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Research Article

A Cross-Sectional survey on Knowledge, Attitude, and Practices of Neuromuscular Monitoring among Indian Anesthesiologists

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ABSTRACT

Background: The utility of Neuromuscular monitoring (NMT) has not been studied in Indian scenario till date. We did a survey to evaluate the knowledge, attitude, practices of NMT among Indian anesthesiologists.

Methods: A questionnaire-based google form was sent to 350 anesthesiologists over 3-months. Demographic data was collected in initial questions, followed by data on their concepts, practices, and knowledge of NMT and postoperative residual nerve block (PRNB). Data were descriptively analysed using frequencies and percentages. Descriptive statistical testing was done using software package IBM SPSS 23.

Results: 88.9% of participants reported the use of clinical assessment. Though majority used clinical parameters, they were well-versed about Train-of-Four criteria. 75.9% stated the use of objective NMT in < 25 % of patients. The reasons for not using objective monitoring were scarcity of neuromuscular monitors, non-familiarity, and complexity of monitors. In regards to PRNB, 79.6 % participants considered PRNB to be an important clinical issue. Although in their clinical practice they rarely encountered PRNB, 74% responded that routine NMT can decrease PRNB. The cross-tabulation table reflected that the use of objective tools (P= 0.014), knowledge about the essentiality of NMT (p=0.003), correctly stating PRNB as an important clinical issue (p=0.006), and their understanding about unreliability of clinical tests (p=0.001) showed significant improvement with increasing anesthesia experience.

Conclusion: Participants showed great understanding of clinical and qualitative tests but not of quantitative tests, with low rate of usage of objective NMT. A lacuna in understanding of quantitative parameters must be addressed considering high incidence of PRNB and lack of sensitivity of clinical parameters.

Nondepolarizing muscle relaxants (NDMR) are commonly used while giving general anesthesia to facilitate tracheal intubation, intraoperative muscle relaxation, and improve surgical conditions [1-2]. Postoperative residual neuromuscular blockade (PRNB) is defined as a train-of-four (TOF) ratio < 0.9 and characterized by the persistence of muscle weakness following NDMR administration in the postoperative period even after the reversal [3]. PRNB is a common complication with a high incidence rate of 20-40% [4-5] and is associated with increased risks of aspiration pneumonia, pharyngeal dysfunction, airway obstruction, hypoxemia, need for re-intubation, and even mortality [6-7].

Neuromuscular monitoring (NMT) is required to monitor the degree of and recovery from neuromuscular blockade. It is also helpful to guide the timing, dosage, and type of reversal agent. The methods of NMT include clinical, qualitative and quantitative evaluation. Clinical evaluation includes respiratory parameters and muscular function tests, i.e., 5s head lift, sustained grip strength. The qualitative assessment assesses nerve stimulators

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guided patterns of nerve stimulation i.e., TOF count, TOF ratio, degree of fade, double burst stimulation, tetanic and post-tetanic count [8]. The quantitative evaluation assesses evoked responses after peripheral nerve stimulation and uses neuromuscular monitors. It includes several techniques like mechanomyography, electromyography, acceleromyography, etc. [9]. The clinical tests for NMT are highly unreliable. Although qualitative tests are better than clinical, the risk of PRNB is still there with qualitative assessment [10-11]. Quantitative methods of NMT are preferred [12-13].

Many anesthetists do not use objective NMT (qualitative or qualitative) in their clinical practice despite the evidence-based recommendations. Based on the surveys performed, about 19.3 % of the Europeans, 9.4 % of the Americans, 10 % of the Australian and New Zealand's anesthetists do not use NMT routinely [14-15]. To date, no data is available regarding their utility in our Indian scenario. Therefore, we did a survey to evaluate the knowledge, attitude, and practices of NMT among Indian anesthesiologists. Our primary objective was to evaluate their current understanding of NMT, their perspective, and the execution of NMT practices (clinical/quantitative/qualitative monitoring). The secondary objective was to assess their knowledge and perceptions of PRNB. We also surveyed to identify the potential difficulties they encounter while practicing NMT.

