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Corresponding author: Alexander Butcher

The provision and practice of neuromuscular monitoring in the East of England

A. Butcher,[1] L. Allen,[2] B. Chisnall,[3] O. Gillman,[4] C Reavley[5] and the EASTRN research group [6]

[1]Department of Anaesthesia, Whipps Cross Hospital, London, UK

[2]Department of Anaesthesia, Cambridge University Hospitals, Cambridge, UK

[3] Department of Anaesthesia, Royal Papworth Hospital, Cambridge, UK

[4] Department of Anaesthesia, University College Hospitals London, London, UK

[5]Department of Anaesthesia, Norfolk and Norwich University Hospital, Norwich, UK

[6]East of England Anaesthetic Trainee Research Network

Correspondence to: Dr Alexander Butcher (alexander.butcher2@nhs.net)

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Summary

Despite quaNtitative neuromuscular monitoring being recommended nationally and internationally whenever neuromuscular blocking drugs are given, practice may be inconsistent. We conducted a prospective observational evaluation of neuromuscular monitoring involving 13 sites in the East of England. QuaLitative monitors were available at 12 of the 13 locations while only nine of the 13 locations had access to quaNtitative monitors. Across all sites there were a total of 220 theatres with 165 quaLitative monitors and 84 quaNtitative monitors. Theatre cases involving neuromuscular blockade were audited. Neuromuscular monitoring was used in 196 out of 335 cases (59%). When neuromuscular monitoring was performed, quaNtitative monitoring was used in 58 out of 196 operations (30%). A staff survey investigating opinions and attitudes towards neuromuscular monitoring was completed by 272 anaesthetists. Responses highlighted availability and a belief that quaNtitative monitoring is not necessary as barriers to increasing usage of quaNtitative monitors. Our study showed that neuromuscular monitoring practice falls short of recommended standards. Issues of monitoring availability and some anaesthetists' attitudes and opinions contribute to this deficit.

Introduction:

The potential consequences of inadequate neuromuscular reversal following general anaesthesia are well documented and include respiratory complications and decreased patient satisfaction (1). There is now consensus amongst international recommendations that quaNtitative neuromuscular monitoring should be used in all anaesthetics involving neuromuscular blockade (2,3). The Seventh National Audit Project (NAP 7) of the Royal College of Anaesthetists found that where neuromuscular blockade was monitored, quaNtitative assessment was used in only 24% of cases (4). The extent to which provision gaps and clinician attitudes influence the adoption of neuromuscular monitoring is not well understood. We designed a region-wide evaluation of the availability, use and attitudes surrounding neuromuscular monitoring within the East of England.

Methods:

This study was a regional, multi-centre, prospective observational evaluation coordinated by the regional trainee network (East of England Anaesthetics Trainee Research Network (EASTRN)). Ethical approval was not required according to Health Research Authority guidelines following discussion with the East of England research ethics committee department. The evaluation consisted of three components.

1. *Site evaluation survey*

To investigate the availability of quaLitative and quaNtitative monitors, registered site leads (anaesthetic trainees affiliated to EASTRN) determined the number of operating theatres at each site where general anaesthesia with neuromuscular blockade could be delivered. These were then grouped based on the feasibility of sharing neuromuscular monitoring devices between them. The number of neuromuscular monitors was gathered for each theatre area.

2. *Audit of practice*

An audit of practice was conducted to determine the utilisation of neuromuscular monitoring. The adequacy of documentation for monitor use was characterised as either fully, partially or not documented. Use of reversal agents was also captured. Inclusion criteria specified adult patients undergoing general anaesthesia with neuromuscular blockade completed between 8am and 8pm within a five day data collection window. Data were collected in real time whilst the case was in progress or shortly after with no submission of any patient identifiable information.

3. *Anaesthetist survey*

The final component of the evaluation consisted of a survey disseminated to anaesthetic departments following the audit data collection window. Inclusion was voluntary, no incentives were given for completion and consent was gained on the introductory page. Branching logic was used to personalise the question set depending on whether respondents answered if they did or did not have access to quaNtitative monitors. This survey was used to evaluate the opinions of anaesthetists regarding neuromuscular monitoring including which factors they saw as enabling or preventing its increased utilisation.

Online survey forms were used to collect all responses (Google Forms (Google, Mountain View, CA)).

Data were analysed using Microsoft Excel (Microsoft® Excel® for Microsoft 365 MSO (Version 2504)). Results are reported using descriptive statistics.

Results:

A total of 13 sites were recruited to contribute to the project from the 17 that employ anaesthetists in training in the region.

