Original research article

Effect of neuromuscular blockade on changes in tidal volume, during face mask ventilation in patients undergoing general anesthesia

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Abstract

Background

Following induction of anaesthesia, the practice of checking the ability to mask ventilate before administering neuromuscular blocking drugs remains controversial. In this context, we wished to study effect of neuromuscular blockade on the ease of facemask ventilation by measuring changes in tidal volume.

Objectives: Objectives of the study was to evaluate any change in expired tidal volume after administering neuromuscular blocking drugs during pressure-controlled ventilation in anesthetized patients and to assess the effect of body mass index & neck circumference on tidal volume and ease of mask ventilation.

Methods: After approval from the ethical committee and obtaining informed written consent from each patient, 87 adult patients aged > 18 years, of ASA physical status 1–2, scheduled to undergo elective surgery under GA were included in this observational study. Preoperative assessment of participants was done on the previous day and the participants were premedicated. Following preoxygenation, general anaesthesia was induced using fentanyl and propofol. The patients' lungs were ventilated using PCV at 15 cmH2O pressure, 12 breaths/min. Initial grade of mask ventilation was assessed as described by Hans *et al*. Anaesthesia was maintained with sevoflurane with a FGF of O_2 6l/min. Once stabilized, the expired tidal volumes with each breath were recorded for 2 min. After administration of Vecuronium, following the absence of twitches on train of four, individual patient values for expired tidal volume at 1 min, 2 min and 3 min after the onset of block were measured and each averaged to get a mean tidal volume. The mean expired tidal volumes were compared using paired t tests.

Results: There was a significant increase in the mean tidal volume (SD) following administration of neuromuscular blocking drugs from 451 (61.5) ml to 557(72.5) ml (p< 0.001) & no deterioration in tidal volume in any of the patients in whom neuromuscular blocking drugs were administered. The increase in mean expired TV was significantly higher in the low-BMI group compared with the high-BMI group. 71% of patients with neck circumference >40 was classified as grade 3 mask ventilation. When comparing the low-neck circumference group (neck circumference < 40) to the high neck circumference group, the increase in mean expired tidal volume was significantly higher in the low-neck circumference group (p<0.001)

Conclusion: Facemask ventilation became easier after administering neuromuscular blocking drugs, as evidenced by improvement of expired tidal volume. Hence, neuromuscular blocking drugs can be considered to facilitate Facemask ventilation in patients with normal airway.

Keywords: Face mask ventilation, neuromuscular blocking drugs, vecuronium, general anaesthesia

Introduction

Neuromuscular blocking drugs (NBDs) are usually administered prior to tracheal intubation in anaesthetic practice[1]. Following induction of anaesthesia, before the administration of neuromuscular blockers, whether effective Facemask Ventilation (FMV) should be established is an area of controversy.

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The main concern is that after administration of neuromuscular blockers there is a period of apnoea during which effective facemask ventilation to be provided. The inability to mask ventilate following neuromuscular blocking drug can compromise patient safety if tracheal intubation proves to be impossible.

This has led to routinely confirming ability to carry out Bag and Mask Ventilation before administering a Neuromuscular Blocker. If facemask ventilation proves to be effective, anaesthetist will administer a neuromuscular blocker. If facemask ventilation is ineffective following induction of anaesthesia, nonparalyzed patients can be woken up, and subsequently an alternative airway management can be considered. However, at this point the chance of restoring sufficient spontaneous respiration before severe hypoxemia develops is very small, because the additional doses of anaesthetics that are likely to have just been administered in an attempt to facilitate FMV will promote upper airway collapse and respiratory depression[2].

On the other hand, difficult mask ventilation secondary to laryngospasm and opioid-induced muscle rigidity can be improved following administration of neuromuscular blocker, making mask ventilation easier. Furthermore, in cases where mask ventilation is difficult or impossible, after Neuromuscular blockers tracheal intubation can be achieved successfully[3].

In the context of ongoing controversy as to whether effective facemask ventilation (FMV) should be established following induction of anaesthesia before a muscle relaxant is administered, we wished to study effect of neuromuscular blockade on ease of FMV by measuring changes in tidal volume, in patients undergoing general anaesthesia.

