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Anaesthetists' knowledge and frequency of use of neuromuscular monitoring at the University of the Witwatersrand

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology.

Johannesburg, 2022

Declaration

I, Michael Kgowe Setsomelo declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



24 March 2022

Abstract

Background

Neuromuscular blocking agents (NMBA) are commonly administered during general anaesthesia (GA). The use of these agents can result in postoperative residual neuromuscular blockade (PRNMB) as a complication. Studies have shown that such complication can be reduced with the use of neuromuscular monitors (NMM).

Data from South Africa as to the knowledge and use of NMM is scanty. Therefore, the aim of this study is to assess the knowledge and the frequency of use of NMM in the Department of Anaesthesia at the University of the Witwatersrand (Wits).

Methods

A prospective, contextual study design was used. Data was collected using a self-administered online questionnaire developed by the researcher with the assistance of senior anaesthetists. The study population consisted of all anaesthetists working in the Department of Anaesthesia at Wits. A convenience sampling method was used and a completion with return of the online questionnaire implied consent to participate in the study. Adequate knowledge was defined by a score of 65.5% as determined by the Angoff method.

Results

Two hundred and eight anaesthetists were available during the period of data collection. Of these, 126 anaesthetists completed the questionnaire. There was inadequate level of knowledge of NMM among anaesthetists in our department. Sixty-four percent of the anaesthetists achieved less than the set Angoff score of 65.5%. The anaesthetist' mean score of the questionnaire was also 57%. The level of knowledge differs significantly depending on professional designation with p-value <0.009. Medical Officers and second year registrars scored significantly below the Angoff score with p-values of 0.0005 and 0.02 respectively, while first year registrars recorded the highest score, followed by fourth year registrars. The frequency of use of NMM in the department is low at 13%.

Conclusion

The level of knowledge among anaesthetists with respect to NMM was inadequate. There is a need for improvement of knowledge regarding NMM use, by ongoing education in our anaesthesia department. Formulating evidence-based guidelines which support the use of NMM in all patient who received NMBA will be beneficial. The use of NMM in our department is also low. The commonest reason for not using NMM was unavailability of these monitors. Healthcare authorities have the obligation to increase the availability and accessibility of NMM. A national study in this subject is warranted to see if this is any different among anaesthetists in South Africa.

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Abbreviations

AMG	Acceleromyography
ASA	American Society of Anesthesiology
CHBAH	Chris Hani Baragwanath Academic Hospital
DAS	Difficult Airway Society
DBS	Double burst stimulation
EMG	Electromyography
GA	General anaesthesia
MMG	Mechanomyography
MO	Medical officer
MS	Millisecond
NDMR	Non depolarising muscle relaxants
NMBA	Neuromuscular blocking agents
NMM	Neuromuscular monitoring/Neuromuscular monitor
PNS	Peripheral nerve stimulator
PRNMB	Postoperative residual neuromuscular blockade
PTC	Post tetanic count
SASA	South African Society of Anaesthesiologists
ST	Single twitch
TOF	Train of four
TORC	Train of four count
TOFR	Train of four ratio
TS	Tetanic stimulation
USA	United States of America
Wits	University of the Witwatersrand

Statement

The Research Report consists of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the author guidelines of the South African journal of Anaesthesia and Analgesia (SAJAA), the journal to which it is intended to be submitted, in order to comply with the university's style guide.

Section 1: Review of the literature

1.1 Introduction

Neuromuscular blocking agents (NMBA) cause muscle relaxation and are often used during general anaesthesia (GA) to improve endotracheal intubation as well as the surgical condition (1, 2). The use of these agents cause postoperative residual neuromuscular blockade (PRNMB) with predominantly airway complications (3). In the 1950's, it was reported that their use was associated with higher mortality rates than when NMBA were not used (4). In 1958 peripheral nerve stimulator (PNS) was introduced to monitor neuromuscular blockade (4-6). In 1965 Churchill-Davidson demonstrated that a PNS was the only method to assess the degree of neuromuscular blockade after using NMBA (4).

The use of NMM has been shown to reduce PRNMB (7, 8). Knowledge on when to extubate a patient based on NMM guidance is paramount (9, 10). It is important to know anaesthetists' knowledge and frequency of use of NMM to allow for focused training and reduce PRNMB complications. The principles of NMM function and its use will be described under the following headings.

1.2 Neuromuscular monitoring

1.2.1 Physics on how neuromuscular monitor works

A pulse duration and current large and long enough to stimulate all nerve fibres is called maximal stimulus (11). If this stimulus is increased by 10-20% to negate the effects of skin resistance it is now called supramaximal stimulus and ensures that all muscle fibres are stimulated (4, 12). The neural response depends on constant current, therefore the voltage in a NMM should change with changes in skin resistance (4, 11). A current between 40-70 mA is adequate (4).

1.2.2 Clinical modes/patterns of neuromuscular monitor

Several patterns or modes of NMM use arise from nerve stimulation. They are single twitch (ST), train of four (TOF), double burst stimulation (DBS) and tetanic stimulation (TS) (5, 13).

A ST is described by the frequency of 1 Hz, with a duration of 0.2 millisecond (ms), and 1 twitch per 10 seconds (s) (11). A ST is of little clinical use, and demonstrates that the muscle is stimulated (11).

A TOF stimulation consists of 4 single twitches with a frequency of 2 Hz. During a TOF stimulation there is 1 twitch per 0.5 s, with a duration of 0.2 ms (5). This is the standard for NMM (13). A train of four count (TOFC) is the number of twitches present. They are called T1, T2, T3 and T4. A train of four ratio (TOFR) is T4/T1 (4, 11). A fade is the reduction in muscle response from T1 toT4 during a TOF with non-depolarizing muscle relaxants (NDMR) (4, 5). This pattern is used to differentiate depolarizing muscle relaxants (DMR) from NDMR (4). It also determines the degree of the block (4, 14). Once T2 is present neostigmine can be administered to reverse NMBA (11). TOFR is used to signify complete recovery from neuromuscular blockade (11).

A DBS consists of a burst of two or three impulses separated by 0.75 seconds, with a frequency of 50 Hz per burst (4). There is a time difference of 0.02 s between twitches (11). DBS surpasses TOF in picking up fade (14). A DBS is used instead of TOF if no objective monitoring is available, but in awake patient it is more painful (4).

A TS occurs at 50 Hz with a duration of 5 s (4). It may induce muscle contraction, and it is usually used with post tetanic count (PTC) (4). During PTC a tetanic stimulation is followed by 3 s of single twitch, at a 1 s interval (4). It is used to evaluate the intensity of a block when there is no twitch on TOF. The number of twitches present gives an estimation of how long it will take for T1 to appear in TOF (11, 14).

1.2.3 Determinants of neural stimulation

Determinants of neural stimulation include the duration of the stimulus (Chronaxy), the distance of the nerve from the electrode, the minimum current needed to stimulate the nerve (Rheobase), and the area of electrode (4, 11).

1.2.4 Site of measurement

The sites that are commonly used for NMM are ulnar nerve/adductor pollicis and the facial nerve/orbicularis oculi (12, 15-17). The most recommended site for NMM is the ulnar nerve (5, 15, 18, 19). The ulnar nerve is susceptible to the action of NMBA and its assessment may show the effects of NMBA at the pharyngeal muscles which are the last one to recover (12).

Thilen et al (17), stated that the risk of PRNMB is five times higher if the orbicularis oculi was used instead of the ulnar nerve, therefore if the ulnar nerve was not used intraoperatively it should be changed to it before administration of muscle relaxant reversal. Orbicularis oculi muscles are more resistant to NMBA (15). The other muscle group that can be used includes the posterior tibial and the common peroneal nerve.

1.2.5 Types of neuromuscular monitors

There are mainly two types of NMM available for perioperative monitoring of neuromuscular blockade which are: the qualitative (subjective) and quantitative (objective) NMM.

Qualitative neuromuscular monitors

A qualitative NMM, also called a PNS, is a medical equipment that provide an electrical current to a peripheral nerve and causing the response of the muscle innervated by that nerve. The evaluation of the evoked response from the innervated muscle is detected subjectively by the anaesthetist either by visual or tactile perception as the muscle responds from electrical stimulation. (3, 12, 20).

Quantitative neuromuscular monitors

Quantitative NMM is a medical equipment that can objectively measure and project an evoked impulse, such as TOFR (12, 20). There are few quantitative neuromuscular monitors available, namely mechanomyography (MMG), electromyography (EMG) and acceleromyography (AMG).