1. *Site survey*

In all, eight of the 13 sites had both quaLitative and quaNtitative monitors available. QuaNtitative monitors were the only type of monitor available at one site and quaLitative monitors were the only monitor type available at four sites. Of the nine sites with quaNtitative monitors, all had access to acceleromyography, two had electromyography and one had kinemography. Across all 13 sites there were a total of 220 theatres with 165 quaLitative monitors and 84 quaNtitative monitors. Ratios of monitors per theatre were calculated for theatre areas within each site. For theatre areas with quaLitative monitors available, the mean ratio of monitors per theatre was 0.878 (SD 0.30) whilst for theatre areas with quaNtitative monitors available the mean ratio of monitors per theatre was 0.492 (SD 0.35).

A local champion for neuromuscular blockade was present at three of the sites. Electronic anaesthetic records were used at four sites but none were able to have neuromuscular monitoring results automatically feed into this record. A dedicated space for the recording of information relating to the use of neuromuscular monitoring was present in the anaesthetic records of five sites.

2. *Audit of practice*

A total of 335 cases were audited (range of cases per location 10-51). Basic surgical and patient details are shown in table 1. Most cases (331/335 (99%)) used only one neuromuscular blocking drug with rocuronium being the most common to be given first (278/335 (83%)). Most patients received pharmacological neuromuscular blockade reversal (298/335 (89%)) with sugammadex being the preferred drug (236/298 (79%)). No reversal agent and no neuromuscular monitoring were used in 27 cases.

Neuromuscular monitoring was used in 196 cases (59%) with quaNtitative monitoring being used in 58 of these cases (30%). Acceleromyography was the most used quaNtitative modality (56/58 cases). Documentation of neuromuscular monitoring was fully completed in 20/58 cases where a quaNtitative monitor was used and in 54/138 (39%) where a quaLitative monitor was used. In the 139 cases where neuromuscular monitoring was not used, clinical tests of reversal were reportedly used in 110 operations (79%). In 70/139 cases (50%) more than one clinical test of reversal was reported to have been used. The most popular reported clinical measures of reversal were adequate tidal volume (72/139 (52%)) and sustained head lift (69/139 (50%)).

3. *Anaesthetist survey*

We received 272 responses to the staff survey (mean site response rate of 26%) with the majority of responses (150/272 (55%)) by anaesthetic consultants.

Access to quaNtitative neuromuscular monitoring was reported by 155/272 participants (57%). Of those that did have access to quaNtitative monitoring, 83/155 (54%) reported that it was their preferred method. However, only 23/155 (15%) reported always using quaNtitative monitoring when giving neuromuscular blockade and only 42/155 (27%) self-reported as being very confident in its use. Anaesthetists with access to quaNtitative monitoring were also asked what they felt would increase its use with availability being the most commonly highlighted factor (82/155 (53%)). Free text responses were collected to determine any other barriers anaesthetists saw to wider, more regular adoption of quaNtitative neuromuscular monitoring. These responses were grouped into themes with the most common theme (18 responses) relating to a belief that quaNtitative monitors were not necessary.

In those that did not have access to quaNtitative monitoring, 88/117 (75%) would like to see quaNtitative monitoring introduced to their department stating greater intra-operative control of neuromuscular blockade, reduced post-operative residual neuromuscular blockade, and adherence to national guidance in their reasoning. Of the 29/117 (25%) who did not want to see quaNtitative monitoring introduced to their department, the most reported reason was that they felt it was not necessary (23/29).

Respondents indicated when they had last received teaching or undertaken self-education about neuromuscular monitoring which for 112 respondents (41%) was greater than two years ago. When considering their own practice of neuromuscular monitoring, 58 (21%) reported that they never document the use and results of neuromuscular

monitoring and 65 (24%) were less likely to use neuromuscular monitoring if using sugammadex. It was correctly answered by 201 respondents (74%) that quaNtitative monitoring is the current national and international recommendation for neuromuscular monitoring.

To determine anaesthetists' opinion on themes relating to neuromuscular monitoring, respondents answered to what extent they agreed with four statements (table 2). One hundred and ten anaesthetists (40%) either agreed or strongly agreed that quaNtitative monitoring should be used for all patients where neuromuscular blockade is used.

Discussion:

The incidence of residual paralysis when a neuromuscular blocking drug is given is high (up to 33%) (5). This is associated with adverse postoperative outcomes (6) and can be reduced by using quaNtitative neuromuscular monitoring (7). Despite this, we have demonstrated that routine use of quaNtitative monitors is not yet practiced in the East of England with contributing factors including monitor availability and anaesthetists' beliefs and training.

A number of sites surveyed did not have access to quaNtitative monitors and in those that did there was greater availability of quaLitative compared to quaNtitative monitors. This contrasts with a recent European survey which found quaNtitative monitors to be proportionally more available (8). The survey of anaesthetists we conducted demonstrated that there was an appetite in those without access to quaNtitative monitors to see them introduced. Additionally, many of those with access expressed support that an increase in monitor availability would increase their utilisation.

