia and / or Reintubation	
	N	Avg Variable Cost of Care	N	Avg Variable Cost of Care
Colorectal	165	\$18,832	14	\$70,642
General	322	\$10,254	14	\$22,502
Gynecology	155	\$5817	2	\$34,336
Neurosurgery	87	\$22,081	4	\$51,681
Orthopedics	254	\$14,664	3	\$19,599
Plastics	61	\$11,260	2	\$106,340
Urology	288	\$12,359	7	\$38,284
Vascular	302	\$21,613	16	\$64,790
Total	1634	\$14,522	62	\$50,895

TOTAL POTENTIAL COST TO THE INSTITUTION

- AVE \$36K ADDED COST PER PATIENT D/T COMPLICATIONS
- TUH PTS AT RISK = 189

$$189 \times \$36\text{k} = \text{\$6.9M}$$

TUH	
Projected case w/ Rocuronium 2021	7500
Cost per vial/ Rocuronium	\$156.00
Projected min cost Rocuronium 2021	\$1,170,000.00
Cost per neostigmine syringe (5ml)	\$11.00
Cost per glycopyrrolate	\$4.28
Min cost/case	\$15.28
Projected min cost Neo/glyco 2021	\$114,600.00
Cost per 2ml vial of Sugammadex	\$100.53
Minimumm Cost Per case (1 vial)	\$100.53
Projected Cost (min)	\$753,975.00
Difference:	-\$639,375.00

SUSTAINABILITY

\$.6 M VS \$6M

- CAN WE DO BETTER?
- DOES SUGAMMADEX SOLVE ALL OF THE ISSUES?
- IS IT SAFE TO SAY THAT WE SHOULD JUST GO WHOLE HOG AND REVERSE EVERYONE WITH SUGAMMADEX?
- WHAT DOES THE LITERATURE SAY?

Postoperative Recurarization After Sugammadex Administration Due to the Lack of Appropriate Neuromuscular Monitoring: The Japanese Experience

by Tomoki Sasakawa, MD, PhD; Katsuyuki Miyasaka, MD, PhD; Tomohiro Sawa, MD, PhD; and Hiroki Iida, MD, PhD

Multicenter Study > *Anesth Analg.* 2013 Aug;117(2):345-51.

doi: 10.1213/ANE.0b013e3182999672. Epub 2013 Jun 11.

Reversal with sugammadex in the absence of monitoring did not preclude residual neuromuscular block

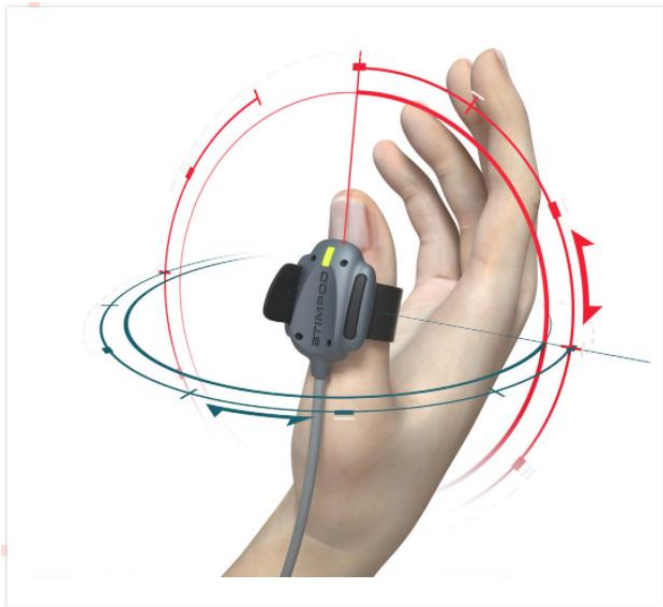
Yoshifumi Kotake¹, Ryoichi Ochiai, Takahiro Suzuki, Setsuro Ogawa, Shunichi Takagi, Makoto Ozaki,
Itsuo Nakatsuka, Junzo Takeda