A MMG consists of fixing the hand while applying a certain preload to the thumb (11, 21). The force of the contraction is measured from the adductor pollicis muscle while the ulna nerve is stimulated. A transducer picks up the force of muscle contraction and amplifies it to produce a value of TOFR. Although considered the gold standard of NMM, a MMG is difficult to set up and is therefore not commonly used (12, 21).

The EMG involves the stimulation of a specific nerve and measures the muscular contraction response by means of the action potential. This electrical activity is considered to be proportional to the force of contraction (12). The advantage of this system is that it measures electrical activity instead of force of contraction, and the patient's limb does not need to be fixed. A disadvantage is that it is disturbed by electrical interference from electrical equipment like diathermy (12).

An AMG is a piezoelectrical sensor which is used to detect the acceleration of the contracting muscle. AMG uses Newton's second law which states that a Force (F) is equal to Mass (M) multiplied by Acceleration (A): (F= M X A) (12, 22). A constant mass is delivered by the thumb. Since the acceleration will be equal to the force of contraction it is then processed and displayed on a monitor (11), (12). AMG is the most used method for monitoring NMBA because it is reproducible, cheap, and practical (23, 24).

1.3 Clinical signs use in monitoring neuromuscular blockade

Clinically assessing respiratory parameters and muscle strength which includes head lift for five minutes, tongue protrusion and grip strength is unreliable and insensitive (3, 4, 23). It is not recommended to exclude PRNMB (4).

1.4 Why Neuromuscular monitoring

NMBA are commonly used during GA to facilitate tracheal intubation and surgical access (25). Unfortunately, the use of these agents comes with serious complications like PRNMB (3).

These include increased risk of airway obstruction, pulmonary aspiration, hypoxia, pharyngeal dysfunction, muscle weakness, reintubation, prolonged postoperative care unit stay as well as patient dissatisfaction (3, 12). The incidence of PRNMB is high and it is estimated to be around 20- 50% (3, 26). NMM use guide the management of NMBA and this help in reducing the incidence of PRNMB as demonstrated by Murphy et al (7) and Todd et al (8) in their respective studies. Baillard et al (27) demonstrated that NMM use decreased PRNMB from 62% to 3% in their centre. It is recommended that quantitative NMM should be used whenever NMBA are administered to reduce PRNMB (4, 15, 20, 28). If objective NMM is not available then subjective NMM can be used (4, 17, 29).

In South Africa, Diedericks et al (30) in 2004 reported that 43% of patients had PRNMB after the use of NMBA. Chetty et al (31), conducted a study in South Africa in 2020 on 55 patients who received NMBA at Chris Hani Baragwanath Academic Hospital (CHBAH) and described an incidence of 45% of PRNMB. However, our literature search did not find South African literature describing the use of NMM.

1.5 Current practice in relation to neuromuscular monitoring use

Few countries around the world have standardized guidelines on NMM use. France is the first country to publish recommendation on NMM use in 2000 to prevent incomplete neuromuscular reversal. The use of PNS with its TOFC is not adequate to assess neuromuscular recovery therefore an instrumental monitor is required (3).

In 2010 the Czech Republic society published its own recommendations on quantitative NMM use, with the ulnar nerve being the recommended site of monitoring (3, 32).

The Australian and New Zealand College of Anaesthetists states that “Quantitative neuromuscular function monitoring must be available for every patient in whom neuromuscular blockade has been induced and should be used whenever the anaesthetist is considering extubation following the use of non-depolarising neuromuscular blockade” (33).

The British guidelines states that “a measure of neuromuscular blockade using a PNS, is essential for all stages of anaesthesia when neuromuscular blockade drugs are administered, however the guidelines stress that this monitoring is best done by objective quantitative peripheral nerve stimulator” (18).

The Difficult Airway Society (DAS) encourage the use of NMBA reversal as well as the PNS use before tracheal extubation of the airway. This is to maximise ventilation and restore airway reflexes as well as preventing the postoperative pulmonary complications (34). The American Society of Anaesthesiology (ASA) standard of intraoperative monitoring which was affirmed in 2015 did not include routine NMM (35). The South African Society of Anaesthesiologists (SASA) recommends the use of a peripheral neuromuscular transmission monitor when NMBA are used (36).

1.6 Neuromuscular monitoring usage

The use of NMM still remains low (37). This is despite ample information stressing routine use of NMM after NMBA were used during GA (3, 4, 12, 15, 23). The use of objective NMM in Australia and New Zealand stands at 17% (9), Singapore 13% (28) , while NMM was used by 10% of anaesthetists in United Kingdom (38). For Lin et al (39) the use of NMM was at 18%. Pongracz et al (40) conducted a study in Hungary and Romania and their study findings showed that the use of NMM was as low as 8% among their anaesthetists. Naguib et al (41) in their survey found out that 19.1% of anaesthetists in Europe and 9.4% of anaesthetists in the United States of America (USA) never use a nerve stimulator to manage NMBA. Di Marco et al (42) conducted a study in Italy and found that 75% of the anaesthetists rely on clinical signs to determine recovery from NMBA during emergence from GA. Soderstrom et al (10) conducted a study in Denmark showing a relatively high use of objective NMM with 58% of anaesthetists always applying NMM whenever NMBA were administered.

1.7 Knowledge of neuromuscular monitoring

In a study conducted by Naguib et al (43) on 1629 anaesthetists from 80 countries to explore anaesthetists' confidence in their knowledge of the core concept in NMM, the respondents completed a 9 questions survey, in which they answered correctly 57% of the questions, which is far from the respondents' confidence of 84%.

In an Australian and New Zealand study in 2011 (9) where they investigated attitudes, knowledge and practices of their anaesthetists on the use of NMM, it was stated that "This survey identifies a lack of knowledge in the area of neuromuscular blockade equipment and monitoring among anaesthetists in Australia and New Zealand responding to this survey". In this study they have 678 respondents out of 3188 members who were sent the online questionnaire. Hundred and eighty-one (27%) of the respondents knew that the TOFR should be more than 0.90 before extubation to ensure neuromuscular blockade recovery, while 186 (28%) knew that the use of clinical signs is unreliable.

In a Danish study in 2017 by Soderstrom et al (10) conducted on 653 respondents to estimate the use of objective NMM among their anaesthetists, the findings were that their anaesthetists have adequate knowledge regarding NMM. Four hundred and sixty-two (71%) of their anaesthetists knew that TOFR need to be above 0.90 to exclude PRNMB and 313 (48%) knew that subjective assessment of a PNS use is not adequate to rule out PRNMB.

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Section 3: Draft article

Anaesthetists' knowledge and frequency of use of neuromuscular monitoring at the University of the Witwatersrand

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Key words: Anaesthetists, knowledge, frequency, use, neuromuscular monitoring

Abstract

Background

Neuromuscular blocking agents (NMBA) are commonly administered during general anaesthesia (GA). The use of these agents can result in postoperative residual neuromuscular blockade (PRNMB) as a complication. Studies have shown that such complication can be reduced with the use of neuromuscular monitors (NMM).

Data from South Africa as to the knowledge and use of NMM is scanty. Therefore, the aim of this study is to assess the knowledge and the frequency of use of NMM in the Department of Anaesthesia at the University of the Witwatersrand (Wits).

Methods

A prospective, contextual study design was used. Data was collected using a self-administered online questionnaire developed by the researcher with the assistance of senior anaesthetists. The study population consisted of all anaesthetists working in the Department of Anaesthesia at Wits. A convenience sampling method was used and a completion with return of the online questionnaire implied consent to participate in the study. Adequate knowledge was defined by a score of 65.5% as determined by the Angoff method.

Results

Two hundred and eight anaesthetists were available during the period of data collection. Of these, 126 anaesthetists completed the questionnaire. There was inadequate level of knowledge of NMM among anaesthetists in our department. Sixty-four percent of the anaesthetists achieved less than the set Angoff score of 65.5%. The anaesthetist' mean score of the questionnaire was also 57%. The level of knowledge differs significantly depending on professional designation with p-value <0.009.

Medical Officers and second year registrars scored significantly below the Angoff score with p-values of 0.0005 and 0.02 respectively, while first year registrars recorded the highest score, followed by fourth year registrars. The frequency of use of NMM in the department is low at 13%.