Lack of monitoring availability however cannot fully explain why neuromuscular monitoring was not used at all in 41% of cases audited. Despite most survey respondents correctly answering that quaNtitative monitoring is the current national and international recommendation, and 82% either agreeing or strongly agreeing that residual neuromuscular blockade is an important clinical problem, only 40% either agreed or strongly agreed that quaNtitative monitoring should be used for all patients where neuromuscular blockade is used. This suggests a belief amongst some anaesthetists that quaNtitative monitoring is not always required. This finding is further reinforced by the fact that only 15% of those with access to quaNtitative neuromuscular monitoring report always using it when giving neuromuscular blockade. The most cited reason for those without access to quaNtitative neuromuscular monitors to be against their introduction was the belief that they were not necessary and the belief that quaNtitative monitors are not necessary was the most common theme when anaesthetists were asked to identify barriers to wider more regular adoption. Where no neuromuscular monitoring was used there was a heavy reliance on clinical tests of reversal and support for clinical tests being adequate signs of reversal was also seen in many responses to the anaesthetist survey. Clinical tests of reversal such as an assessment of tidal volume or sustained head lift have been shown to be unreliable and are not recommended (6,9). It has previously been demonstrated that anaesthetists are often overconfident in their knowledge and ability to manage the use of neuromuscular blocking drugs (10) which our findings would support.

There are a number of steps that could be taken to improve practice in our region beyond increasing availability of monitoring. Only 27% of those with access to quaNtitative monitors reported being very confident in their use and relevant training for many is infrequent with 41% of anaesthetists reporting that they had received teaching or undertaken self-education about neuromuscular monitoring greater than two years ago. It is likely that concerted and repeated educational programmes would be required to bring about significant changes in anaesthetist behaviour (11,12). At the time of the site survey only 3 sites had a local neuromuscular blockade champion in their department. Expanding the prevalence of those championing improved neuromuscular blockade practice as has been previously suggested (9,13) and using them to lead repeated programs to raise awareness may help bridge the

cultural divide in this area. Finally, our site survey found that less than half of the anaesthetic records in the region have a dedicated space for the documentation of neuromuscular monitoring and that for those with electronic records none automatically record the results of neuromuscular monitoring. This may be a contributing factor to the poor level of overall neuromuscular documentation completion found in this study. National guidance suggests that adequacy of recovery (train of four ratio > 0.9) should be demonstrated and documented before emergence and extubation (2). Electronic charts using integrated systems to improve the ease of documentation and prompt the use of quaNtitative monitoring may be beneficial.

This study had a number of limitations which may affect interpretation of our findings. Investigators could not be present at all times when neuromuscular monitoring might be used meaning some data collection relied on discussions with anaesthetic teams to determine monitoring use and outcomes introducing a potential for recall bias. Our relatively low survey response rate means there is a greater chance for our results to be skewed by those with particular strong feelings for or against quaNtitative monitoring.

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Table 1. Surgical details of audited cases involving neuromuscular blockade. Results are presented as number or mean (SD).

	Mean (SD)
Patient age (years, n=330*)	58.4 (19)
	Mean (SD)
Duration of surgery (minutes, n=333†)	135 (87)
ASA grade	**n**
1	23
2	156
3	135
4	21
Grade of surgery	**n**
Major or complex	176
Intermediate	132
Minor	27
Mode of anaesthesia	**n**
Inhalational agent	160
TIVA	175
Grade of anaesthetist‡	**n**
Consultant	230
SAS	41
ST4-8	26
CT1-4	19
Non-training grade	11
CESR fellow	5
Anaesthesia associate	3
Specialty of operation	**n**
Breast	7
Dental	2
ENT	16
General	111
Gynaecology	46
Hepatobiliary	3
Maxillo-facial	4
Neurosurgery	25
Obstetrics	3
Ophthalmic	1
Orthopaedics	36
Other	9
Plastics/burns	3
Radiology	1
Thoracic	5
Trauma	16
Urology	34
Vascular	13

*Five patients did not have their ages recorded. †Two patients did not have the duration of their surgery recorded. ‡Grade of anaesthetist primarily responsible for decisions around neuromuscular blockade, monitoring and reversal.

Table 2. Degree to which participants agreed or disagreed with statements relating to neuromuscular blockade and monitoring. Results are presented as number (proportion, %).