Methods

A prospective cross-sectional online survey was conducted over three months from October 2021 to December 2021. The practicing anesthesiologists from different institutes of three metropolitan cities (Delhi, Mumbai, Kolkata) and the institutes of Uttarakhand state were invited to participate in this online survey. The questionnaire was adapted to assess the following aspects: 1) current NMT concepts and practices 2) anesthesiologists' criteria to use neuromuscular blockade antagonists 3) availability and usage of NMT monitors in various institutes 4) problems encounter while using NMT monitors 5) concept about PRNB and its significance.

We initially created a print version of the first draft, and it was distributed to ten experienced anesthesiologists. Shortcomings in the questionnaire were noted, and necessary changes were incorporated. The final validated questionnaire-based google survey was sent to 350 known anesthesiologists over three months. An online Google form containing descriptions of the survey, objectives, and questionnaire was circulated to anesthesiologists via various social media networks. Participation was strictly voluntary. Participants were informed about the anonymity and confidentiality of all responses and that only a few minutes would be required to answer. We sent the invitation twice to ensure that all the members received the message and had a sufficient opportunity to respond and increase the response rate. From one email address, only one response was permitted. At the end of the three months, the survey was closed.

After the completion of the survey, we downloaded the data and entered it into a Microsoft Excel sheet. Demographic data of the respondents was collected in initial questions, followed by data on knowledge of NMT, availability, and usage of NMT devices, and respondents' perception of NMT and PRNB. Data were descriptively analysed using frequencies and percentages. Descriptive statistical testing was done using software package IBM SPSS 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.), using Chi-square test and Fischer's exact test for categorical variables. The p-value < 0.05 was considered statistically significant.

Results

The invitation was sent to 350 anesthesiologists and a total of 108 responses was received producing an overall response rate of 30.9%. 81.5% of the respondents were working in government hospitals and stated their hospital setup as partially equipped, 18.5 % were working in a private setup. Nearly 50 % of the respondents in this survey had 1-5 years of experience as an anesthesiologist. 57.4% of participants acquired their NMT knowledge by operating room teaching. 55.6% of participants used clinical assessment to administer neuromuscular blockade antagonists and only 5.7% used qualitative/quantitative monitoring. Though the majority of responders used clinical parameters for monitoring with or without TOFC/TOFR, they were well-versed about TOF count/ratio criteria. 53.7 % of participants agreed that NMT should be used for all the stages of anesthesia when NDMR was administered. The questionnaire responses are shown in (Table 1).

Table 1- Demographics of participants and knowledge/ attitude/practice regarding NMT

1. DEMOGRAPHIC INFORMATION	
Questions and their responses in n (%)	**n=108; n (%)**
Number of years of Anesthesia practice? (In years)	
< 1	20 (18.5)
1-5	54 (50)
5-10	24 (22.2)
> 10	10 (9.3)
Type of hospital	
Government	88 (81.5)
Private	20(18.5)
2. KNOWLEDGE, ATTITUDE AND PRACTICE REGARDING NMT	
Where have you been taught about NMT?	