Conclusion

The level of knowledge among anaesthetists with respect to NMM was inadequate. There is a need for improvement of knowledge regarding NMM use, by ongoing education in our anaesthesia department. Formulating evidence-based guidelines which support the use of NMM in all patient who received NMBA will be beneficial. The use of NMM in our department is also low. The commonest reason for not using NMM was unavailability of these monitors. Healthcare authorities have the obligation to increase the availability and accessibility of NMM. A national study in this subject is warranted to see if this is any different among anaesthetists in South Africa.

Introduction

NMBA cause muscle relaxation and are often used during GA to improve endotracheal intubation as well as the surgical condition (1,2). The use of these agents is not without complications, since the 1950's, it has been reported that their use was associated with higher mortality rates than when NMBA were not used (3).

In 1965 Churchill-Davidson demonstrated that peripheral nerve stimulator (PNS) was the only method to assess the degree of neuromuscular blockade after using NMBA (3).

There are mainly two types of NMM available for perioperative monitoring of neuromuscular blockade which are: the qualitative and quantitative NMM. A qualitative NMM, also called a PNS, is a medical equipment that provide an electrical current to a peripheral nerve and causing the response of the muscle innervated by that nerve. The evaluation of the evoked response from the innervated muscle is detected subjectively by the anaesthetist either by visual or tactile perception as the muscle responds from electrical stimulation (4,5). Quantitative NMM is a medical equipment that can objectively measure and project an evoked impulse such as a train of four ratio (TOFR) (4,5).

A quantitative NMM is recommended over a qualitative monitoring because of the ability to objectively pick up TOFR above 0.9 (3,4,6). In instances where a quantitative NMM is not available, a PNS should be used (3).

The use of clinical signs such as head lift and hand grip for 5 seconds in timing the reversal of NMBA is inaccurate and unreliable (3,5). NMM should be used in all patients who receive NMBA to decrease the risk of postoperative residual neuromuscular blockade (PRNMB) (3,5,6,7).

Baillard et al (8) demonstrated that NMM use decreased PRNMB from 62% to 3% in their centre. In South Africa, Nell et al (9) in 2004 reported that 43% of patients had PRNMB after the use of NMBA. Chetty et al (10) conducted a study, in South Africa in 2020 on 55 patients who received NMBA at Chris Hani Baragwanath Academic Hospital (CHBAH) and described an incidence of 45% of PRNMB. Our literature search did not find South African literature describing the use of NMM.

It is important to utilise NMM in patients who receive NMBA but, only few countries around the world have included NMM into their standard of care practice (6). The American Society of Anaesthesiology (ASA) standard of intraoperative monitoring which was affirmed in 2015 did not include routine NMM (11). The South African Society of Anaesthesiologists (SASA) recommends the use of a peripheral neuromuscular transmission monitor when NMBA are used (12).

The use of NMM decreases the incidence of postoperative complications caused by NMBA (4,5,13). Studies from high income countries showed that a limited number of anaesthetists used NMM routinely in their daily practice, despite ample information supporting routine NMM in patients who received NMBA (3,5,6,7,14). The knowledge of anaesthetists from high income countries on NMM varies greatly (14,16).

There is scarcity of literature on the knowledge and frequency of use of NMM especially in the middle and low- income countries. The knowledge as well as the frequency of use of NMM among anaesthetists in South Africa or at Wits are unknown. Therefore, the aim of this study is to determine the knowledge and frequency of use of NMM by anaesthetists working in the Department of Anaesthesia at Wits.

Methods

The study followed a prospective, contextual study design. Approval to conduct the study was obtained from the Human Research Ethics Committee (Medical) (certificate No: M200807 MED 20-07-154) and the Graduate Studies Committee at Wits. The Academic Head of the Department of Anaesthesia at Wits gave permission to conduct this study in the department.

The questionnaire was developed from reviewed literature and with the help of a senior anaesthetist with special interest in NMM. Prof Naguib gave permission to adapt and use his questionnaire (17). The content validity was ensured by extensive reading to have a representative questionnaire on the topic. Face validity was ensured by three senior anaesthetists working in the Department of Anaesthesia at Wits. The questionnaire consisted of 2 questions on demographics, 15 questions on NMM knowledge and 5 questions on frequency of use of NMM.

The study population comprised of all consenting anaesthetists working in the Department of Anaesthesia at Wits. A convenient sampling method was used. During the time of the study the Department of Anaesthesia had 208 anaesthetists. An online questionnaire was sent to all anaesthetists via their email boxes and the biostatistician determined that a minimum response rate of 125 (60%) is required for this study. Medical interns were excluded from participating.

The questionnaire was loaded into google forms and distributed to the participants via email because of the Covid-19 pandemic. The participants completed and made an online submission of the questionnaire. The return of the questionnaire implied consent to participate in the study while blank questionnaires were excluded from the study.

The Angoff method (18,19) was used to assess the adequacy of knowledge among anaesthetists in the Department of Anaesthesia at Wits. The Angoff score of 65.5% was determined by three consultants in the Department of Anaesthesia at Wits.

Data was analysed using Statistical Package for the Social Sciences (SPSS-Version 25, manufactured by IBM corporation). Categorial variables were reported using frequencies and percentages. Data was described and analysed using descriptive and inferential statistics.

The Kolmogorov Smirnov test was used to assess normality. An ANOVA test was used to compare whether professional designation would make a difference in level of knowledge.

One sample t-test was used to compare if the mean score of the questionnaire per professional designation differs significantly from the set Angoff score. A p-value of 0.05 was considered statistically significant.

Results

A total of 208 anaesthetists were available during the 3 months period of data collection. After multiple reminders,128 anaesthetists were able to reply to the online questionnaire. Of the 128 completed questionnaires received, 2 were excluded as they were returned blank. Therefore, 126 questionnaires were included in this study. The 126 questionnaires were above the estimated sample size of 125 (60%) to power the study with a p-value of 0.05.

The majority of anaesthetists were medical officers 29 (23%) and consultants 25 (20%). The distribution of anaesthetists according to their professional designation is illustrated in table I.

Table I: Anaesthetists' distribution

Professional designation	**Number**	**Percentage**
Consultant	25	20
Career Medical Officer	3	2
Registrar year 4	18	14
Registrar year 3	24	19
Registrar year 2	15	12
Registrar year 1	12	10
Medical officer	29	23
Total	126	100

Of the 126 anaesthetists, 45 (36%) showed adequate level of knowledge based on the set score of 65.5% using the Angoff method. Of the 45 anaesthetists with adequate knowledge 10 (22%) were consultants. The distribution of Angoff score according to professional designation is shown in table II.

Table II: Angoff score and professional designation

Professional designation	**Angoff score**	
	Pass **Number (Percentage)**	**Fail** **Number (Percentage)**
Consultants	10 (40)	15 (60)
Career Medical Officer	1 (33)	2 (67)
Registrar year 4	9 (50)	9 (50)
Registrar year 3	9 (37.5)	15 (62.5)
Registrar year 2	4 (27)	11 (73)
Registrar year 1	6 (50)	6 (50)
Medical Officer	6 (21)	23 (79)
Total	45 (36)	81 (64)

The mean score attained by the anaesthetists who answered the questionnaire was 57% (SD19.1). Medical Officers and second year registrars scored significantly below the Angoff score of 65.5% with p-values of 0.0005 and 0.02 respectively. First year registrars recorded the highest score. The distribution of mean score according to professional designation is shown in table III.

Table III: Distribution of mean score according to professional designation

Professional designation	Number	Mean (SD)	P- Value
Consultant	25	59 (17.2)	0.55
Career Medical Officer	3	42 (21.4)	0.20
Registrar year 4	18	63 (18.0)	0.55
Registrar year 3	24	61 (18.6)	0.28
Registrar year 2	15	53 (17.1)	0.02
Registrar year 1	12	66 (10.9)	0.99
Medical Officer	29	47 (21.2)	<0.0005
All Anaesthetists	126	57 (19.1)	<0.0005

The anaesthetists performed well in 6 questions and did not do well in 3 questions of the questionnaire. The questions and the proportion of correct and incorrect answers are shown in table IV.

