

## ORIGINAL RESEARCH ARTICLE

# Neuromuscular monitoring during general anaesthesia: a review of current national and international guidelines

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## Abstract

**Background:** The extent to which neuromuscular monitoring is included in professional anaesthesia society guidelines is unclear. Our aim was to comprehensively review neuromuscular monitoring guidelines published by these societies.

**Methods:** National societies were identified using the World Federation of Societies of Anaesthesiologists' member list and further manual searches were undertaken to identify multinational societies and specialist medical colleges. A web search and secondary literature search were conducted to locate guidelines for monitoring during anaesthesia. The income of each nation or group of nations was determined using the World Bank classification.

**Results:** Forty guidelines were identified. Of 38 nations or classifiable groups of nations, 25 (66%) were high-income nations and 13 (34%) were middle-income nations. Neuromuscular monitoring was mentioned in 36 (90%) of the 40 guidelines. Availability of neuromuscular monitoring was mentioned in 17 (47%) guidelines (mandated in eight [47%] and recommended in nine [53%]). Use of neuromuscular monitoring was mentioned in 26 (72%) guidelines (mandated in three [12%] and recommended in 23 [88%]). Quantitative neuromuscular monitoring was specified in nine (25%) of the guidelines, with the type of monitoring unspecified in the remaining 27 (75%) of the 36 guidelines. Quantitative monitoring was only mandated in one guideline, and this was only when monitoring equipment was available.

**Conclusions:** We identified a gap in the availability of professional anaesthesia society neuromuscular monitoring guidelines, particularly in middle- and low-income nations. Recommendations about availability, use and type of monitoring varied among guidelines. An effort to improve the availability and consistency of guidelines is required.

**Keywords:** guidelines; neuromuscular monitoring; residual neuromuscular block

Despite increasing availability of shorter acting neuromuscular blocking drugs, effective reversal agents, and neuromuscular monitoring, residual neuromuscular block is common<sup>1</sup> and may lead to complications, poor patient experience, and increased cost.<sup>2</sup> Evidence supports the effectiveness of quantitative neuromuscular monitoring<sup>3</sup> and experts consistently recommend quantitative neuromuscular monitoring for all patients receiving neuromuscular blocking drugs.<sup>4–6</sup> Despite these recommendations, neuromuscular monitoring is inconsistently applied, with surveys from the USA,<sup>7</sup> Europe,<sup>7,8</sup> China,<sup>9</sup> Australia, and New Zealand<sup>10</sup> revealing inconsistent availability and use of monitors in practice.

Guidelines published by national and multinational professional societies are powerful tools for promoting safe practice.<sup>6</sup> They provide standards against which individuals and health services are assessed and are critical to raising standards in middle- and low-income nations. For example, the World Federation of Societies of Anaesthesiologists (WFSA) published a monitoring guideline,<sup>11</sup> which was endorsed by all its member societies and which underpins its Lifebox campaign to bring pulse oximetry to all patients having anaesthesia.<sup>12</sup> National guidelines for neuromuscular monitoring could result in similar improvements in patient safety.

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A recent narrative review sampled published monitoring guidelines and highlighted the inadequacies and inconsistencies of their recommendations.<sup>13</sup> However, a comprehensive analysis of global monitoring guidelines is not available. Our aim therefore was to identify all monitoring guidelines published by national and multinational professional anaesthesia societies and to assess them for their requirements for availability, use, or both of neuromuscular monitoring and the type of monitoring recommended.

## Methods

### Definitions

We used the definitions offered by an expert panel in a recent guideline.<sup>6</sup> Subjective (or qualitative) neuromuscular monitoring involves observing clinical signs such as the 5-s head lift or handgrip strength or stimulating a peripheral nerve and observing the muscular response by visual or tactile means. Objective (or quantitative) neuromuscular monitoring involves stimulating a peripheral nerve and measuring the response using acceleromyography or another technology.<sup>6</sup> Subjective (qualitative) neuromuscular monitoring cannot reliably assess train-of-four ratios  $>0.4$ , so objective (quantitative) neuromuscular monitoring is highly recommended.<sup>14</sup>

### Eligibility criteria

We defined a guideline as any document or webpage titled as a guideline, manual, policy, recommendation, requirement, standard, or statement. Guidelines for monitoring during anaesthesia in general, or neuromuscular block alone, were included. Only guidelines intended for medically trained anaesthesia providers were included. Guidelines intended for other medical practitioners (e.g. emergency medicine physicians) and non-medically trained anaesthesia providers (e.g. nurse anaesthetists) were not included. Professional anaesthesia societies were defined as associations, boards, colleges,

faculties, federations, and societies established to train, represent, or both, anaesthesiologists. National and multinational professional societies were included. There were no language exclusions.