Classroom teaching	38 (35.2)
Operating room teaching	62 (57.4)
Workshop/conferences	6 (5.6)
Self	2 (1.9)
Never taught	0
Availability of neuromuscular monitors in your hospital operating rooms	
All equipped [1 monitor per 1 OR]	14 (13)
Partially equipped [1 monitor per 2/3 OR]	88 (81.5)
No monitors available	6 (5.6)
What are your criteria to use neuromuscular blockade antagonists in your clinical practice? (You can mark more than one)	
Always used	62 (57.4)
Never used	8 (7.4)
Depend upon elapsed time from last NDMR administration	36 (33.5)
Type and duration of action of NDMR used	42 (39)
Clinical assessment (respiratory parameters and muscle function (5-s head lift, grip strength)	60 (55.6)
Depends on qualitative/quantitative NMT	6 (5.7)
How often do you use objective NMT in patients given NDMR?	
Never	14 (13)
< 25% of cases	82 (75.9)
25-50% of cases	12 (11.1)
>50 % of the cases	0
The use of NMT is essential for all stages of anesthesia when NDMR are administered	
Strongly disagree	12 (11.1)
Disagree	4 (3.7)
Neutral	34 (31.5)
Agree	38 (35.2)
Strongly agree	20 (18.5)
Are you aware of clinical tests (respiratory parameters and muscle function) of NMT?	
Yes	86 (79.6)
No	10 (9.3)
Maybe	12 (11.1)
Are you aware of qualitative tests (PNS guided patterns of nerve stimulation) of NMT?	
Yes	76 (70.4)
No	16 (14.8)
Maybe	16 (14.8)
Are you aware of quantitative tests (mechanomyography, electromyography, acceleromyograph, etc.) of NMT?	
Yes	52 (48.1)
No	38 (35.2)
Maybe	18 (16.7)
Which NMT technique do you use in your routine practice?	
1. Clinical tests	
Yes	96 (88.9)
No	6 (5.6)
Sometimes	6 (5.6)
2. TOFC or TOFR	
Yes	48 (44.4)
No	20 (18.5)
Sometimes	40 (37)
3. Double-burst stimulation	
Yes	12 (11.1)
No	66 (61.1)
Sometimes	30 (27.8)
4. Post-tetanic count	
Yes	6 (5.6)
No	74 (68.5)
Sometimes	28 (25.9)
5. Quantitative monitoring	
Yes	16 (14.8)
No	74 (68.5)
Sometimes	18 (16.7)
Which of the following do you use for TOF monitoring? (More than one may be true)	
I don't use TOF monitoring	24 (22.3)
Facial nerve orbicularis oculi muscle	4 (3.8)
Facial nerve corrugator supercilii muscle	6 (5.6)
Ulnar nerve adductor pollicis muscle	84 (78.2)
Common peroneal nerve big toe	0
Posterior tibial nerve big toe	2 (1.9)
Intense block: TOFC=0, PTC=0?	
True	82 (75.9)
False	2 (1.9)
Don't know	24 (22.2)
Deep block: TOFC=0, PTC=1-2?	
True	66 (61.1)
False	16 (14.8)
Don't know	26 (24.1)
Residual block: TOFR< 0.7?	
True	44 (40.7)
False	30 (27.8)
Don't know	34 (31.5)
Residual block: TOFR < 0.9?	
True	48 (44.4)
False	30 (27.8)
Don't know	30 (27.8)
Adequate recovery: TOFR > 0.7?	
True	16 (14.8)
False	52 (48.1)
Don't know	40 (37)
Adequate recovery: TOFR > 0.9?	
True	80 (74.1)
False	6 (5.6)
Don't know	22 (20.4)
TOFR at which extubation is recommended: > 0.9?	
True	86 (79.6)
False	6 (5.6)
Don't know	16 (14.8)

I would use NMT more often but: (you can mark more than one)	
I am not familiar with it	22 (20.4)
There are not enough neuromuscular monitors in theatres	80 (74.2)
The use of the neuromuscular monitor is complicated	22 (20.4)
I don't think it is necessary	6 (5.7)
I use it often or all the time	6 (5.6)
If you're using it often, then the most common difficulty experienced with NMT (you can mark more than one)	
Error message on monitor	36 (33.5)
Fluctuating TOF value	44 (40.8)
Frequent electrode detachment due to position of patient's arm	28 (26)
Do not know	22 (20.4)
Other	2 (1.9)

NMT= Neuromuscular monitoring; NDMR= non-depolarising muscle relaxant; PNS= Peripheral nerve stimulator; TOF= Train-of-four; TOFC= Train-of-four count; TOFR= Train-of-four ratio; PTC= post-tetanic count; PRNB= Postoperative residual nerve block

In regards to PRNB, 79.6 % of participants considered PRNB to be an important clinical issue that can lead to serious complications. Latent PRNB that cannot be revealed by clinical tests was not considered dangerous by 16.7 % of respondents. Although in their clinical practice they rarely encountered PRNB (as reported by 66.7 % of participants), 74 % of participants responded that routine NMT can decrease the incidence of PRNB. 61.2 % of participants stated the inadequacy of clinical tests to preclude the PRNB and responded that objective NMT should be preferred (Table 2).