QUANTITATIVE TRAIN OF FOUR:

THE ANSWER TO
IMPROVING
OUTCOMES AND
MAINTAINING
SUSTAINABILITY

ACCELEROMYEOLOGRAPHY (AMG)





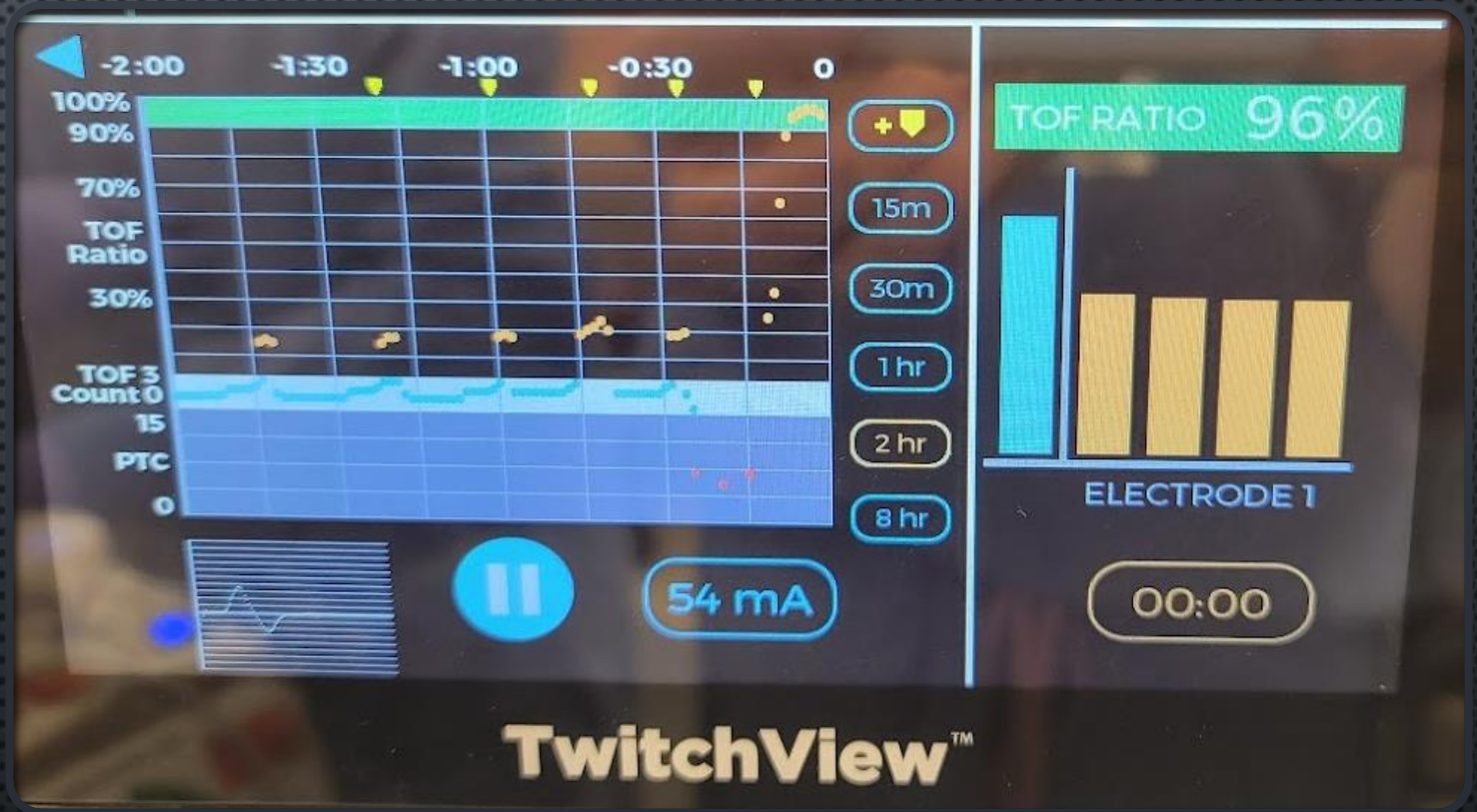
AMG: STIMPOD



ELECTROMYEOGRAPHY (EMG): TWITCHVIEW

WHAT I'VE LEARNED

- EVERYONE RESPONDS VERY DIFFERENTLY TO OUR NMBS
- NOT EVERYONE REVERSES EASILY
- REAL TIME EVIDENCE IS SO FUN
- DEFINITIVE PROOF OF REVERSAL
- ITS USUALLY NOT ABOUT MINUTE VENTILATION: ITS ABOUT YOUR UPPER AIRWAY
- COMPLETELY ALTERED MY DOSING STRATEGIES



LIMITATIONS

Cost

- But we can cover that

Education-