Methodology

An observational study was conducted after obtaining approval from the ethical committee & obtaining informed written consent from each patient. 87 adult patients aged > 18 years, of ASA physical status 1–2, scheduled to undergo surgery under general anaesthesia and receiving a Neuromuscular blocking Drug (NBD) to facilitate tracheal intubation were included in the study. Patients in whom an NBD was not indicated or patients with anticipated difficult mask ventilation (rapid sequence induction, difficult airway), any patient with respiratory diseases, patients with BMI> 35 kg/m^2, neuromuscular disorder, craniofacial abnormalities, patients who refuse to participate in the study were not included in the study.

Preoperative assessment of participants was done on the previous day and informed written consent was taken. Participants were premedicated with oral pantoprazole 40 mg and alprazolam 0.5 mg the night before and 2 hours prior to surgery. On the day of surgery, patient was reassessed. In the operating room, airway cart and drugs were kept ready. The anaesthesia machine (MINDRAY WATO EX-20) was checked. Then patient was brought to the operating room, blood pressure, heart rate, ECG and SpO_2 monitors were connected. After securing IV access, patient was premedicated with Inj Midazolam 0.02-0.05mg/kg iv, InjGlycopyrrolate 0.005 mg/kg iv, InjOndansetron 0.1mg/kg iv, Inj Fentanyl 1-2mcg/kg iv. Following preoxygenation , general anaesthesia was induced with Inj Propofol 2–3 mg/kg preceded by Inj Lignocaine 1.5 mg/kg iv. The head and neck of patient was maintained in the in the 'sniffing the morning air' position with one pillow under the head, ensuring that the lower level of the pillow did not extend beyond the shoulders. The patients' lungs were ventilated using pressure-controlled ventilation at 15 cmH2O pressure, at a rate of 12 breaths/min. The initial grade of mask ventilation was assessed as described by Han *et al*[4]. (Table 1).

Table 1: Han scale for mask ventilation

	Description
Grade 1	Ventilated by mask single- handed
Grade 2	Difficult to ventilate, oropharyngeal airway inserted
Grade 3	Ventilated by mask with jaw thrust, airway manoeuvres and two-handed technique
Grade 4	Unable to ventilate

An appropriately sized oropharyngeal airway was inserted, an optimum jaw thrust was performed and the mask was held with both hands as tightly as possible to achieve an adequate tidal volume. Anaesthesia was maintained with Sevoflurane 2% with a fresh gas flow of oxygen 6 l/min. Once stabilized, the expired tidal volumes with each breath were recorded for 2 min. At this time, vecuronium 0.1mg/kg was administered and ventilation was continued. The onset of neuromuscular blockade was monitored using train-of-four by stimuli. The absence of response to train of four stimuli was considered as establishment of neuromuscular blockade. The expired tidal volumes with each breath were recorded for another 3 min. The individual patient values for expired tidal volume before administering the Neuromuscular blocking drug, 1 min, 2 min and 3 min after the establishment of block was measured and each averaged to get a mean tidal volume. All recordings were performed by the investigator.

The primary endpoint in this study was a change in the expired tidal volume following administration of Neuromuscular blocking Drug. An improvement in the expired tidal volume by 20% following administration of Neuromuscular blocking Drug was considered to be significant.

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After collecting data, it was entered to a computer and was analysed by SPSS software. Quantitative variables were expressed in mean (SD). And then mean expired tidal volume was compared using paired T test. To test the effect of BMI on Tidal volume, correlation coefficient was computed. The necessary tables were constructed along with charts and diagrams.

Observations and Results

The mean age (±SD) in years of the study participants was 44.9±14.3
The mean weight(±SD) in kg of the study participants was 66.5±11.7
The mean height(±SD) in metres of the study participants was 1.6±0.08
The mean BMI (±SD) of the study participants was 27±4.2

Distribution of study participants based on the gender

Table 2: Distribution of study participants based on the gender, N=87

Gender	Frequency (%)
Male	36(41.4)
Female	51(58.6)