Table 2- Attitude and practice regarding PRNB

Questions and their responses in, n (%)	**n=108; n (%)**
Do you think PRNB is an important clinical issue and can cause serious complications?	
Yes	86 (79.6)
No	9 (8.3)
Don't know	13 (12.1)
Do you think latent PRNB that cannot be revealed with clinical tests is not dangerous?	
Yes	18 (16.7)
No	54 (50)
Don't know	36 (33.3)
How commonly is PRNB seen in the post-anesthesia care unit in your hospital?	
Never	16 (14.8)
Rare (once a year)	56 (51.9)
Sometimes (once a month)	22 (20.4)
Frequent (once a week)	14 (13)
Always (almost daily)	0
Do you think routine NMT can reduce PRNB?	
Yes	80 (74)
No	16 (14.8)
Don't know	12 (11.2)
Do you think clinical tests are inadequate to preclude PRNB, objective NMT should be preferred?	
Yes	66 (61.2)
No	12 (11)
Don't know	30 (27.8)

PRNB= Postoperative residual nerve block; NMT=Neuromuscular monitoring

75.9% of participants reported that they were using objective NMT in < 25 % of patients given NDMR. We inquired to find out the reason for non-using and the results were surprising. 74.2% of participants stated that they are not using NMT due to scarcity of neuromuscular monitors in their setups and 40.8 % reported non-familiarity and complexity of neuromuscular monitors as the reason. The most common difficulties encountered by those who are using are fluctuating TOF value (40.8%), error message on monitors (33.5%), frequent electrode detachment (26%) and 22.3% reported unknown reasons. (Table 3) depicts the relationship of the participant's responses regarding the use of objective NMT and their number of years of anesthesia practice (P= 0.014) and indicates the increased utilization of objective NMT tools as the years of experience as an anesthesiologist increased.

Table 3- Relationship of responses regarding use of NMT and number of years of anesthesia practice

Years of experience	**How often objective NMT used in patients given NDMR**			**Total**	
	Never	**< 25% of cases**	**25-50 % of the cases**		
< 1 year	2	14	4	20	
1-5 years	8	42	4	54	'r'= 15.924
5-10 years	2	22	0	24	
>10 years	2	4	4	10	P= 0.014
Total	14	82	12	108	

NMT= Neuromuscular monitoring; NDMR= Nondepolarizing muscle relaxant; r= Pearson's Correlation coefficient

79.6% and 70.4% of participants were fully aware of clinical tests and qualitative tests of NMT respectively, whereas only 48.1% of participants were aware of quantitative tests of NMT. Maximal participants (88.9%) stated the use of clinical tests of NMT in their practice. The cross-tabulation table reflects the knowledge of participants and actual usage of NMT tools with their years of anesthesia experience. The awareness ($p < 0.001$) and usage ($p=0.008$) of quantitative monitors, use of TOF count/ratio ($p=0.006$) showed a significant increase with increasing years of experience. The significantly improved knowledge and perception about NMT, PRNB,

reliability of objective NMT ($p < 0.05$) with increased anesthetists experience was also seen (Table 4).

Table 4- Cross-tabulation table

1. Reflecting the awareness of participants about NMT tools with their anesthesia experience		
Tests of NMT	**'r'**	**P**
Clinical tests (respiratory parameters and muscle function)	12.188	0.058
Qualitative tests (PNS guided patterns of nerve stimulation)	11.701	0.069
Quantitative tests (mechanomyography, electromyography, acceleromyograph, etc.)	24.964	<0.001
2. Reflecting the usage of NMT tools by the participants with their anesthesia experience		
Tests of NMT	'r'	P
Clinical tests	9.742	0.136
TOFC and/ TOFR	18.247	0.006
Double-burst stimulation	7.593	0.269
Post-tetanic count	11.647	0.070
Quantitative monitoring	17.480	0.008
3. Reflecting the knowledge and perception of participants regarding PRNB with their anesthesia experience		
About PRNB	**'r'**	**P**
PRNB is an important clinical issue	23.098	0.006
Routine use of NMT does not reduce the PRNB incidence	26.207	0.010
Latent PRNB that cannot be revealed with clinical tests is not dangerous	46.951	<0.001
Clinical tests are inadequate to determine PRNB, objective NMT is preferred	26.939	0.001
The use of NMT is essential for all stages of anesthesia when NDMR are administered	29.984	0.003