Table IV: Questions and proportion of correct and incorrect answers

Questions	Answers		P-value
	Correct	Incorrect	
1.Supramaximal stimulus definition	33 (26)	93 (74)	<0.0005
2.Recommended site for neuromuscular monitoring	106 (84)	20 (16)	<0.0005
3.Definition of postoperative residual neuromuscular blockade	72 (57)	54 (43)	0.13
4.Train of four description	74 (59)	52 (41)	0.61
5.Neostigmine administration	109 (87)	17 (13)	<0.0005
6.Fade	94 (75)	32 (25)	<0.0005
7.Return of airway reflexes	58 (46)	68 (54)	0.42
8.Double burst stimulus description	27 (21)	99 (79)	<0.0005
9.Post tetanic count description	70 (56)	56 (44)	0.25
10.Post tetanic count application	77 (61)	49 (39)	0.02
11.Definition of deep block by post tetanic count	81 (64)	45 (36)	0.02
12.Factors that produce optimal nerve stimulation	65 (52)	61 (48)	0.79
13.Train of four prior to extubation	93 (74)	33 (26)	<0.0005
14.Commonest method to monitor neuromuscular block	68 (54)	58 (46)	0.42
15.Requirements to eliminate skin resistance in a nerve stimulator	44 (35)	82 (65)	0.01

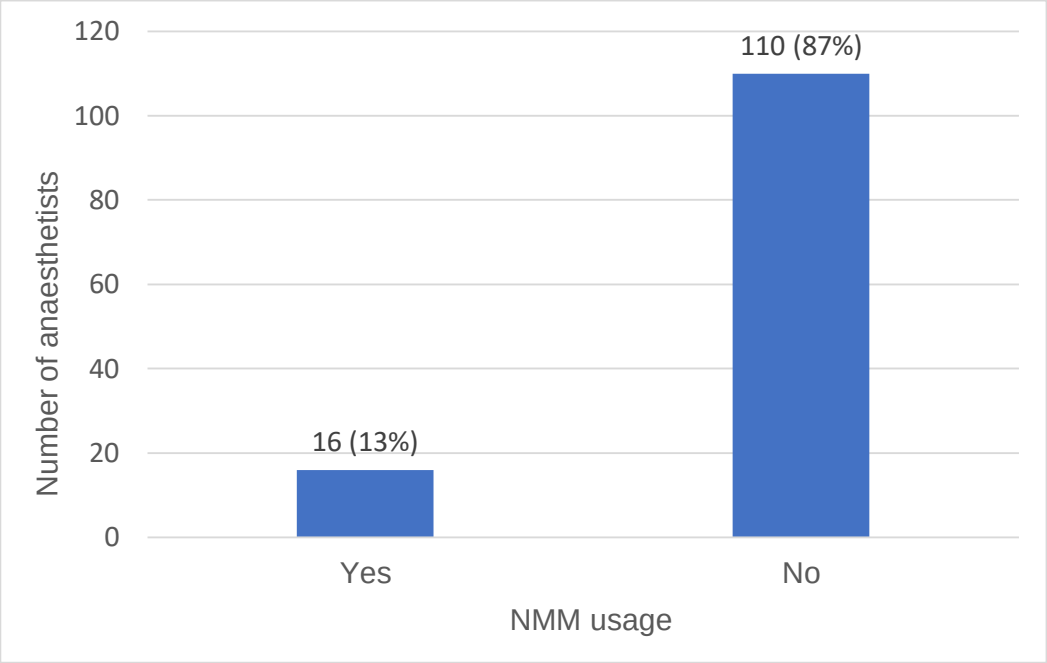
The ANOVA test was used to compare whether the professional designation would make a difference in the level of knowledge. The level of knowledge differs significantly depending on professional designation with p-value <0.009. First year registrars showed the best knowledge amongst the professional designations. The table V shows the comparison of level of knowledge across professional designations.

Table V: Comparison of level of knowledge across professional designation

Professional designation	**Level of knowledge** **Percentage** **Mean (SD)**	**P-value**
Consultant	59 (17.2)	0.009
Career Medical Officer	42 (21.4)	
Registrar year 4	63 (18.0)	
Registrar year 3	61 (18.6)	
Registrar year 2	53 (17.1)	
Registrar year 1	66 (10.9)	
Medical Officer	47 (21.2)	

Of the 126 anaesthetists 110 (87%) do not use NMM. Only 16 (13%) mostly use NMM in their daily practice. The frequency of use of NMM by anaesthetists is shown in figure 1.

Figure I: Use of NMM by anaesthetists



Of the 126 anaesthetists 91 (72%) reported not using NMM due to unavailability of it. Table VI shows reasons for not using NMM.

Table VI: Reasons for not using NMM

Reasons	**Number (Percentage)**
Lack of availability of neuromuscular monitors	91 (72.2)
Limited knowledge on neuromuscular monitoring use	18 (14.3)
Time consuming	4 (3.2)
I use reversal agent in all patients who receive neuromuscular blocking agents	13 (10.3)
Total	126 (100)

Discussion

In this study we determined the level of knowledge and frequency of use of NMM among the anaesthetists working in the Department of Anaesthesia at Wits. The results had shown that the level of knowledge was inadequate among the anaesthetists in the Anaesthetic Department at Wits. Sixty-four percent of the anaesthetists achieved less than the set Angoff score of 65.5% and the mean score of the questionnaire was 57%. This inadequate knowledge may be attributed to the lack of objective NMM in the department as well as the lack of guidelines on the use of NMM in the department. A contributary reason for these low scores could be the lack of regular training, education and testing of anaesthetists on the subject.

A study contacted by Phillips et al (14) in Australia and New Zealand in 2011, identified a lack of knowledge in the area of NMM among anaesthetists. More than 70% of the anaesthetists, did not know a safe criterion to exclude PRNMB during extubation or the shortcomings of clinical signs use when NMBA were administered. This was mainly due to lack of awareness on current literature on NMBA and NMM use. The study emphasized that for the lack of knowledge to be addressed there is need for availability of NMM accompanied by education. In our study 64% of the anaesthetists showed inadequate knowledge and we lack objective NMM as well as regular re-education on the use which are the same reasons highlighted in the study above, as factors to be addressed to improve knowledge on NMM. This is of concern, as PRNMB is high (6,13). Naguib et al (15) in 2019 conducted a world-wide study to explore anaesthetists' confidence in their knowledge of the core concept in NMM, the respondents got 57 % in that questionnaire. The respondents' confidence in getting the answers right was however high. Our anaesthetists achieved the same percentage, with both questionnaires being focused on the core concepts of NMM.

In a Danish study in 2017 conducted by Soderstrom et al (16) the anaesthetists were found to have adequate knowledge on NMM. Seventy-one percent of their anaesthetists knew that TOFR need to be above 0.90 to exclude PRNMB. In other 2 previously mentioned studies the knowledge was widely varied between 27-57% (14,15).

The adequate knowledge was attributed to the availability of NMM in Danish hospitals. In our department we do not have NMM readily available, therefore the availability of NMM could help in improving the level of knowledge about the subject among our anaesthetists.

Regarding professional designations, this study had shown that first year registrars had adequate knowledge with a mean score of 66% which was above the set Angoff score. This could be attributed to most first year registrars in our department having just wrote their anaesthesia first part of the Fellowship of the College of Anaesthesiologists (FCA) examination or their preparation to write this examination. Fourth year registrars followed with better knowledge at 63%, which could be explained by the preparation for their exit examination. Career Medical Officers scored the least however, the statistical significance was negligible because the sample size was too small for this group. Medical Officers followed with significantly lower score. This could be that most of the medical officers who join the department are novices to the anaesthetic field. Second year registrars had a low score after medical officers, of importance is that this group of anaesthetists have attempted their first part of the FCA examination and have experience in anaesthesia. We could not find a reasonable explanation for this low score in this group of anaesthetists.

The use of NMM is recommended perioperatively whenever NMBA are used (3,5,6,20). PRNMB can only be assessed by NMM as clinical signs are very unreliable (7,21,22-23). Although there is consensus in the literature showing the need for NMM, the frequency of use remains low even in high income countries (24). This study had shown that the frequency of use of NMM in our department is low at 13% which is similar to the findings made by Teoh et al (7). However, their study showed this low use despite the availability of NMM. Their study found that the lack of re-education as well as the unavailability of NMM in each theatre leads to its lack of use. This is in keeping with our study which showed that 72% of the anaesthetists do not use NMM because it is unavailable. It is important to note that the same study found that there was a discrepancy between high knowledge base on use of NMM and actual practical use of monitoring among the respondents.

In 2020 a study conducted by Lin et al in Singapore (25) found 18% of NMM use among their anaesthetists, this is in keeping with our study finding. The reason for low rate of use of NMM in their study was found to be multifactorial and included undermining of the negative consequences and the incidence of PRNMB, inadequate training, the poor availability, and the confidence in using PNS. In our study, the 2 commonest reasons stated were the unavailability of NMM (72%) and the lack of knowledge on NMM use (14%).