- TRUE interpretation of TOF
- Understanding what they are seeing
- HOW CAN YOU HAVE a TOF 2 and have Spont ventilation?
- HOW CAN YOU get a TOFr of >100%
- Proper probe placement
- “It will slow down my induction”

SUSTAINABILITY: TUH EXAMPLE

Table 3

Annual cost of implementing universal qTOFR monitoring at TUH.

Category	Unit Cost	Volume Required	Annual Cost
Disposables	\$20	7500	\$150,000
Monitor	\$2000	30	\$12,000*
Total			\$162,000

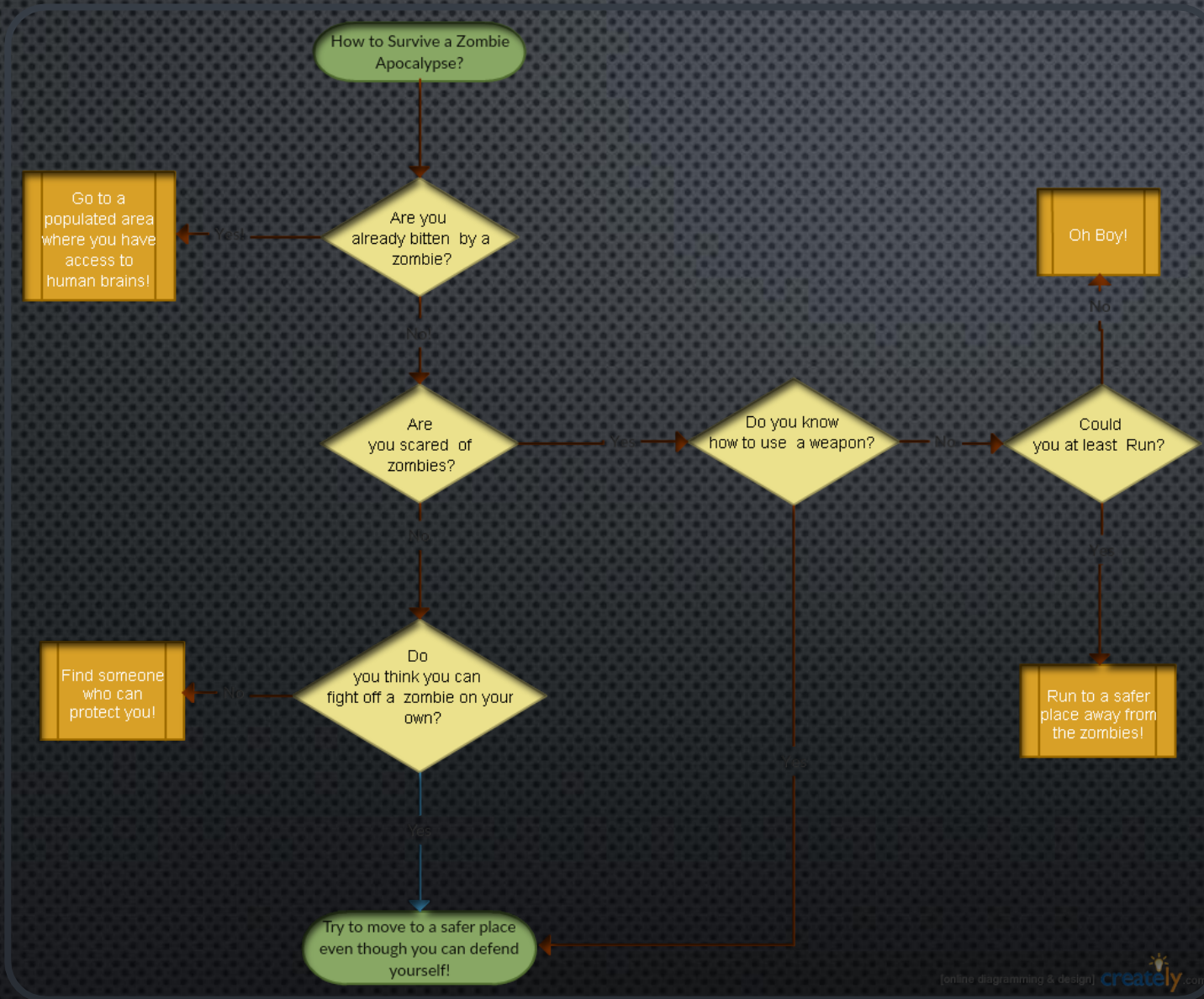
* Depreciated over an estimated 5-year usable life span.

