

Monitoring Neuromuscular Blockade

Intraoperative teaching · CA-1

THE QUESTION

Where the evidence disagrees

This topic was selected because an evidence synthesis beats a textbook on it: the trials disagree, or the guidance has moved recently.

THE EVIDENCE

What each source contributes, and how strong it is

Study design first — a cohort and a randomised trial do not carry the same weight.

Design	Year	Journal	What it found
Other	2013	Eur J Anaesthesiol	Residual paralysis means a train-of-four ratio below 0.9, it is common rather
Other	2023	Anesthesiology	The 2023 American Society of Anesthesiologists practice guidelines for monitor
Other	2000	Br J Anaesth	Where you put the electrodes changes the answer you get
Other	2025	J Clin Monit Comput	Electrode placement is not a detail you can wave at
Other	2005	Anesth Analg	Direct muscle stimulation is the classic explanation for a twitch that lies, b
Other	2006	Br J Anaesth	Quantitative and qualitative monitoring are not two grades of the same measurement

9 resolved citations behind this deck; every point above traces to one of them.

IN PRACTICE

What the cohorts and reviews add

6 findings, each on the slide that follows.

EUR J ANAESTHESIOLOG 2013

Residual paralysis means a train-of-four ratio below 0.9, it is common rather

Residual paralysis means a train-of-four ratio below 0.9, it is common rather than rare — 26% of adults in a multicentre acceleromyographic study had...

ANESTHESIOLOGY 2023

The 2023 American Society of Anesthesiologists practice guidelines for monitor

The 2023 American Society of Anesthesiologists practice guidelines for monitoring and antagonism of neuromuscular blockade exist because monitoring...

BR J ANAESTH 2000

Where you put the electrodes changes the answer you get

Where you put the electrodes changes the answer you get: measured simultaneously in the same patients after mivacurium, the adducting laryngeal...

J CLIN MONIT COMPUT 2025

Electrode placement is not a detail you can wave at

Electrode placement is not a detail you can wave at: when an independent observer checked electromyographic electrode positions before and after a...

IN PRACTICE

Residual paralysis means a train-of-four ratio below 0.9, it is common rather

Other · Eur J Anaesthesiol

Residual paralysis means a train-of-four ratio below 0.9, it is common rather than rare — 26% of adults in a multicentre acceleromyographic study had a ratio below 0.9 on arrival in recovery, and incomplete recovery was more frequent among the patients who had been given a reversal agent — and you cannot see it, because patients who developed critical respiratory events in recovery averaged a train-of-four ratio of 0.62 against 0.98 in matched controls.

Esteves et al., Eur J Anaesthesiol 2013 · PMID 23344123

IN PRACTICE

The 2023 American Society of Anesthesiologists practice guidelines for monitor

Other · Anesthesiology

The 2023 American Society of Anesthesiologists practice guidelines for monitoring and antagonism of neuromuscular blockade exist because monitoring and reversal are the two levers that move this problem, and a single-centre study found that no patient who received both intraoperative neuromuscular monitoring and sugammadex had residual block, while the absence of monitoring and the use of neostigmine were identified risk factors for it.

Thilen et al., Anesthesiology 2023 · PMID 36520073

IN PRACTICE

Where you put the electrodes changes the answer you get

Other · Br J Anaesth

Where you put the electrodes changes the answer you get: measured simultaneously in the same patients after mivacurium, the adducting laryngeal muscles and the diaphragm were blocked and recovered fastest, while the adductor pollicis was the slowest of the five muscles studied and lagged the corrugator supercilii and orbicularis oculi by several minutes to 90% twitch recovery — so a reassuring twitch beside the eyebrow is reporting on a muscle that recovers early, not on the muscles that will hold her airway open.

Hemmerling et al., Br J Anaesth 2000 · PMID 11732519

IN PRACTICE

Electrode placement is not a detail you can wave at

Other · J Clin Monit Comput

Electrode placement is not a detail you can wave at: when an independent observer checked electromyographic electrode positions before and after a teaching intervention, ideal positioning over the ulnar nerve groove rose from 74.5% to 95% and ideal distal placement within 2 cm of the wrist crease rose from 61.8% to 96.7%, and correct placement tracked directly with whether clinicians believed the number the monitor gave them.

Ebert et al., J Clin Monit Comput 2025 · PMID 39433701

IN PRACTICE

Direct muscle stimulation is the classic explanation for a twitch that lies, b

Other · Anesth Analg

Direct muscle stimulation is the classic explanation for a twitch that lies, but it is easier to invoke than to demonstrate — when electrodes were deliberately placed over the hand between the first and second metacarpals instead of over the ulnar nerve at the wrist, the train-of-four ratios agreed with wrist stimulation (bias 0.5%) rather than exceeding them, so a suspicious twitch is a reason to go back and check where your electrodes are sitting rather than proof of anything by itself.