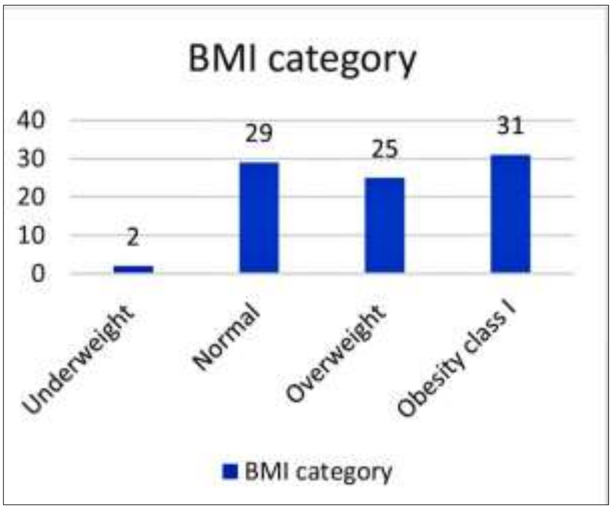
Male gender distribution was found to be 41% and the female gender was found to be 59% among the study population.

Distribution of study participants based on the BMI category

Table 3: Distribution of study participants based on the BMI category, N=87

BMI category	Frequency (%)
Underweight (<18.5)	2(2.3)
Normal (18.5-24.9)	29(33.3)
Overweight (25-29.9)	25(28.7)
Obesity class I (30- 34.9)	31(35.6)

More than half (65%) of study population had BMI
>25(obesity class I of 36%, overweight of 29%) followed by normal BMI in 33% and underweight in 2%, of the study population.



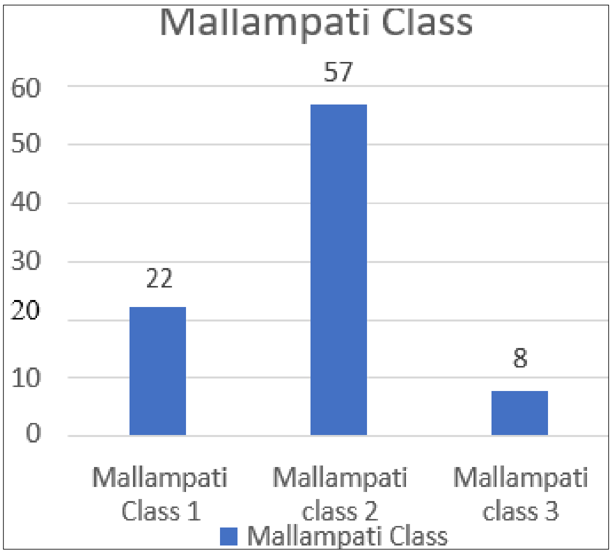
Graph 1: Distribution of study participants based on the BMI category

Distribution of the study population on the basis of Mallampati score, N=87

Table 4: Distribution of the study population on the basis of Mallampati score, N=87

Mallampati class	Frequency (%)
1	22(25.3)
2	57(65.5)
3	8(9.2)
4	0

On the basis of the Mallampati class it was found that 66% of the patients had a score of 2, followed by 25% with score 1 and 9% of the people had score of 3.



Graph 2: Distribution of the study population on the basis of Mallampati score

Distribution of study participants based on difficult airway markers, N=87

Table 5: Distribution of study participants based on difficult airway markers, N=87

Characters	Frequency (%)
Edentulous	17(19.5)
Presence of beard	6(6.9)
History of snoring	19(21.8)
Receding jaw	3(3.4)
Limited neck movement	2(2.3)

On the basis of the history given by the study population, it was found that 22% had history of snoring and 20% had evidence of being edentulous.
In 7% of the people, beard was present. Receding jaw was seen in 3.4 % of the population followed by limited neck movements in 2.3 % of the individuals.

Distribution of study participants based on grading of mask ventilation before neuromuscular Blockade, N=87

Table 6: Distribution of study participants based on grading of mask ventilation before neuromuscular Blockade, N=87

Grading of mask ventilation	Frequency (%)
Grade 1	30(34.5)
Grade 2	43(49.4)
Grade 3	14(16.1)
Grade 4	0

On the basis of grading of mask ventilation before neuromuscular blockade, 49% of the study people were in grade 2 followed by the grade 1 and 16% in grade 3.