\$6.9 M = COST TO INSTITUTION FOR POPC (REINTUBATION, PNEUMONIA, ETC)

\$600K = SUGAMMADEX ONLY APPROACH

\$162K = QUANTITATIVE MONITORING APPROACH

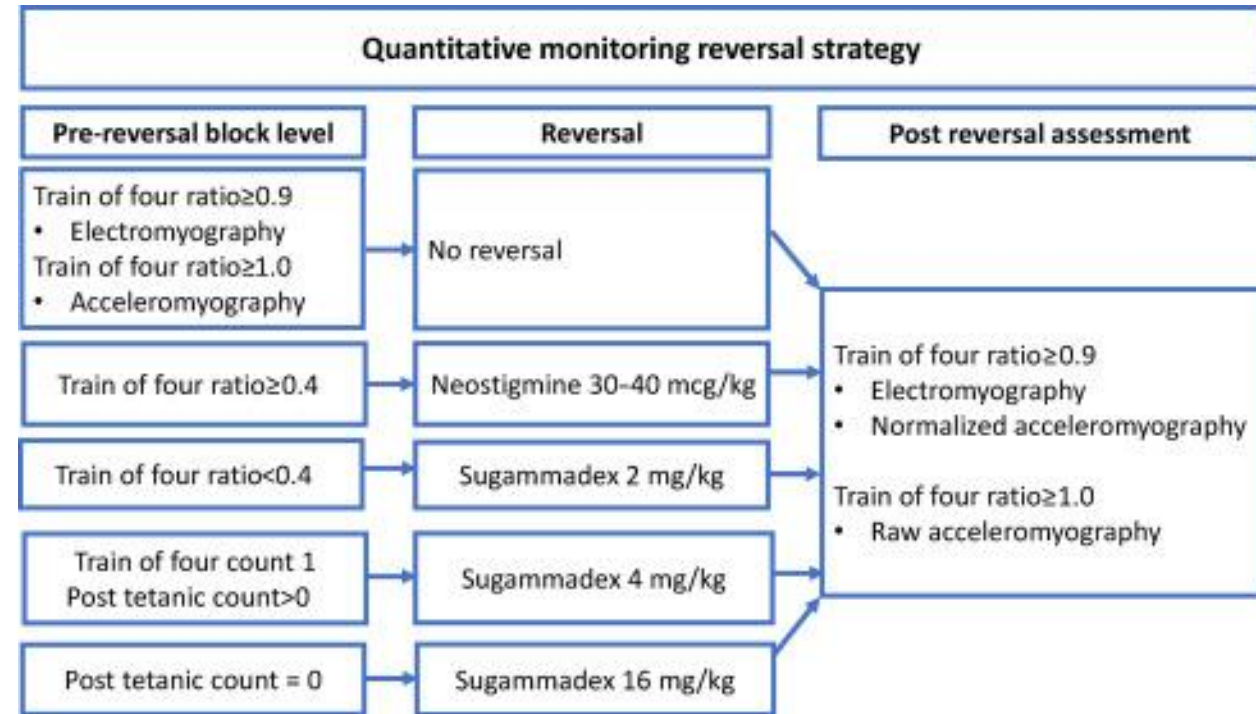
THEORETICALLY, ONLY 5 SERIOUS EVENTS WOULD HAVE TO BE PREVENTED TO COVER THE COST.