More studies show typical results on use of NMM around the world with 17% in Australia and New Zealand study, 8% in Hungarian and Romanian study and 10% in a United Kingdom (UK) study (14,21,26) These study results show that the use of NMM is low and this is congruent with 13% NMM use in the Department of Anaesthesia at Wits. The findings raise a serious concern as PRNMB is high with estimations around 20-50% (6,13) The study was done among anaesthetists in the Department of Anaesthesia at Wits, and it does not necessarily represent the level of knowledge and frequency of use of NMM among anaesthetists in South Africa.

Conclusion

The level of knowledge among anaesthetists with respect to NMM was inadequate. There is a need for improvement of knowledge regarding NMM use, by ongoing education in our anaesthesia department. Formulating evidence-based guidelines which support the use of NMM in all patient who received NMBA will be beneficial. The use of NMM in our department is also low. The commonest reason for not using NMM was the unavailability of these monitors. Healthcare authorities have the obligation to increase the availability and accessibility of NMM. A national study in this subject is warranted to see if this is any different among anaesthetists in South Africa.

Conflict of interest

The authors declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this paper.

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Section 4: Proposal

Anaesthetists' knowledge and frequency of use of neuromuscular monitoring at the University of the Witwatersrand

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4.1 Introduction and problem statement

Neuromuscular blocking agents (NMBA) cause muscle relaxation and are often used during general anaesthesia to improve endotracheal intubation as well as the surgical condition (1, 2). The use of these agents is not without complications. In the 1950's, it was reported that their use was associated with higher mortality rates than when NMBA were not used (3).

In 1958 peripheral nerve stimulators (PNS) were introduced to monitor neuromuscular blockade (3-5). In 1965 Churchill-Davidson demonstrated that PNS was the only method to assess the degree of neuromuscular blockade after using NMBA (3).

Two types of neuromuscular monitors have been developed and are available for perioperative monitoring of neuromuscular blockade: the qualitative and quantitative neuromuscular monitors.

A qualitative neuromuscular monitor, also called PNS, is a simple medical device that delivers a current to a peripheral nerve causing an evoked response of the muscle innervated by that nerve. The assessment of the evoked response from the innervated muscle is detected subjectively by the clinician by visual or tactile perception of the muscle contraction (6, 7).

The function of a PNS involves an action potential or stimulus that is initiated when a sufficient amount of electrical current of adequate duration is applied to a nerve (3). The stimulus is increased by 10-20 % to negate the effect of skin resistance. This is known as a supramaximal stimulus, and ensures that all muscle fibres are stimulated (3). The subsequent decrease in the strength of muscle contraction will therefore be due to the effect of the NMBA, and not to the skin resistance (3). A current between 40-70 mA is often adequate. In general, a nerve stimulator that produces a constant current density is preferred as the effects of skin resistance is avoided (3, 8).

Quantitative neuromuscular monitors are medical devices that can objectively measure and display an evoked impulse, such as train of four ratio (TOFR) in real time (6, 7). There are few quantitative neuromuscular monitors available, namely mechanomyography (MMG), electromyography (EMG) and acceleromyography (AMG).

A MMG consists of fixing the hand while applying certain preload to the thumb (8). The force of the contraction is measured from the adductor pollicis muscle while the ulna nerve is stimulated. A transducer picks up the force of muscle contraction and amplifies it to produce a value of TOFR. Although considered the gold standard for neuromuscular monitoring, a MMG is difficult to set up and is therefore not used frequently (7).

The EMG involves the stimulation of a certain nerve and measures the muscular contraction response by means of the action potential. This electrical activity is considered to be proportional to the force of contraction (7). The advantage of this system is that it measures electrical activity instead of force of contraction, and the patient's limb does not need to be fixed. It is however disturbed by electrical interference from electrical equipment like diathermy (7).

An AMG is a piezoelectrical sensor which is used to detect the acceleration of the contracting muscle. AMG is based on Newton's second law which states that a Force (F) is equal to Mass (M) multiplied by Acceleration (A): (F= M X A) (7). A constant mass is delivered by the thumb. Since the acceleration will be equal to the force of contraction it is then processed and displayed on a monitor (8). The patient's hand should be secured on an arm board and the thumb should be free to move (7).

Quantitative neuromuscular monitoring is recommended over qualitative monitoring because of its ability to objectively pick up train of four ratio (TOFR) above 0.9 (3, 7, 9). But, in instances where a quantitative monitor is not available, a PNS should be used (3).

The determinants of neural stimulation include the duration of the stimulus (Chronaxy), the distance of the nerve from the electrode, the minimum current needed to stimulate the nerve (Rheobase), and the area of electrode (3, 8). The smaller the electrode the higher the current density (8).

Several patterns can result from nerve stimulation and are used in clinical practice for monitoring of neuromuscular blockade. These include a single twitch, a train of four (TOF), double burst stimulus (DBS), and a tetanic stimulation (4).

A single twitch is described by the frequency of 1 Hz, with a duration of 0.2 millisecond (ms), and 1 twitch per 10 seconds (s). A single twitch is of little clinical use, and demonstrates that the muscle is stimulated (8).

A TOF stimulation consists of 4 single twitches with a frequency of 2 Hz. During a TOF stimulation there is 1 twitch per 0.5 s, with a duration of 0.2 ms (4). A train of four count (TOFC) is the number of twitches present. They are called T1, T2, T3 and T4. A TOFR is T4/T1 (3, 8). A fade is the reduction in muscle response from T1 toT4 during a TOF with non-depolarizing muscle relaxants (NDMR) (3, 4). This pattern is used to differentiate depolarizing muscle relaxants (DMR) from NDMR. It also determines the degree of the block (3).

A DBS consists of a burst of two or three impulses separated by 0.75 seconds, with a frequency of 50 Hz per burst (8). There is a time difference of 0.02 s between twitches. A DBS is used instead of TOF if no objective monitoring is available, but in awake patient it is more painful (3).

A tetanic stimulation occurs at 50 Hz with a duration of 5 s. It may induce muscle contraction, and it is usually used with post tetanic count (3). During the post tetanic count (PTC) a tetanic stimulation is followed by 3 s of single twitch, at a 1 s interval. It is used to evaluate the intensity of a block when there is no twitch on TOF. The number of twitches present gives an estimation of how long it will take for T1 to appear in TOF (8).

The use of clinical signs such as head lift and hand grip for 5 seconds in timing the reversal of NMBA is inaccurate and unreliable (3, 6). Tracheal extubation of a poorly reversed patient from neuromuscular blockade can result in airway complications with increase in morbidity and mortality (3). Therefore, neuromuscular monitors should be used in all patients who receive NMBA to reduce the risk of postoperative complications such as postoperative residual neuromuscular blockade (PRNMB) (3, 6, 9-11).

PRNMB is defined as train of four ratio below 0.9 (7, 9, 12). Its incidence is estimated to be as high as 40% (9, 10, 13). Patients with PRNMB have an increased risk of airway obstruction, pulmonary aspiration, hypoxia, pharyngeal dysfunction, muscle weakness, reintubation, prolonged postoperative care unit stay as well as patient dissatisfaction (7, 9).

Unfortunately, the literature has shown that 10% and 20% of anaesthetists respectively from North America and Europe do not use any type of neuromuscular monitoring (9, 10). This was despite ample information from publications stressing routine use of neuromuscular monitoring after NMBA were used during general anaesthesia (3, 7, 9, 10, 14).

The use of neuromuscular monitoring in a French hospital increased from 2% in 1995 to 60% in 2004. This has resulted in a decrease in the incidence of PRNMB form 62% to 3% (15). In South Africa, Diedericks et al (16) in 2004 reported that 43% of patients had PRNMB after the use of NMBA. Hassim, also in South Africa in 2016 described an incidence of 45% of PRNMB, after a study on 55 patients that received NMBA at Chris Hani Baragwanath Academic Hospital (CHBAH) (17). This is comparable to other studies that have been conducted elsewhere around the world. However, there was no literature describing the use of neuromuscular monitors in South Africa.

Although, there is a wealth of literature showing the importance of utilising neuromuscular monitoring in patients who receive NMBA, only few countries around the world have included neuromuscular monitoring into their standard of care practice (9).

The American Society of Anaesthesiology (ASA) standard of intraoperative monitoring which was affirmed in 2015 does not yet include routine neuromuscular monitoring (18).

In France, the Czech Republic, New Zealand and Australia neuromuscular monitoring has been incorporated into anaesthetic guidelines (9). Recently, the United Kingdom (UK) introduced PNS as a mandatory tool to be used when NMBA are used. However, the UK also stress that the best monitoring is through quantitative monitors (19).