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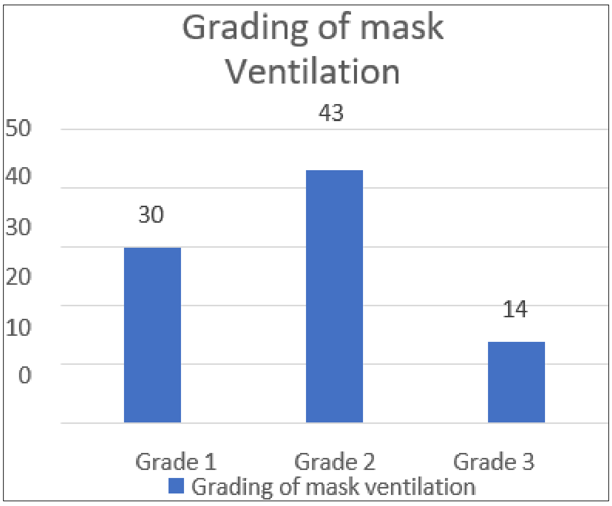


Graph 3: Distribution of study participants based on grading of mask ventilation before neuromuscular Blockade

Distribution of study participants-based grade of mask ventilation before administrating the NMB, N=87

Table 7: Distribution of study participants-based grade of mask ventilation before administrating the NMB, N=87

Grade of mask ventilation	Underweight	Normal	Overweight	Obesity class 1
Grade 1	2(6.7%)	23(76.7%)	5(16.7%)	0
Grade 2	0	6(14%)	19(44.2%)	18(41.9%)
Grade 3	0	0	1(7.1%)	13(92.9%)
Grade 4	0	0	0	0

Among patients with BMI ≤25 kg.m2, 80% were classified as grade 1 mask ventilation. On the other half, ie patients with BMI ≥ 25 kg.m2, 91% were classified as grade 2&3 mask ventilation.

Distribution of study population based on neck circumference and grades of MV, N=87

Table 8: Distribution of study population based on neck circumference and grades of MV, N=87

Grades	Neck circumference<40 cm (%)	Neck circumference>40 cm (%)
Grade 1	30(100)	0
Grade 2	39(90.7)	4(9.3)
Grade 3	4(28.6)	10(71.4)

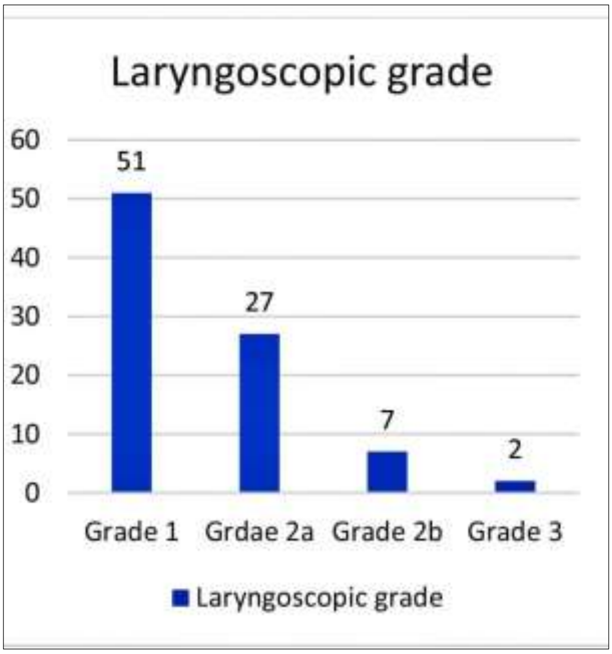
71% of patients with neck circumference >40 was classified as grade 3 mask ventilation.

Distribution of study participants based on Cormack Lehane laryngoscopy grade, N=87

Table 9: Distribution of study participants based on Cormack Lehane laryngoscopy grade, N=87

Laryngoscope grade	Frequency (%)
1	51(58.6)
2a	27(31)
2b	7(8)
3	2(2.3)
4	0

On the basis laryngoscopic grading, 59% patients were grade 1 , 31% grade 2a , 8% for grade 2b. Only 2% of patients were grade 3.