TAKING IT ONE
STEP FURTHER:
PROTOCOLIZING
CARE

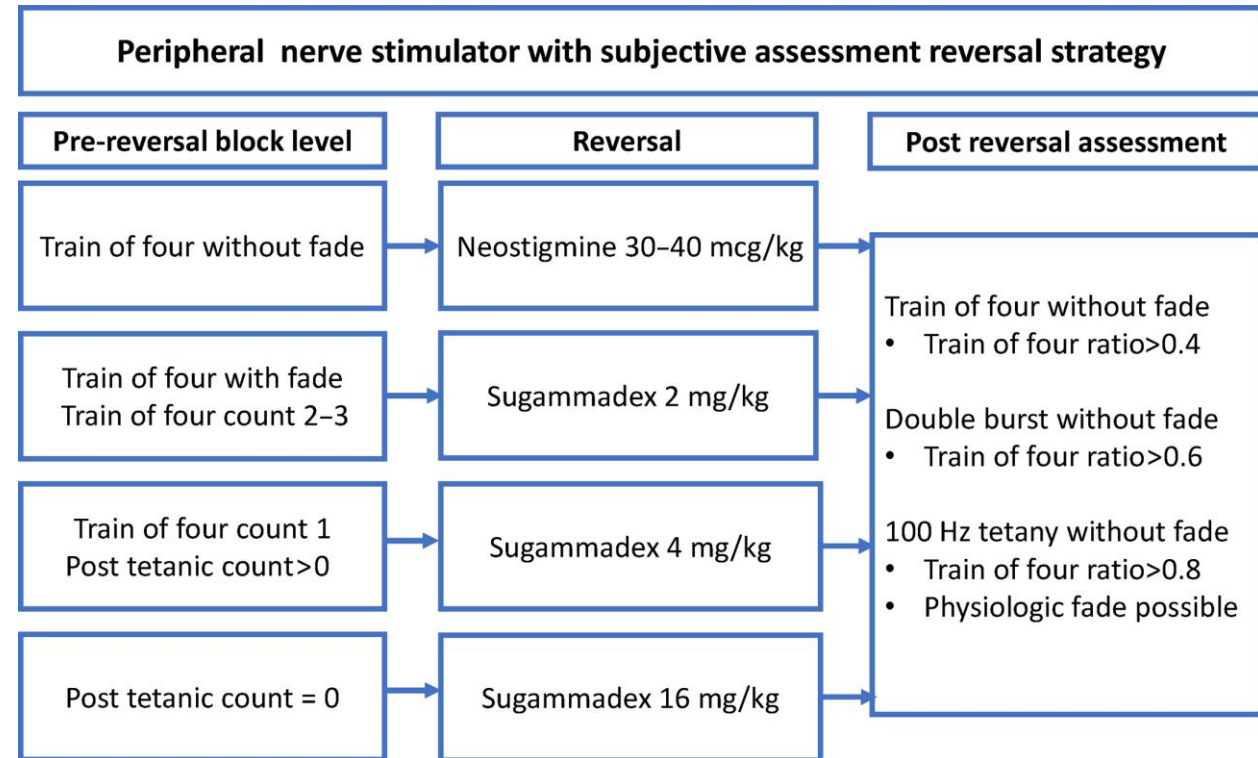
INSTITUTIONAL IMPLEMENTATION OF NMDR AND REVERSAL GUIDELINES - TOFR

• WADE A. WEIGEL, MD STEPHAN R. THILEN, MD, MS NEUROMUSCULAR BLOCKADE MONITORING AND REVERSAL: A CLINICAL AND PHARMACOECONOMIC UPDATE