Statement	Strongly disagree n(%)	Disagree n(%)	Neutral n(%)	Agree n(%)	Strongly agree n(%)
Residual neuromuscular blockade is an important clinical problem	10(4)	16(6)	23(8)	110(40)	113(42)
Clinical tests are adequate to exclude the presence of postoperative residual neuromuscular blockade	50(18)	97(36)	61(22)	58(21)	6(2)
Neuromuscular monitors should be used in all cases where neuromuscular blockers are used	11(4)	38(14)	46(17)	98(36)	79(29)
QuaNtitative neuromuscular monitoring should be used for all patients where neuromuscular blockade is used	27(10)	56(21)	79(29)	76(28)	34(13)

Appendix 1

List of EASTRN collaborators:

Site leads: Ahmed Soliman, Alfie Wright, Amit Kurani, Angus McDonnell, Ben Chisnall, Chenxian Wu, Chiamaka Oladipo, Clare Mashford, Dominic O-Neill, Fabiha Parveen, Islam Hamed, Kate McGibbon, Katherine Meadows, Marwan Nassar, Neha Sadik, Piriyanga Kesavan, Sara Hui, Thomas Payne

Collaborators: Aakanksha Aggarwal, Ankit Mishra, Anna Turmeau, Anwuli Odili, Bazlah Sultan, Esther Eweni, Fabian Uys, Harrison Plumpton, Helen Burgess, Himashi Niwamani, Islam Hamed, Jayani Meepegamage, Lahiru Deiyagala, Manisha Jalal, Michael Haycock, Nilofer Shaik, Nneka Azuike, Samir Petker, Sophie Winter, Sunil Gupta, Swati Narnaware, Tim Nye

Appendix 2

Site survey

Trust/hospital

Please confirm the hospital/trust that this survey is being completed for:

Anaesthetic records, personnel and neuromuscular governance.

Does a departmental guideline for neuromuscular monitoring exist for your Trust?

Does your department have a local/departmental champion for neuromuscular blockade?

Is the anaesthetic chart used in your theatres electronic or paper?

Does your anaesthetic chart (paper or electronic) have a dedicated space for the recording of information relating to the use of neuromuscular monitoring?

If your anaesthetic chart is electronic, do the results of neuromuscular monitoring automatically feed in to the anaesthetic record?

What is the availability of sugammadex within your trust?

What is the total number of anaesthetic personnel within your department?

Theatre and equipment breakdown

How many locations would you like to include in this survey?

What would you like to use as a descriptor for this location? e.g main theatres, day surgery, maternity

How many theatres where neuromuscular blocking drugs may be given are in this location?

How many qualitative nerve stimulators are available at this location?

What types of quaNtitative neuromuscular monitors are available at this location? If the neuromuscular monitors at this location can perform more than one type of monitoring then please tick all boxes that apply

How many quaNtitative neuromuscular monitors are available at this location?

Do you have any further locations you would like to add?

Appendix 3

Anaesthetist survey

Demographics

Which hospital/trust are you currently based at?

What is your professional background?

Neuromuscular monitoring practice

In what proportion of cases do you use qualitative neuromuscular monitoring (i.e peripheral nerve stimulator with visual or tactile assessment of response) when neuromuscular blockers are used?

How often do you document use of neuromuscular monitoring and monitoring results?

When did you last receive teaching or undergo self-education about neuromuscular monitoring?

If using sugammadex for reversal, how does this influence your decision to use neuromuscular monitoring?

Do you have access to quaNtitative neuromuscular monitoring (e.g acceleromyography, electromyography) in your primary place of work?

Quantitative neuromuscular monitoring (available)

What is your preferred method of neuromuscular monitoring?

In what proportion of cases do you use quaNtitative neuromuscular monitoring (e.g acceleromyography, electromyography) when neuromuscular blockers are used?

At which points during anaesthesia do you utilise quaNtitative neuromuscular monitoring? Please tick all that apply.

How confident are you in the use of quaNtitative neuromuscular monitors (e.g acceleromyography, electromyography)?

What would increase your use of quaNtitative neuromuscular monitors? Please choose all that are applicable.

Are there any other barriers that you see to wider, more regular adoption of quaNtitative neuromuscular monitoring?

Quantitative neuromuscular monitoring (not available)

How confident are you in the use of quaNtitative neuromuscular monitors (e.g acceleromyography, electromyography)?

Would you like to see quaNtitative neuromuscular monitors introduced to your department?

Quantitative neuromuscular monitoring - would like to see monitor introduction.

You have answered that you would like to see quaNtitative neuromuscular monitors introduced to your department. Please tick any of the reasons below for why this might be or provide your own reason as 'other'.

Quantitative neuromuscular monitoring - would not like to see monitor introduction.

You have answered that you would not like to see quaNtitative neuromuscular monitors introduced to your department. Please tick any of the reasons below for why this might be or provide your own reason as 'other'.

Neuromuscular monitoring opinions

Residual neuromuscular blockade is an important clinical problem.

Clinical tests are adequate to exclude the presence of postoperative residual neuromuscular blockade.

Neuromuscular monitors should be used in all cases where neuromuscular blockers are used.

QUANTITATIVE neuromuscular monitoring (e.g acceleromyography, electromyography) should be used for all patients where neuromuscular blockade is used.

What is the current national and international recommendation for monitoring?