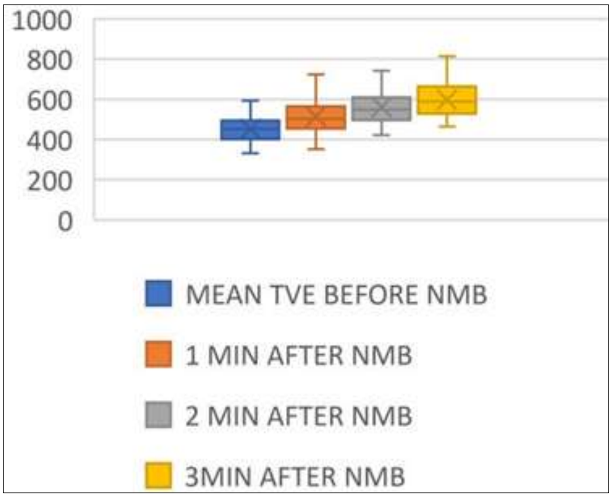
Graph 4: Distribution of study participants based on laryngoscope blade grade

Distribution of study population on the basis of expired tidal volume (TVE) before and after neuromuscular blockade (NMB), N=87

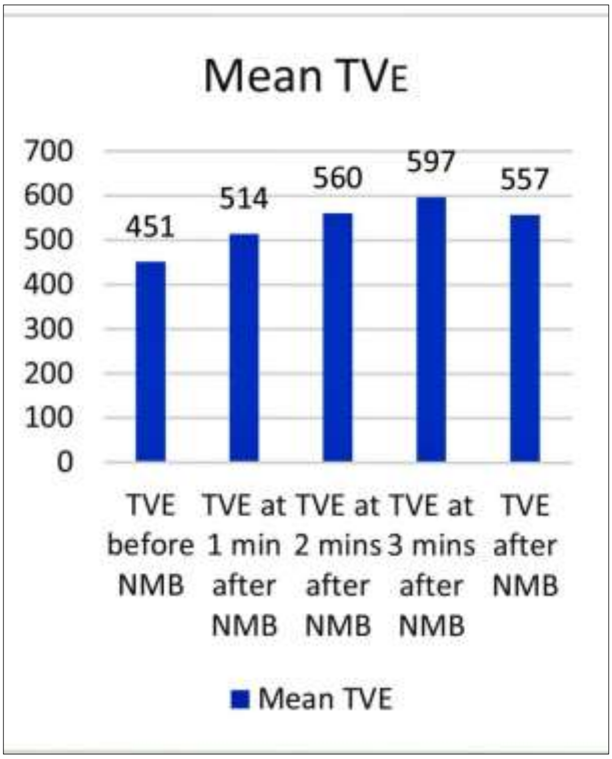
Table 10: Distribution of study population on the basis of expired tidal volume (TVE) before and after neuromuscular blockade (NMB), N=87

TVE	Mean (SD)
TVE before NMB	451.9(61.5)
TVE 1 minute after NMB	514.1(75)
TVE 2 minutes after NMB	560.6(72.5)
TVE 3 minutes after NMB	597.9(81.1)
Mean TVE after NMB	557.6(72.5)

The mean (SD) expired tidal volume was calculated before and after the administration of neuromuscular blockade which was found to be 451.9(61.5) and 557.6(72.5) respectively. TVE was assessed at 1 min ,2 mins and 3 mins which was found to be 514.1(75), 560.6(72.5) and 597.9(81.1) respectively.



Graph 5: Expired tidal volume (TVE) before and after administering NMB



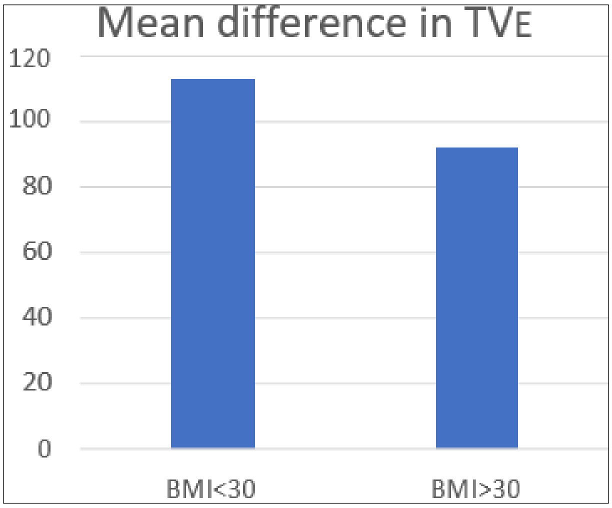
Graph 6: Mean expired tidal volume (TVE) before and after neuromuscular blockade (NMB)

Distribution of study population on the basis of mean difference between the expired tidal volume (TVE) before and after neuromuscular blockade (NMB), N=87