'r'= Pearson's Chi-Square; NMT= Neuromuscular monitoring; PNS= Peripheral nerve stimulator; TOF= Train-of-four; TOFC= Train-of-four count; TOFR= Train-of-four ratio; PRNB= Postoperative residual nerve block; NDMR= non-depolarising muscle relaxant

Discussion

NMT guided administration, maintenance, and reversal of NDMRs are recommended to improve the quality of intubation, reduced airway injury, good surgical relaxation, and reduce the incidence of PRNB [16]. There is a great discrepancy between the recommendations and actual clinical practice due to a plethora of reasons that need to be addressed. Recent studies demonstrated that nerve stimulator-guided subjective assessment and objective monitoring are performed for less than 40% and 17% of patients respectively [14,17].

This survey was done to assess the knowledge, attitude, and practice of Indian anesthesiologists regarding the NMT, its use, and its implication in the occurrence of PRNB. Whether they are routinely practicing it or not and what are the reasons that are limiting the standard recommended practice of objective monitoring. Lin et al. [18] conducted an online survey among Singaporean anesthesiologists to assess their knowledge and clinical practices on NMT pertaining to PRNB. The response rate was 74.3% and the study concluded that the routine rates of NMT were low in their institute, reported PRNB to be a clinically significant problem, which was further compounded by incorrect knowledge and inappropriate clinical practices related to NMT.

In this survey, awareness regarding the clinical parameters and qualitative nerve stimulator-guided tests of NMT was seen in nearly 70-80 % of the participants. Most of them correctly answered the TOF ratio definition of the intense block, deep block, residual block, extubation criteria despite not using it that often. >50 % of participants responded that they were either unaware or not sure about their understanding of quantitative NMT, this showed a lacuna in their current knowledge about quantitative tests.

Despite standard guidelines calling for routine objective NMT whenever NDMRs are administered, we found in this survey that 75.9% of anesthetists were using it in < 25 % of the cases. Most of the practitioners were predominantly using clinical assessment to administer neuromuscular blockade antagonists (55.6%) and continuing with their old practices based on type, duration of action of NDMR, and time elapsed from the last dose given (nearly 40%). The possible reasons for this disparity between recommendation and actual practice of objective NMT depicted from the questionnaire were partially equipped hospital setups (81.5 %), non-availability was reported by 5.6% responders, 40.8% reported either non-familiarity or complicated use, 5.7% of participants thought NMT is not necessary.

Clinical parameters (respiratory and muscle function; 5s head lift, grip strength) are extensively used but are highly unreliable with low sensitivity and positive predictive value [8,19]. A 5-s head lift can be performed even at a TOF ratio as low as 0.5 in more than 70 % of individuals [20]. Also, a certain amount of patients' cooperation and awareness is needed to assess them clinically which can be difficult to perform in an emergent patient [21]. Qualitative nerve stimulator-guided visual/ tactile response to stimulated muscle provides several nerve stimulations patterns that allow the evaluation of TOF count, TOF ratio, degree of fade [8]. Although more sensitive than clinical tests, qualitative tests don't eliminate the risk of PRNB. TOF fade can only be detected subjectively even by experienced clinicians only when the TOF ratio is < 0.4

[11]. Quantitative monitoring (Acceleromyography, Mechanomyography) measure evoked responses following nerve stimulation, are precise, reproducible, and gold-standard monitoring to avoid residual curarization [9]. 68.5 % of participants in the survey have reported not using quantitative monitors, regardless of its high sensitivity.