### Data collection

The WFSA list of member societies was used as a starting point for this study.<sup>15</sup> We also searched for multinational professional societies and specialist medical colleges. Medline and EMBASE were also systematically searched using relevant keywords for national or multinational monitoring guidelines. A manual search of each society's website was conducted. Online translation tools (e.g. DeepL Translator [[www.deepl.com](http://www.deepl.com)] and DocTranslator [[www.onlinedoctranslator.com](http://www.onlinedoctranslator.com)]) were used to navigate non-English websites and translate non-English documents.

For each society, the following data were collected:

1. Availability of a monitoring guideline.
2. Inclusion of neuromuscular monitoring in the guideline.
3. Monitoring equipment availability (mandatory or recommended).
4. Monitoring equipment use (mandatory or recommended).
5. Type of monitoring (subjective [qualitative] or objective [quantitative] or not specified).
6. World Bank classification by income (high, upper-middle, lower-middle, low) for national societies and assessable multinational societies.<sup>16</sup>

### Data analysis

Data are presented as number (%). No statistical tests were planned or undertaken.

## Results

We identified 153 professional societies: 136 WFSA member societies, eight multinational societies (including the WFSA

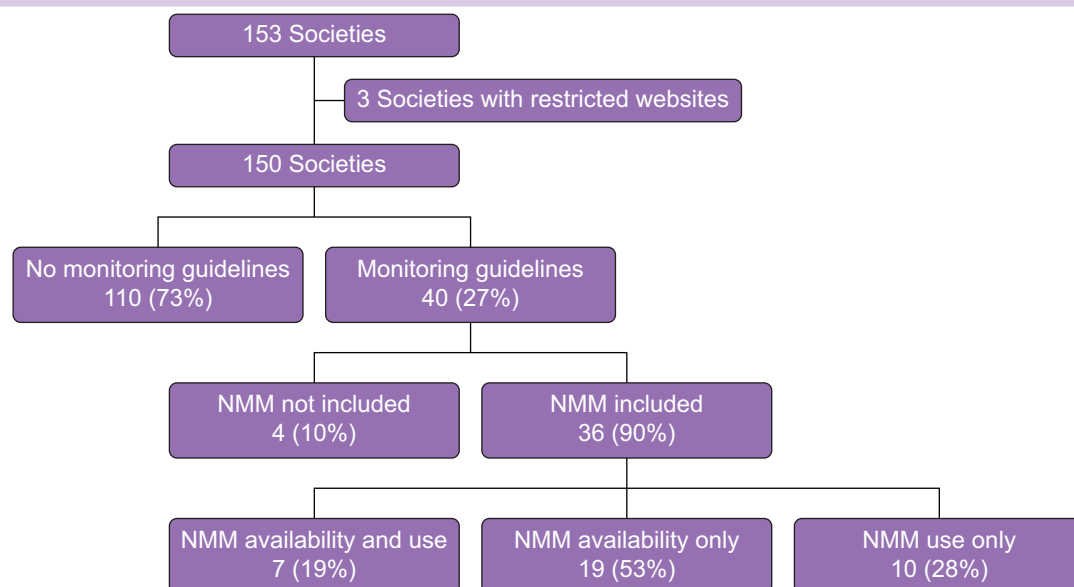


Fig. 1. Flowchart for monitoring guidelines and neuromuscular monitoring (NMM).

itself), and nine specialist medical colleges (Supplementary Table S1). Data from 150 societies were analysed (Fig 1). Three member societies were excluded as their websites were only accessible by members.