Table 11: Distribution of study population on the basis of mean difference between the expired tidal volume (TVE) before and after neuromuscular blockade (NMB), N=87

TVE	Mean difference	P value
TVE before NMB and TVE after 1 minute of NMB	-62.3	0.0001
TVE before NMB and TVE after 2 minutes of NMB	-108.7	0.0001
TVE before NMB and TVE after 3 minutes of NMB	-146.1	0.0001
TVE before NMB and mean TVE after NMB	-105.7	0.0001

The mean difference between TVE before the NMB administration and TVE after NMB at 1 min,2 min and 3 mins was found to be -62.3, -108.7 and -146.1 respectively. The mean difference was found to statistically significant between the points of assessment at various time points.



Graph 7: Mean expired tidal volumes before and after administering NBD in low and high BMI groups

The increase in mean expired tidal volume was significantly higher in low BMI group (BMI<30) compared with the high BMI group ($p<0.001$)

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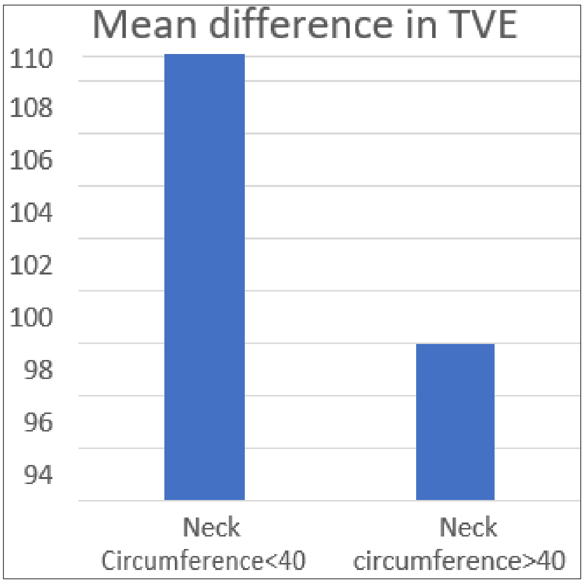


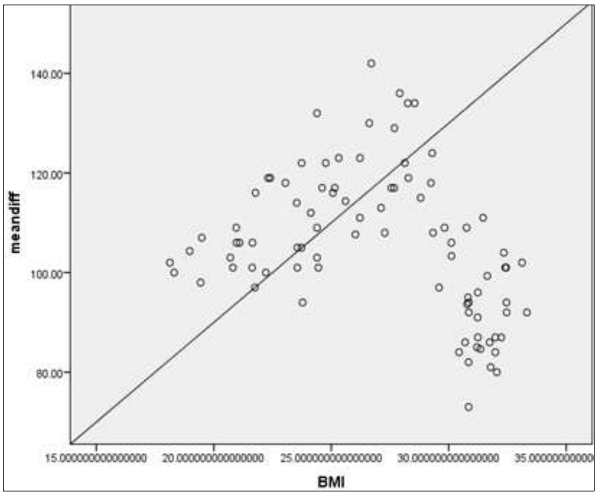
Graph 8: Mean expired tidal volumes before and after administering NBD in low and high Neck circumference groups

The increase in mean expired tidal volume was significantly higher in low neck circumference group (neck circumference <40) compared with the high neck circumference group (neck circumference >40) (p<0.001).

Correlations between TVE before and after NMB with neck circumference and BMI among the study population, n=87

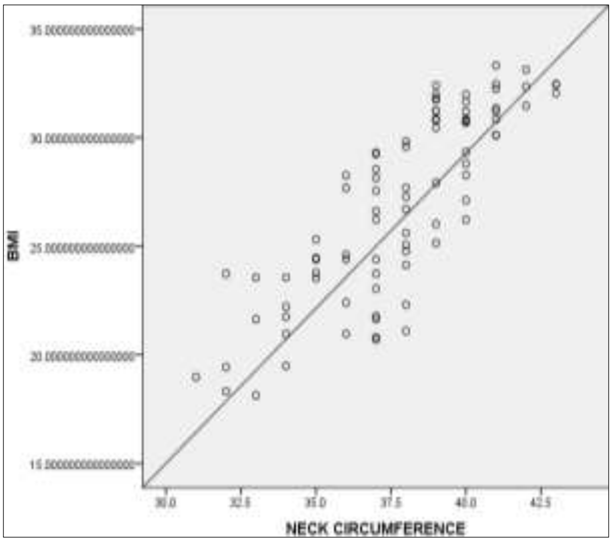
The correlation was found between Neck circumference, Mean difference of TVE before and after the NMB administration & BMI. It was found that the Neck circumference was found to have significant positive weak correlation (r=0.2) with mean difference of TVE. The BMI was found to have strong correlation with neck circumference(r=0.8).