Nepveu et al., Anesth Analg 2005 · PMID 15616069

IN PRACTICE

Quantitative and qualitative monitoring are not two grades of the same measurement

Other · Br J Anaesth

Quantitative and qualitative monitoring are not two grades of the same measurement: a qualitative twitch monitor gives you no ratio at all, only twitches you count and fade you guess at, while even a quantitative acceleromyograph needs care, because baseline train-of-four ratios before any relaxant ranged from 0.95 to 1.47 in one series and a displayed 0.9 therefore does not always represent real recovery unless it is normalised to that patient's own starting value.

Suzuki et al., Br J Anaesth 2006 · PMID 16299046

IN THE ROOM

What this changes about the next case

Colour is the strength of the evidence behind each step, not the urgency.

1

Residual paralysis means a train-of-four ratio below 0.9, it is common rather than rare — 26% of adults in a multicentre acceleromyographic study had a ratio below 0.9 on arrival in recovery, and incomplete recovery was more frequent among the patients who had been given a reversal agent — and you cannot see it, because patients who developed critical respiratory events in recovery averaged a train-of-four ratio of 0.62 against 0.98 in matched controls.

2

The 2023 American Society of Anesthesiologists practice guidelines for monitoring and antagonism of neuromuscular blockade exist because monitoring and reversal are the two levers that move this problem, and a single-centre study found that no patient who received both intraoperative neuromuscular monitoring and sugammadex had residual block, while the absence of monitoring and the use of neostigmine were identified risk factors for it.

3

Where you put the electrodes changes the answer you get: measured simultaneously in the same patients after mivacurium, the adducting laryngeal muscles and the diaphragm were blocked and recovered fastest, while the adductor pollicis was the slowest of the five muscles studied and lagged the corrugator supercilii and orbicularis oculi by several minutes to 90% twitch recovery — so a reassuring twitch beside the eyebrow is reporting on a muscle that recovers early, not on the muscles that will hold her airway open.

4

Electrode placement is not a detail you can wave at: when an independent observer checked electromyographic electrode positions before and after a teaching intervention, ideal positioning over the ulnar nerve groove rose from 74.5% to 95% and ideal distal placement within 2 cm of the wrist crease rose from 61.8% to 96.7%, and correct placement tracked directly with whether clinicians believed the number the monitor gave them.

5

Direct muscle stimulation is the classic explanation for a twitch that lies, but it is easier to invoke than to demonstrate — when electrodes were deliberately placed over the hand between the first and second metacarpals instead of over the ulnar nerve at the wrist, the train-of-four ratios agreed with wrist stimulation (bias 0.5%) rather than exceeding them, so a suspicious twitch is a reason to go back and check where your electrodes are sitting rather than proof of anything by itself.

KEY TAKEAWAYS

What to carry into the next case

Residual paralysis means a train-of-four ratio below 0.9, it is common rather

Eur J Anaesthesiol 2013

The 2023 American Society of Anesthesiologists practice guidelines for monitor

Anesthesiology 2023

Where you put the electrodes changes the answer you get

Br J Anaesth 2000

Electrode placement is not a detail you can wave at

J Clin Monit Comput 2025

A train-of-four ratio below 0.9 is residual paralysis even when the patient looks strong, and only a quantitative monitor at the adductor pollicis can tell you where you are.

QUESTIONS I'LL ASK YOU IN THE ROOM

1. Show me your electrodes. Which nerve are you stimulating, and how do you know it is that nerve and not the muscle underneath?
2. Four twitches with no visible fade — what range of train-of-four ratios is that compatible with?
3. You are reading the eyebrow. Which muscle recovers first, the eyebrow or the hand, and which one guards her airway?
4. What is the actual number you need before extubation, and is your monitor capable of producing it?

ORAL BOARDS STEM

A 74-year-old is finishing a laparoscopic cholecystectomy. She has had two doses of rocuronium, the last one about 35 minutes ago. The surgeon is closing, the patient is grimacing and taking shallow breaths, and the nerve stimulator — with its electrodes on the forehead, beside the eyebrow — shows four strong twitches with no fade that you can see. The examiner asks whether this patient is reversed, where you would rather the electrodes had been, and what number, measured how, you actually need before that tube comes out.

A train-of-four ratio below 0.9 is residual paralysis even when the patient looks strong, and only a quantitative monitor at the adductor pollicis can tell you where you are.

SOURCES

- [1] Esteves et al., Eur J Anaesthesiol 2013 · PMID 23344123
- [2] Murphy et al., Anesth Analg 2008 · PMID 18635478
- [3] Raval et al., J Clin Anesth 2020 · PMID 32585565
- [4] Thilen et al., Anesthesiology 2023 · PMID 36520073
- [5] Özbey et al., Turk J Med Sci 2022 · PMID 36422506
- [6] Hemmerling et al., Br J Anaesth 2000 · PMID 11732519
- [7] Ebert et al., J Clin Monit Comput 2025 · PMID 39433701
- [8] Nepveu et al., Anesth Analg 2005 · PMID 15616069

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