The South African Society of Anaesthesiologists (SASA) recommends the use of a peripheral neuromuscular transmission monitor when NMBA are used (20).

4.2 Problem statement

The administration of NMBA is associated with perioperative complications (6, 21). It has been shown that the use of neuromuscular monitors decreases the incidence of postoperative complications caused by NMBA (6, 7, 12). Studies from high income countries have shown that only few anaesthetists use neuromuscular monitoring routinely in their daily practice, despite ample information supporting routine neuromuscular monitoring in patients who received NMBA (3, 6, 9-11). Conversely, there is a scarcity of studies assessing the knowledge and frequency of use of neuromuscular monitors in middle- and low-income countries. The knowledge as well as the frequency of use of neuromuscular monitors among anaesthetists at the University of the Witwatersrand (Wits) are unknown. Therefore, a study assessing the knowledge and the frequency of use of neuromuscular monitors in the Anaesthesia Department at Wits is necessary.

4.3 Aim and objectives

4.3.1 Aim

The aim of this study is to determine the knowledge and use of neuromuscular monitoring by the anaesthetists working in the Department of Anaesthesia at Wits.

4.3.2 Objectives

The primary objectives of this study are to:

- determine the level of knowledge on neuromuscular monitoring among anaesthetists in Department of Anaesthesia at Wits.
- determine the frequency of use of neuromuscular monitoring in the perioperative period among anaesthetists in Department of Anaesthesia at Wits.

The secondary objective is to determine factors associated with adequate level of knowledge.

4.4 Research assumptions

The following definitions will be used in this study:

Anaesthetist: is any qualified doctor in the Department of Anaesthesia including medical officers, registrars and consultants. The term anaesthesiologist and specialist anaesthetist are used interchangeably in the literature, and it will be used as it appears in the literature.

Medical officer: is a qualified doctor practising in the Department of Anaesthesia under specialist supervision. Medical officers with more than 10 years of experience are career medical officers and can be regarded as consultants.

Registrar: is a qualified doctor who is registered with the Health Professional Council of South Africa as a trainee anaesthetist.

Consultant: is a specialist anaesthetist or a career medical officer of more than 10 years of experience.

Knowledge: The Angoff method will be used to determine adequate knowledge. In the Angoff method two important components are needed, namely a completed test and judges who are subject experts (22).

An organisation must define who is a subject expert. The group of interest for the judges are borderline or minimally competent candidates. The judges rate each item in the test, of how many minimally competent candidates will likely answer the item correct (22-24). Each item of the test will receive a score or percentage. The ratings of each item must fall within a certain percentage range from each judge such as 30% range (23). The mean of everyone's judgement for each item is calculated.

The mean of individual items is added together and divided by the total number of items in that test. This result is a percentage score that a minimally competent candidate can achieve or the cut-off mark for passing. If the judges are not in agreement, they discuss on how they arrive at their decisions. The Angoff is then recalculated or repeated (23).

Neuromuscular monitoring: a qualitative neuromuscular monitor or PNS is a simple medical device that delivers a current to a peripheral nerve causing an evoked response of the muscle innervated by that nerve. The assessment of the evoked response from the innervated muscle is detected subjectively by the clinician by visual or tactile perception of the muscle contraction (6, 7). In contrast, quantitative neuromuscular monitors are medical devices that can objectively measure and display evoked impulses such as TOFR in real time (6, 7).

4.5 Demarcation of study field

The study will be conducted in the Department of Anaesthesia affiliated to the Faculty of Health Sciences at Wits. The staff complement of the department is 74 consultants, 112 registrars, and 22 medical officers.

4.6 Ethical considerations

The approval to conduct the study will be obtained from the Human Research Ethics Committee (Medical) and the Graduate Studies Committee at Wits.

The academic Head of the Department of Anaesthesia at Wits has given permission to conduct this research in her department (Appendix A). Permission has been granted by Prof Naguib to adapt and use some of his questionnaire (Appendix B).

The participation will be voluntary, using a questionnaire during an academic departmental meeting. The study will be explained, an information letter (Appendix C and D) together with the questionnaire (Appendix E) will be given to participants to answer and return in a sealed container. This will constitute an implied consent. The anonymity and the confidentiality will be maintained as no personal identifying information will be used or asked. Only the primary researcher and supervisor will have access to raw data. Raw data will be stored in a secure cupboard for 6 years from the date of completion of the study.

Academic meetings have been replaced by online meetings for unforeseeable time because of Covid-19 pandemic, as a result an online questionnaire using google forms was considered for data collection. Google forms is provided by Google®. An information letter (Appendix D) will be attached to the online questionnaire. Following approval of the study, anaesthetists working at Wits will be invited to participate in the study via e-mail. The e-mail will also have a link for questionnaire completion. Consent will be implied when the participant clicks on the link and proceed to answer the questionnaire and clicking on the “submit” tab to submit the response.

A soft copy of captured raw data will be protected by a password only known to the primary researcher. Since this is a study assessing knowledge, findings of inadequate knowledge from the participants warrants information workshop and answers to specific questions will form part of the recommendations to the department.

The study will be conducted according to the principles of the Declaration of Helsinki (25) and the South African Guidelines for Good Clinical Practice (26).

4.7 Research methodology

4.7.1 Research design

The study will follow a prospective, contextual study design.

In a prospective study data on a specific cause is collected, after which it is analysed for the outcome, or the researcher identifies a certain population and follows it over some time to observe the outcome (27). In this study data will be collected from anaesthetists who will be working at Wits Department of anaesthesia attending academic meeting or via online questionnaire.

A contextual study refers to a specific population or environment (28). This study is contextual because the specific population will be anaesthetists working in Department of Anaesthesia at Wits.

4.7.2 Study population

The study population will comprise of all consenting anaesthetists working in the Department of Anaesthesia at Wits.

4.7.3 Study sample

Sample size

A questionnaire will be distributed to anaesthetists working in the Department of Anaesthesia at Wits. In consultation with a biostatistician, it was determined that a response rate of 60% is required to assess the level of knowledge and detect a difference in knowledge between participants, assuming a 5% margin of error and a 95% confidence level.

Sampling method

In this study a convenience sampling method will be used. It is a non-probability method of sampling in which the researcher determines and chooses the participants who know most about the subject and can comfortably articulate it to the researcher (27).

In a convenience sampling, there is easy availability and accessibility of participants to the researcher (27). Participants will be anaesthetists working for the Department of Anaesthesia at Wits attending academic meeting or the online questionnaire will be sent to anaesthetists working for the Department of Anaesthesia at Wits.

4.7.4 Inclusion and exclusion criteria

The inclusion criteria for this study will be all anaesthetists working in the Department of Anaesthesia at Wits:

- attending the academic meeting or via email for online questionnaire.
- that will give the consent to participate.

The exclusion criteria for this study will be:

- rotating doctors from other departments.
- anaesthetic interns.
- Anaesthetists included in validating the questionnaire.

4.7.5 Data collection

Questionnaire development

The questionnaire was developed reviewed literature and with the help of a senior anaesthetist with special interest in neuromuscular monitoring. One questionnaire was identified as appropriate for this study form (29). Approval for use of adapted questions from study was granted (Appendix B).

Content validity was ensured by extensive reading in order to have a representative questionnaire on the topic. Face validity was ensured by three senior anaesthetists working in the Department of Anaesthesia at Wits. Angoff method will be used to determine the level of knowledge among anaesthetists in the Department of Anaesthesia at Wits.

Data collection

A questionnaire (Appendix E) will be distributed to the consenting participants. It comprises of 20 questions on clinical use of neuromuscular monitoring with multiple choice and tick box questions. It also has demographic questions like age and designation. The questionnaire will be administered during our departmental academic meeting and participants will answer during a single sitting and the questionnaires will then be collected in a sealed box. The questionnaire should take approximately 15 minutes to complete. Academic meetings have been replaced by online meetings for unforeseeable time because of Covid-19 and as a result online questionnaire using Goole forms will be considered. Google forms is provided by Google®. It allows for information to be collected by simple web form.

A questionnaire is electronically prepared and sent out to participants via an email (30). The participants will answer the questionnaire and return it to the researcher. An information letter (Appendix D) will be attached for the participants. Google forms is available for free.