Correlation between BMI and mean TVE difference before and after NMB(r=0.2)



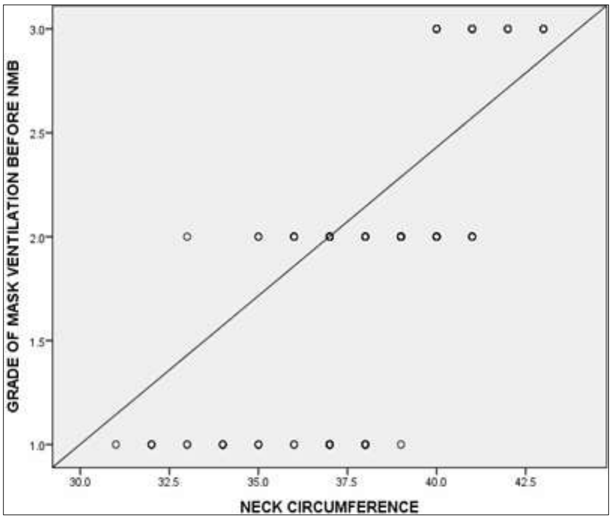
Graph 9: Correlation between BMI and mean TVE difference before and after NMB

Correlation between BMI and neck circumference (r=0.8)



Graph 10: Correlation between BMI and neck circumference

Correlation between grade of mask ventilation before NMB and neck circumference



Graph 11: Correlation between grade of mask ventilation before NMB and neck circumference

Discussion

The present study showed that the mean (±SD) age in years of the study participants was 44.9±14.3 whereas in a study conducted by the Sachdeva*et al*[3]the mean and SD of the 50.7 (17.6).However in a study conducted by Joffe the mean (SD) among the study population was found to be 45(17). In a study conducted in a single centre in Germany by Soltész*et al*[5] showed that the mean (SD) was found to be 62.2(13.7). The mean and SD varied across the different studies which could be due to the difference in study population.

The current study showed that the mean weight(±SD) in kg of the study participants was 66.5 ±11.7 and the mean height(±SD) in metres of the study participants was 1.6 ±0.08 where as in the study done by Joffe*et al*[4] the mean weight (SD) of the population was found to be 85(22) and the subsequent height of the study population was found to be 173 (13).

The present study showed that mean BMI (±SD) of the study participants was 27±4.2 however the study done by the University of Washington4 it was found to be 27 (23-32).This findings showed that the study participants were found to be in similar weight category. However on the checking the weight of the study population it was found to be on the higher aspects showing the majority were on the obese category.

Soltész*et al*[5] found that the mean (SD) BMI was found to be 31.7 (5.9) which was found to be higher than the current study which could be attributable to the difference in the geographic location and the ethnicity. Indirectly attributing to the food and physical activity of the particular global region. Male gender distribution was found to be 59% and the female gender was found to be 41% among the study population. The difference between the gender distributions was found to be due to the study perspective and context with different surgical indications.

On the basis of the Mallampati grade it was found that 66% of the patients had a score of 2, followed by 25% with grade 1 and 9% of the people had score of 3. In a study done by Joffe*et al* it was found that the grade 3 of the Mallampati score was found to be 30%. ShitalKuttarmare[6] did a study in Pune among 100 patients in the BJ medical collegeshowed that 23% of the study population belonged to Mallampati Grade > 3.

Calder and Yentis*et al*[7] did a review about the facemask ventilation before and after the administration of the neuro muscular blockade among the study population. The identified risk factors were found to be person who were having with the difficult facemask ventilation, BMI ≥ 30, presence of a beard, patients who were categorised to have Mallampati grade 3-4, old age especially age ≥ 57 years, patients with limited jaw protrusion to a severe extent and people with history of snoring.

In Joffe[4] study it was found that age > 55yeras were seen in 30%, BMI>30 was found in 34%, Mallampatti score was found to be >3 in 30% of the study group. Presence of beard in 15%, history of OSA/snoring was seen in 15%, edentulous in 7% of the study group.