PRNB has a high incidence rate, is associated with serious complications, increases the length of stay in the post-anesthesia care unit (PACU), and can be a great discomfort for both patients and surgeons [3,6,7]. Nearly 80% of participants in this survey reported PRNB as an important clinical issue and most of them agreed over the reliability of NMT to identify PRNB. 61.2 % of participants stated that clinical tests are inadequate to determine PRNB and objective neuromuscular monitors are necessary.

As reflected in the cross-tabulation table (Table 3,4), with increasing years of anesthesia experience, the use of NMT tools has increased (P= 0.014). The awareness (p <0.001) and usage (p=0.008) of quantitative monitors, use of TOF count/ratio (p=0.006) showed a significant increase as the years in anesthesia advanced. The respondents' knowledge and perception about the essentiality of NMT for all stages of anesthesia (p=0.003), correctly stating PRNB as an important clinical issue (p=0.006), understanding about the unreliability of clinical tests to preclude PRNB (p=0.001) showed significant improvement with increasing experience as anesthesiologists.

The French society of Anesthesiology and intensive care in 2000 stated that the TOF stimulation is not enough to assess recovery and therefore instrumental monitoring is required [22]. The Czech Republic society has recommended the quantitative evaluation from the year 2010, along with the choice of the ulnar nerve stimulation. TOF ratio > 0.9 is considered the sign of adequate recovery from the effect of NDMR [23]. Australian and New Zealand College of Anesthetists (ANZCA) also issued a guideline stating that NMT, preferable quantitative, must be available for every patient undergoing neuromuscular blockade and should be used during extubation [24]. The Association of Anesthetists of Great Britain and Ireland in 2015 recommended peripheral nerve stimulator as a mandatory device and should be used from the induction to the recovery until consciousness returns, if a neuromuscular blocker is used during anesthesia. TOF ratio > 0.9 depicted by a quantitative device was considered much reliable and safe, therefore instead of qualitative, quantitative was encouraged and preferred [25]. Difficult airway society guideline for tracheal extubation recommended the use of a peripheral nerve stimulator to ensure TOF ratio ≥ 0.9 to reduce the incidence of postoperative airway complications [26]. The American Society of Anesthesiologists (ASA) hasn't published any guidelines yet regarding intraoperative neuromuscular monitoring despite the high incidence of PRNB [27].

Insufficient availability of neuromuscular monitors in both government and private operating room setups, cumbersome setup and complexity of quantitative monitors, technical difficulties, lack of anesthetists understanding, and their attitude towards the objective NMT are some of the reasons for the reluctant behaviour of anesthetists to use objective monitoring. To address this, a comprehensive educational strategy is needed that clarifies the practical issues faced by the anesthetists in implementing the standard recommended practice along with the lecture room teaching of every aspect of NMT, recent updates, and developments in objective monitoring. A change in practice was reported by Baillard et al, the rate of NMT and use of reversal agents increased from 2 % and 6 % to 60 % and 42 % respectively in the operating room of a French hospital from the year 1995 to 2004. The decreased incidence of PRNB from 62 % to 3 % was reported as a result of changed practice [28].

The limitations of this survey include: lower response rates that limit its validity; participants of the study were from a relatively smaller number of institutes in India, therefore findings cannot be generalized; we didn't include the questions about the neuromuscular blocking agents and their antagonists (neostigmine, sugammadex) as questionnaire mainly focuses on concepts and practice of NMT.

Conclusion

In this survey participants showed great understanding of the clinical and qualitative tests, with a low rate of usage of objective NMT. Quantitative tests are still not known to the majority of participants despite the evidence-based recommendation for its use. A lacuna in the understanding of quantitative parameters must be addressed for safe anesthesia practice considering the high incidence of PRNB and lack of sensitivity of clinical parameters. The well-equipped hospital setups, re-education about objective NMT, motivational training to use objective monitors, easy-to-implement practical guidelines, are some of the prerequisites to be adapted in daily practice. Comprehensive, more practical, and global guidelines are needed for NMT to minimize postoperative complications associated with residual curarization.

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