4.7.6 Data analysis

All raw data will be captured using Microsoft® excel spread sheet. The knowledge score will be further analysed into mean and standard deviation or median and interquartile range depending on how data is distributed. To compare knowledge between professional designations Anova test will be used for normally distributed data while Kruskal-Wallis test will be used if data is not normally distributed. A p-value < 0.05 will be taken as statistically significant.

Data will be analysed using STATA version 16 Statistical software. Factors associated with adequate level of knowledge will also be determined. Incomplete questionnaire returned will be included and a score of zero will be allocated to unanswered question.

4.8 Significance of the study

With scanty information available on PRNMB and neuromuscular monitoring in South Africa the introduction of routine neuromuscular monitoring can help improve our patient outcomes postoperatively. Though the results of this study cannot be generalised, these will provide a good idea on the current state of neuromuscular monitoring use as well as the level of knowledge among anaesthetists in Wits.

This can be used as a foundation for further research. Since this is a study assessing knowledge, findings of inadequate knowledge from the participants warrants information workshop and answers to specific questions will form part of the recommendations to the department.

4.9 Validity and reliability of the study

The validity and reliability of this study will be ensured by:

- appropriate study design
- having a representative sample of the study population
- involving a biostatistician for data analysis
- have one person collecting data
- no data contamination during academic meeting
- risk of data contamination if online questionnaire is used
- data checks to assess accuracy and validity.

4.10 Potential limitations

The study population will depend on the number of anaesthetists who attend academic meeting or who respond to the online questionnaire. This might make it difficult to achieve the calculated sample size.

Although this study will represent the anaesthetists working in Department of Anaesthesia at Wits, it cannot reflect the practise in other centres in the country. This will be a single centre study.

4.11 Project outline

4.11.1 Time frame

Activity	08/ 2019	10/ 2019	12/ 2019	02/ 2020	04/ 2020	06/ 2020	08/ 2020	10/ 2020	12/ 2020	02/ 2021	04/ 2021	06/ 2021
Proposal preparation												
Literature review												
Proposal submission												
Ethics approval												
Postgraduate approval												
Data collection												
Data analysis												
Draft article												
Submission												

4.11.2 Budget

The Wits Department of Anaesthesiology will incur the costs of paper and printing

Item	Price per page	Number of pages	Copies	Total
Proposal	1	15	10	R 150
Ethics	1	10	25	R 250
Postgraduate form	1	2	6	R 12
Complete report	1	100	4	R 400
Information letter	1	2	150	R 300
Questionnaire	1	6	150	R 900
Grand total				R 2,012

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4.13 Appendices

Appendix A: Permission form academic Head of Department



GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

WITS UNIVERSITY

Department of Anaesthesia – University of the Witwatersrand

7 York Road, Parktown, 2193 South Africa • Telegrams "Witsmed" • Telephone (011) 488-4344 • Fax (011) 488-4343

Department of Anaesthesia
Area 361
Charlotte Maxeke Johannesburg Academic Hospital

Tel: 011 488-4344

10th December 2019

Subject: **Permission to conduct survey from Department of Anaesthesiology**

To whom it may concern,

This letter stands to affirm that I, Dr PMV Motshabi, grant permission to Dr Michael Kgowe Setsomelo HPCSA number MP 0826413, to conduct survey in Department of Anaesthesiology at University of Witwatersrand for his study "Anaesthetist's knowledge and frequency of neuromuscular monitoring use at the University of the Witwatersrand".

The approximate period will be, but not limited to, the months of January 2020 to June 2020, until his sample size is obtained. The information obtained from the data will be used for
Dr Setsomelo research study for his Masters in Medicine only, and will include information and data relevant to his study.

Yours sincerely,

WITS UNIVERSITY

Dr Palesa Motshabi
Academic Head: Department of Anaesthesia
Head of Clinical Unit: Cardiac Anaesthesia

Tel: +27 (0)11 488 4344
Cell: 083 432 1994
Email: palesa.motshabi@wits.ac.za
Website: www.wits.ac.za

WITS SCHOOL OF CLINICAL MEDICINE

FACULTY OF HEALTH SCIENCES

Charlotte Maxeke Johannesburg Academic Hospital, 6th Floor, Area 361/16, Jubilee Road, Parktown, Johannesburg

Appendix B: Permission from authors

Naguib, Mohamed, MB, BCh, MSc, FFARCSI, MD <NAGUIBM@ccf.org>

To: Michael Kgowe Setsomelo

Sep 4 at 1:27 AM

Dr. Setsomelo,

You have my permission to use the questionnaires provided that you clearly acknowledge the source in the text and in references.

Regards,

Mohamed Naguib

Professor of Anesthesiology

Appendix C: Hard copy information letter

Dear colleague

My name is Michael Kgowe Setsomelo. I am a registrar in the Department of Anaesthesia at Wits. I would like to invite you to participate in my research study entitled “Anaesthetists’ knowledge and frequency of use of neuromuscular monitoring at the University of the Witwatersrand**”.** This research report will be submitted to the Faculty of Health Science to fulfil the requirements for my Master of Medicine (MMed) degree.

The aim of the study is to determine the knowledge and frequency of use of neuromuscular monitoring by anaesthetists in our department using a self-administered questionnaire. It is important to know the latest guidelines and recommendations to help prevent possible postoperative residual neuromuscular blockade complications.

Participation in the study is voluntary and there is no penalty for refusal to do so. By completing the questionnaire, consent is implied. Information will be kept anonymous and confidential as none of your personal details will be required. My supervisors and I are the only people who will have access to the raw data. Completion of the questionnaire should take approximately 15 minutes. Please fold the completed questionnaire and place it in the provided sealed collection box at the door. Please do not share information during the completion of the questionnaire to allow an accurate reflection of anaesthetists’ knowledge.

Permission to conduct this study will be sought from the Health Research Ethics Committee (HREC) and the Wits Graduate Studies Committee. If you have any questions, please contact me. My contact details are Michael Kgowe Setsomelo, Cell: 0767507541, Email: mikekese@yahoo.com . You are also welcome to contact any one of my supervisors, Dr Lunganga Toms Lushiku on 0826874211 or Dr Sithandiwe Dingezweni on 0738165451 or the Chairperson of the Human Research Ethics Committee (Medical), who is Professor Clement Penny, who may be contacted on the telephone number 0117172301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee

Secretariat are 0117172700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mkansi@wits.ac.za .

Thank you for taking time to read this letter.

Yours Sincerely

Michael Kgowe Setsomelo

Appendix D: Electronic copy information letter

Dear colleague

My name is Michael Kgowe Setsomelo. I am a registrar in the Department of Anaesthesia at Wits. I would like to invite you to participate in my research study entitled “Anaesthetists’ knowledge and frequency of use of neuromuscular monitoring at the University of the Witwatersrand**”.** This research report will be submitted to the Faculty of Health Science to fulfil the requirements for my Master of Medicine (MMed) degree.

The aim of the study is to determine the knowledge and frequency of use of neuromuscular monitoring by anaesthetists in our department using a self-administered questionnaire. It is important to know the latest guidelines and recommendations to help prevent possible postoperative residual neuromuscular blockade complications.

Participation in the study is voluntary and there is no penalty for refusal to do so. By clicking on the link and proceeding to answering the questionnaire and clicking the “Submit” tab to submit, consent is implied. Information will be kept anonymous and confidential as none of your personal details will be required. My supervisors and I are the only people who will have access to the raw data. Completion of the questionnaire should take approximately 15 minutes.

Permission to conduct this study will be sought from the Health Research Ethics Committee (HREC) and the Wits Graduate Studies Committee. If you have any questions, please contact me. My contact details are Michael Kgowe Setsomelo, Cell: 0767507541, Email: mikekese@yahoo.com . You are also welcome to contact any one of my supervisors, Dr Lunganga Toms Lushiku on 0826874211 or Dr Sithandiwe Dingezweni on 0738165451 or the Chairperson of the Human Research Ethics Committee (Medical), who is Professor Clement Penny, who may be contacted on the telephone number 0117172301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee Secretariat are 0117172700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mkansi@wits.ac.za .

Thank you for taking time to read this letter.

Yours Sincerely

Michael Kgowe Setsomelo

Appendix E: Questionnaire

Demographics

Please tick the appropriate box

AGE	20-30 ☐	31-40 ☐	41-50 ☐	51-60 ☐	>60 ☐

Designation

Medical officer	☐
Registrar	1st year ☐ 2nd year ☐ 3rd year ☐ 4th year ☐
Consultant	☐
Career Medical Officer	☐

Please complete the following questions by circling the letter next to your choice. There is only one correct answer per question.