In the current study, the prevalence of the risk factors among the study population was 22% had history of snoring and 20% had evidence of being edentulous. In 7% of the people, bread was present. Receding jaw was seen in 3% of the population followed by limited neck movements in 2% of the individuals.

On the basis of grading of mask ventilation before neuromuscular blockade, 49% of the study people were in grade 2 followed by the grade 1 and 16% in grade 3.

The mean (SD)Expired Tidal Volume was calculated before and after the administration of Neuromuscular Blockade which was found to be 451.9(61.5) and 557.6(72.5) respectively. TVE was assessed at 1 min,2 mins and 3 mins which was found to be 514.1(75), 560.6(72.5) and 597.9(81.1).

The mean difference between was calculated before the NMB administration and after NMB at 1 min,2 min and 3 mins was found to be -62.3, -108.7 and -146.1. The mean difference was found to statistically significant between the points of assessment at various time points.

The study done by Sachdeva*et al*[3] and Kannan*et al*[3] found that the tidal volume seems to increase significantly from 535 to 586 ml with significant p value (p< 0.001) following the administration of the NMB drugs. Similar study by Ron M Joffe and Ramesh Ramaiah*et al*. (2015) showed that the mean tidal volume increased from 400 ml (169) to 428 (166) p with statistical significance < 0.0011. The results of all these studies were similar to our study. Shital Kuttarmare study included patients those who had with normal as well as difficult airway among the study participants. In the study it was found that 28% of the study population had > 3 or more risk factors with regard to difficult mask ventilation whereas 27% were found to have 2 risk factors for difficult ventilation. So, it was found that 50% of the study population were found to have difficult airway. In another study by Soltezs S *et al*. it was found that neuromuscular blockade effect on expiratory tidal volume among 120 patients with difficult mask ventilation. It was clear that the administration of rocuronium was found to be associated with facemask ventilation among all cases who seemed to have potential difficult mask ventilation by increasing in the tidal volume post administration which was found to similar to our study These results were similar to our study.

On the other aspects, it was found that many other researchers had arrived at a different conclusion. Goodwin *et al*[8] did a study among 200 participants in the oxford region and could not find any differences before and after neuromuscular blockade in 30 patients with normal airways. Ikeda *et al*[9] did a study among 35 patients and compared the effects of rocuronium or succinylcholine among the patients whose lungs were ventilated in a pressure-controlled mode. Although rocuronium did not influence ventilation, succinylcholine improved tidal volume. Thus, the authors had concluded that facemask ventilation was not worse after administration of neuromuscular blocking agents.

The overall evidence suggests that following the administration of an NMBD, the quality of FMV either remains unchanged or improves, but never worsens. In conditions like supraglottic obstruction, laryngospasm, and chest wall rigidity due to opioids, neuromuscular blocking drug may be helpful in establishing adequate ventilation. While no airway strategy under general anaesthesia is guaranteed to work every time, NMBDs appear to be the solution for most of the issues with ventilation. Underdosing the anaesthetic induction agent in order to keep the option of waking up the patient in the event of difficult FMV may make FMV more difficult. When hypoxemia develops during failed FMV, efficient muscular relaxation increases the chances of successful endotracheal intubation. In certain ways, the reluctance to provide early effective muscle relaxation may contribute to, rather than prevent, a 'can't intubate, can't ventilate' situation. Furthermore, by reducing the time gap between anaesthesia-induced apnoea and intubation, early relaxation may lower the risk of hypoxemia and pulmonary aspiration.

Our study has limitations, which we admit. Instead of using hand breathing, we used mechanically generated breaths from the anaesthetic ventilator in our study. It's worth noting that the Han scale was developed using manually ventilated patients. Because we didn't include individuals with difficult airways in our study, more research is needed to see if this conclusion holds true for this crucial population.

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Conclusion

The study concluded that NMB administration significantly increased Expired Tidal Volume. So, NBD can be considered to facilitate facemask ventilation in patients with normal airway. The independent factors like neck circumference had positive correlation with increase in mean expired tidal volume . Low BMI group had significantly higher increase in mean expired tidal volume compared with the high BMI group. Neck circumference had positive correlation with grade of mask ventilation before administering NBD.

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