Forty professional societies (26%) published monitoring guidelines. The professional societies were in Africa (n=2), Asia (n=9), Europe (n=18), global (n=1), Middle East (n=2), North America (n=2), Oceania (n=1), and South America (n=5). Thirty-three (82.5%) were WFSA member societies, two (5%) were groups of member societies, four (10%) were specialist medical colleges, and one (2.5%) was a collaboration between a member society and a specialist medical college. Of 38 nations or assessable groups of nations with World Bank classifications, 66% were high-income nations and 34% were middle-income nations.

Neuromuscular monitoring was mentioned in 36 (90%) of the 40 guidelines. Availability of neuromuscular monitoring was mentioned in 17 (47%) guidelines (mandated in eight [47%] and recommended in nine [53%]). Use of neuromuscular monitoring was mentioned in 26 (72%) guidelines (mandated in three [12%] and recommended in 23 [88%]). Seven (19%) guidelines mentioned both availability and use, 19 (53%) mentioned availability only, and 10 (28%) mentioned use only. Quantitative neuromuscular monitoring was specified in nine (25%) of the guidelines and unspecified in the remaining 27 (75%) guidelines. Use of quantitative monitoring was mandated in only one guideline, and this was only for situations where the necessary equipment was available. Universal availability was not mandated.

## Discussion

We identified a gap in the availability of professional anaesthesia society neuromuscular monitoring guidelines, in high-, middle-, and low-income nations. Recommendations about availability, use, and type of monitoring varied widely, with only three guidelines mandating use and only one mandating quantitative neuromuscular monitoring. An effort to improve the availability and consistency of guidelines is required.

The gap in the availability of neuromuscular monitoring guidelines between professional societies in higher- and lower-income nations is not unexpected and could be attributed to the financial and human resource costs of developing and publishing of guidelines, a recognition that local hospitals may be unable to provide and maintain the necessary equipment, or both.<sup>17,18</sup> To overcome this gap, the World Health Organisation (WHO) and WFSA published standards for safe anaesthesia, including recommendations for neuromuscular monitoring.<sup>11</sup> It was not clear from our review how many professional societies without their own guidelines have adopted the WHO/WFSA guideline, but this would be an excellent temporary or permanent solution. Overcoming lack of suitable equipment is a greater challenge. The WFSA has successfully implemented pulse oximetry in middle- and lower-income nations through its Lifebox campaign.<sup>12</sup> A similar campaign focusing on neuromuscular monitoring is possible, as the equipment is relatively inexpensive and simple to use, and is likely to prevent costly postoperative complications associated with residual neuromuscular block.<sup>18</sup>

Recommendations about availability, use, and type of monitoring varied widely between guidelines. No guideline was completely aligned with expert opinion that quantitative neuromuscular monitoring should be used in all patients receiving neuromuscular blocking drugs.<sup>3 6 17</sup> The reluctance

of clinicians to embrace universal quantitative neuromuscular monitoring is well known and may be related to workload and erroneous perceptions of unreliability and no benefit.<sup>19</sup> However, the reasons for lack of alignment by professional societies is unclear, as there is ample evidence that quantitative neuromuscular monitoring is more effective than qualitative monitoring in preventing residual neuromuscular block.<sup>3 17</sup>

The strength of our work is that it was a comprehensive survey of monitoring guidelines of professional anaesthesia societies, using a pre-planned evaluation of recommendations about availability and use of neuromuscular monitoring. We conducted a systematic web-based search for guidelines of societies affiliated with the WFSA, multinational societies, and specialist medical colleges, but we may have missed guidelines of other relevant organisations or guidelines that were not posted on the internet. We may also have missed those societies that promoted use of the WHO/WFSA guideline to their members. We were also unable to access society websites that were exclusive to their members. Finally, the online translation services we used may have provided imperfect translations.

In conclusion, we identified a gap in the availability of professional society neuromuscular monitoring guidelines, particularly in middle- and low-income nations. Recommendations about availability, use, and type of monitoring varied widely among guidelines. An effort to improve the availability and consistency of guidelines is required.

## Authors' contributions

Data collection, data entry, first draft of manuscript, approved final draft: NSL.

Concept and protocol, revisions of manuscript, approved final draft: KL.

## Declaration of interest

KL is an editor of the *British Journal of Anaesthesia*. NSL declares that they have no conflicts of interest.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.bjao.2022.100028>.

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