INSTITUTIONAL IMPLEMENTATION OF NMDR AND REVERSAL GUIDELINES - PNS

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ANOTHER APPROACH TO SUSTAINABILITY

Projected 2021 Volume	46984.5
%Cases Rocuronium	38.70%
Projected case w/ Rocuronium 2021	18183
Cost per vial/ Rocuronium	\$156.00
Projected min cost Rocuronium 2021	\$2,836,548.23
%Cases Neostigmine	12.50%
Cost per neostigmine syringe (5ml)	\$11.00
Cost per glycopyrrolate	\$4.28
Min cost/case	\$15.28
Projected min cost Neo/glyco 2021	\$277,836.26
%cases using Sugamedex 2021	27.20%
Projected 2021 use	12921
Cost per vial	100.53
Projected Cost (min)	\$1,827,937.14
Cost of Twitchview Probe	\$20.00
Projected Annual Cost of disposables	\$363,660.03
Cost per case increase (cc74)	\$7.74
Projected annual cost of NMDR+Reversal	\$4,942,321.64
Amount of RX needed to reduce to be net even	7.36%

WE GOTTA WRAP THIS UP...



WHAT DO SMARTER PEOPLE THAN ME SAY?

- EUROPEAN SOCIETY OF ANAESTHESIOLOGY AND AMERICAN SOCIETY OF ANESTHESIA HAVE CONSPICUOUSLY BEEN QUIET ON THE SUBJECT, UNTIL RECENTLY
- BOTH SOCIETIES HAVE CONVENED EXPERT GROUPS TO DEVELOP CLINICAL PRACTICE GUIDELINES FOR THE USE OF NMDRS, REVERSAL AND MONITORING.
 - EXPECTATIONS WILL BE THAT QUANTITATIVE MONITORING WILL BE A HIGH RECOMMENDATION AND AT MINIMUM PNS WILL BE A STANDARD OF PRACTICE

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††

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RECOMMENDATIONS:

“QUANTITATIVE (OBJECTIVE) NMB MONITORING SHOULD BE USED WHENEVER A NONDEPOLARIZING NMBD IS ADMINISTERED”

“SUBJECTIVE OR CLINICAL TESTS OF NMB ARE NOT PREDICTIVE OF ADEQUATE NEUROMUSCULAR RECOVERY AND ARE NOT SENSITIVE TO THE PRESENCE OF RESIDUAL NEUROMUSCULAR WEAKNESS; THEIR USE SHOULD BE ABANDONED IN FAVOR OF OBJECTIVE MONITORING