1. Supramaximal stimulus is defined as

A A stimulus 0-10% greater than the maximal stimulus.

B A stimulus 11-20% greater than the maximal stimulus.

C A stimulus 30% greater than the maximal stimulus.

D I do not know.

2. The most recommended site for neuromuscular monitoring is

A Ulna/adductor pollicis.

B Facial nerve/orbicularis oculi.

C Facial nerve/corrigator suppercili.

D I do not know.

3. Postoperative residual neuromuscular blockade is defined as

A Train of four ratio less than 0.7.

B Train of four ratio more than 0.7.

C Train of four ratio less than 0.9.

D I do not know.

4. In train of four stimulation

A Four stimuli are provided at 2-Hz frequency.

B Four stimuli are provided at 50-Hz frequency.

C Four stimuli are provided at 100-Hz frequency.

D I do not know.

5. The earliest that neostigmine should be administered to achieve complete reversal is

A Reappearance of a single twitch on train of four.

B Train of four ratio less than 0.9.

C Train of four count more than 2.

D I do not know.

6. Fade

A Is usually seen when using depolarizing muscle relaxants.

B Is a reduction of muscle response from the first to the last twitch in a train of four in non-depolarizing muscle relaxants.

C Is a reduction of muscle response from the first to the last twitch in a train of four in depolarizing muscle relaxant.

D I do not know.

7. Airway reflexes are returned at

A Train of four ratio greater than 0.6.

B Train of four ratio greater than 0.7.

C Train of four ratio greater than 0.9.

D I do not know.

8. Double burst stimulus

A consists of 2 or 3 impulses at 100-Hz separated by 0.75 seconds.

B Consists of direct comparison of 2 sequential contractions.

C Consists of comparison of the fourth and first responses in a train of four.

D I do not know.

9. In post-tetanic count

A A 5 seconds tetanic stimulus is provided, followed 3 seconds later by 10-20 single stimuli.

B A 3 seconds tetanic stimulus is provided, followed 5 seconds later by 10-20 single stimuli.

C A frequency of 50-Hz is applied for 5 second.

D I do not know.

10. In post-tetanic count

A More post-tetanic single twitch responses indicate profound block.

B More post-tetanic single twitch responses indicate no block.

C More post-tetanic single twitch responses indicate less block.

D I do not know.

11. Deep block is defined as post-tetanic count of

A Less than 4.

B 4-10.

C More than 10.

D I do not know.

12. What would produce optimal nerve stimulation

A 50 V.

B 50 Hz.

C 50 mA.

D I do not know.

13. Prior to tracheal extubation, train of four ratio should be

A 71-80%.

B 81-90%.

C 91-100%.

D I do not know.

14. Which of the following is the commonest method used to monitor a block

A Electromyography.

B Mechanomyography.

C Acceleromyography.

D I do not know.

15.To eliminate the effects of skin resistance a peripheral nerve stimulator should provide

A Constant voltage.

B Constant current.

C Both constant voltage and current.

D I do not know.

16. How many general anaesthesia cases do you do in an average week?

☐ 0-10.

☐ 11-20.

☐ 21-30.

☐ >30.

17. How many of these general anaesthesia cases do you usually paralyse?

☐ 0-10.

☐ 11-20.

☐ 21-30.

☐ >30.

18. In how many of the cases that you paralyse do you use neuromuscular monitoring?

☐ 0-10.

☐ 11-20.

☐ 21-30.

☐ >30.

19. How do you decide which cases you use neuromuscular monitoring on?

☐ Type of muscle relaxant used.

☐ Length of surgical procedure.

☐ Patient comorbidity.

☐ Others (specify).

.....

.....

20. Why would you not use neuromuscular monitoring in every case?

☐ Depends on availability of neuromuscular monitors.

☐ Limited knowledge on neuromuscular monitoring use.

☐ Time consuming.

☐ Others (specify).

.....

.....

The End

Section 5: Annexures

5.1 Ethics Approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Dr Michael Kgowe Setsomelo

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M200807 MED20-07-154

NAME: (Principal Investigator)	Dr Michael Kgowe Setsomelo
DEPARTMENT:	Anaesthesiology
PROJECT TITLE:	Anaesthetists' knowledge and frequency of use of neuromuscular monitoring at the University of the Witwatersrand
DATE CONSIDERED:	28/08/2020
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Lunganga Toms Lushiku and Dr Sithandiwe Dingezweni
APPROVED BY:	Dr C Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	28/10/2020

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed August and will therefore be due in the month of August each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

5/11/20
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

5.2 Graduate studies approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

06 January 2021
Person No: 2051294
PAG

Dr MK Setsomelo
P O Box V1920
Ramotswa
Botswana
4001
Botswana

Dear Dr Michael Setsomelo

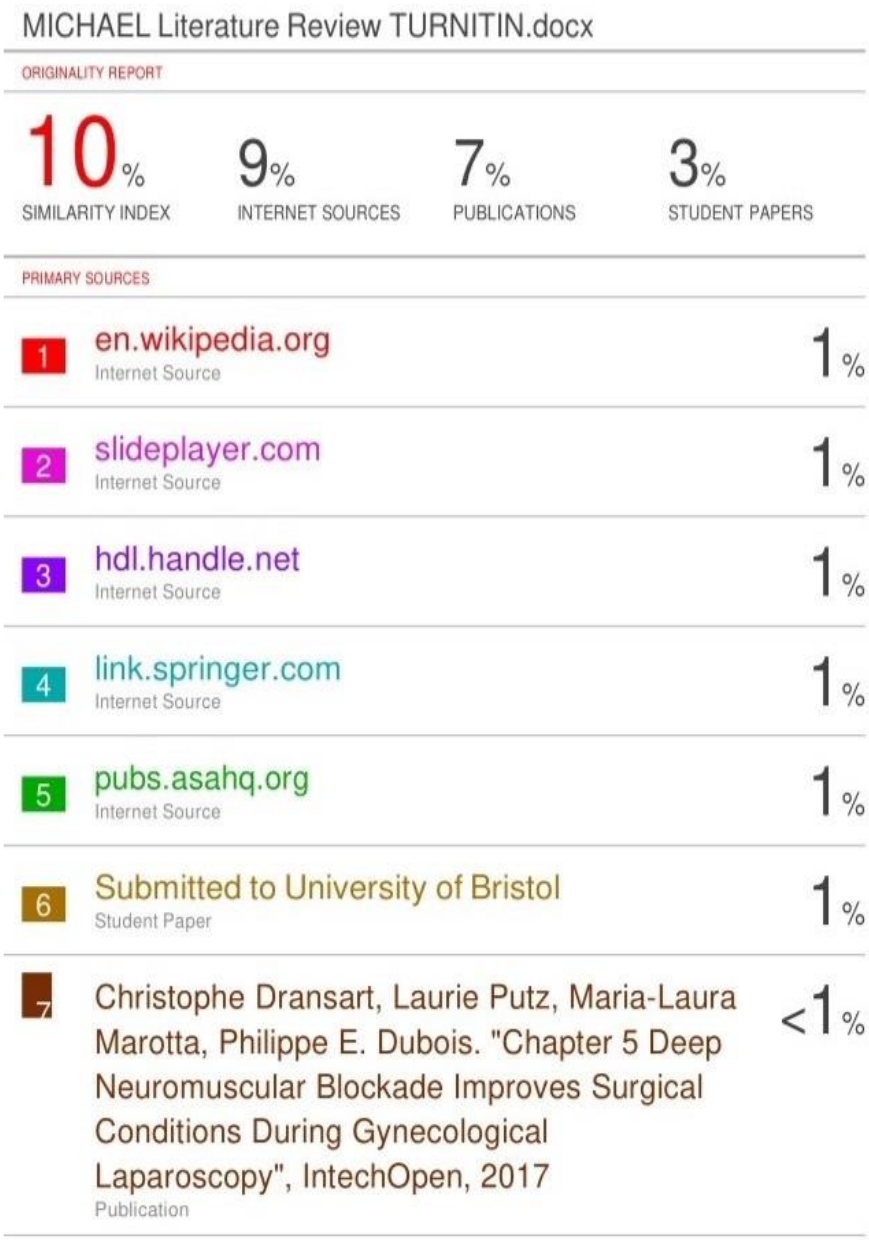
Master of Medicine in Anaesthesia: Approval of Title

We have pleasure in advising that your proposal entitled *Anaesthetists' knowledge and frequency of use of neuromuscular monitoring at the University of Witwatersrand* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

5.3 Turnitin report



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