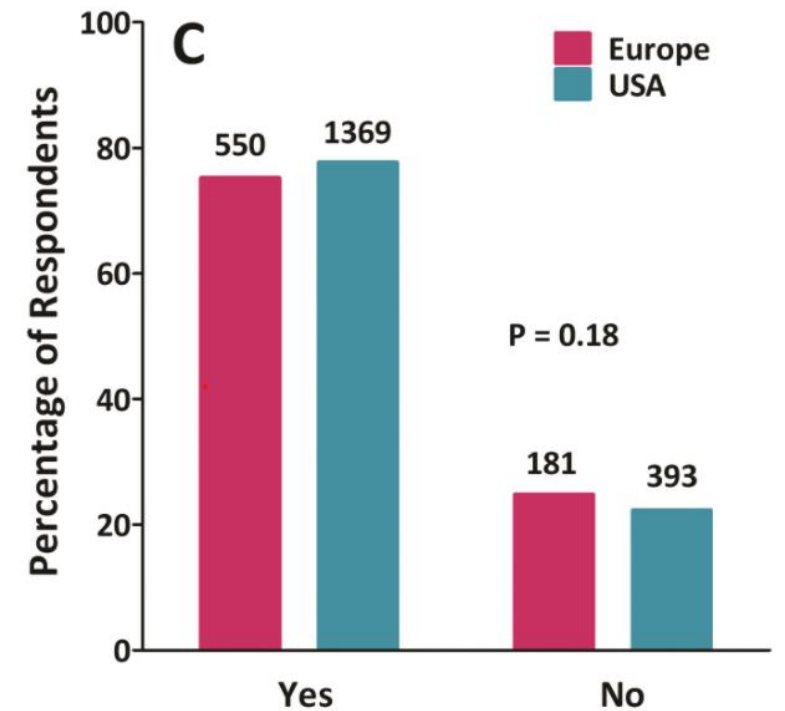
- >2600 RESPONDENTS IN EUROPE AND THE USA
- MOST BELIEVED THE INCIDENCE OF RNMDR = <1%
- HOWEVER, 19.3% OF EUROPEANS AND 9.4% OF AMERICANS NEVER USE NEUROMUSCULAR MONITORS.
- MOST RESPONDENTS REPORTED THAT NEITHER CONVENTIONAL NERVE STIMULATORS NOR QUANTITATIVE TRAIN-OF-FOUR MONITORS SHOULD BE PART OF MINIMUM MONITORING STANDARDS.
- 19.3% (EUROPE) AND 9.4% (US) IN THE US DO NOT USE TOF MONITORING IN THEIR PRACTICE

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

Naguib, Mohamed MD^{*}; Kopman, Aaron F. MD[†]; Lien, Cynthia A. MD[‡]; Hunter, Jennifer M. MB, PhD, FRCA[‡]; Lopez, Adriana MS[§]; Brull, Sorin J. MD^{||}

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Do you think that postoperative residual paralysis represents a significant public health problem?

THE EVIDENCE IS STRONG- WHAT'S HOLDING IT UP?

- OVERCOMING INGRAINED PRACTICE
 - MISCONCEPTIONS
 - COST CONSIDERATIONS

ANSWER: EDUCATE, STANDARDIZE AND PROTOCOLIZE

- **CLINICAL PRACTICE GUIDELINES TO STANDARDIZE TOF MONITORING:**
 - 2014 SWISS: **MANDATE**
 - 2015 GREAT BRITAIN AND IRELAND: **MANDATE**
 - 2016 NORWAY: ADVOCATE
 - 2016 FINLAND: ADVOCATE
 - 2016 CANADA: ADVOCATE
 - 2017 AUSTRALIAN AND NEW ZEALAND: ADVOCATE
 - 2017 CHILE: ADVOCATE
 - 2018 JAPAN: ADVOCATE
 - 2018 SOUTH AFRICA: **MANDATE**
 - 2019 DUTCH: **MANDATE**
 - OTHERS: SPAIN, ITALY, FRANCE, PORTUGAL, CZECH AND MORE

CONCLUSION

- OUR CURRENT APPROACH IS MISGUIDED AND ULTIMATELY WRONG
- MUCH OF WHAT WE LEARNED HAS SINCE BECOME “OLD NEWS”
- PREVALENCE OF rNMB IS HIGHER THAN ANYONE THINKS
- ITS EFFECT ON SEVERE POPC AND PT OUTCOMES IS UNKNOWN
- WE HAVE NEW AND OLD TECHNIQUES THAT HELP TO MITIGATE THESE CONCERNS
- EDUCATE, STANDARDIZE, PROTOCOLIZE
- THIS IS FAR MORE SUSTAINABLE THAN PREVIOUSLY THOUGHT

