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Comparison of Face Mask Ventilation before and after the Administration of Neuromuscular Blocking Drugs: A Prospective Study

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Abstract

Background: Anesthesiologist often check for the ability to ventilate the patient before administering neuromuscular blocking drugs to avoid cannot intubate-cannot ventilate scenario. *Aim:* To compare the ease of ventilation before and after administration of Neuromuscular Blocking Drugs (NMBD) in terms of expired tidal volume as the primary aim. *Materials and Methods:* One hundred adult (> 18 years of age) patients of both sexes, undergoing elective surgery under general anesthesia were selected. Different predictors for difficult mask ventilation were assessed preoperatively. Peak Inspiratory Pressure (PIP) in cm H_2O, expired tidal volume (TV) in *ml*, minute ventilation (MV) in litres and ease of ventilation of the patient were noted one minute after induction with propofol and again one minute after giving NMBD. *Results:* It was seen that facemask ventilation was better after administration of NMBD. The mean (SD) expired tidal volume in ml increased from 414 (110) to 442 (115) and the peak inspiratory pressure decreased from 18 (5.4) to 14 (3.5) ($p < 0.001$). No patient who was difficult to ventilate after induction became impossible after NMBD. *Conclusion:* We concluded that facemask ventilation improves after NMBD.

Keywords: Facemask ventilation; NMBD; Airway.

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Introduction

Face mask ventilation is the most basic and essential skill in airway management. It is considered as the first line technique for maintaining patency of airway in unconscious and apneic patients.[1]It is rescue method for ventilation and oxygenation if tracheal intubation is difficult.[2]

In our routine anesthesia practice for administration of general anesthesia we administer neuromuscular blocking drugs for tracheal intubation. There is a dictum for testing the ability to ventilate the patient before giving NMBD.

During induction of anesthesia whether to administer neuromuscular blocking drugs before confirmation of ventilation is still a debatable question.

In the awake state, the upper airway is maintained by physiologic reflexes and neural activity of the upper airway muscles.[3] In the unconscious state, neuromuscular control of the upper airway muscles is reduced or abolished contributing to upper airway narrowing and collapse.[4–6]

Those who opt for testing the ability to ventilate fear that the use of NMBDs causes airway collapse which leads to severe hypoxia if the trachea cannot

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be intubated and the patient's lungs cannot be ventilated; resulting in a "cannot intubate–cannot ventilate" situation.[1,7] Thus, if facemask ventilation is ineffective, non paralyzed patients can be awaken and spontaneous respiration can be achieved early.

However, some argue that withholding an NMBD in cases where it is clearly indicated, such as laryngospasm or opioid-induced muscle rigidity increases the resistance to mask ventilation. With early administration of NMBD there is improvement in mask ventilation, moreover, optimal intubation conditions can be obtained and patients with difficult mask ventilation can be identified and earlier intervention for alternative airway management can be done.

It is said that "If difficulty in mask ventilation is observed before paralysis, a short-acting neuromuscular blocking drug should always be preferred over a long-acting one to maximise the chance of return of spontaneous ventilation".[8] This recommendation is obviously based on the still frequently held view that the administration of suxamethonium preserves the option of restoring adequate spontaneous respiration before severe hypoxemia develops.[9-11]

Furthermore, muscle relaxation will facilitate placement of a supraglottic airway device and endotracheal intubation, interventions which may become essential should the patient become hypoxemic during failed FMV. Insertion of these devices may be difficult without muscle relaxation.

Now-a-days videolaryngoscopes, fiberoptic bronchoscope and suproglottic airway devices are readily available. The use of these devices becomes easy in fully relaxed patients and it is not equally effective in non-paralyzed patients.[12]

Administration of a NMBD has been compared with 'crossing the Rubicon'.[13] The Rubicon is the administration of a hypnotic at a dose that abolishes spontaneous respiration.[14] Thus, once we have crossed that Rubicon (i.e., have abolished spontaneous respiration), our goal must not be to 'consider preserving a way back over the bridge' (i.e., wake up the patient),[13] but to concentrate all our efforts on putting up camp quickly and safely on the other side of the river (i.e., provide effective ventilation).

Various studies done previously have demonstrated improvement in ventilation or no effect after administration of NMBD. However, none of the studies showed worsening of facemask ventilation. Based on these studies our aim was to compare the ventilation in terms of exhaled tidal volume before and after administration of NMBD.

Materials and Methods

The trial was conducted at a tertiary care government hospital. One hundred adult (> 18 *years of age*) patients of both sexes, undergoing elective surgery under general anesthesia where placement of tracheal tube was considered were selected. Written informed consent and institutional review committee approval was obtained. Patients with known allergy or contra-indication to muscle relaxants, congenital heart disease, hiatus hernia, pregnant and full stomach patients were excluded from the study.

Patients enrolled for the study underwent thorough preoperative assessment including detailed case history, clinical examination and all necessary investigations. Baseline patient characteristics, including age, sex, height, weight, and ASA physical status were recorded. Each participant underwent an independent airway exam by the study coordinator in addition to that of the primary anesthesia team prior to induction. Risk factors for DMV, including Mallampati grade, BMI>30, presence of beard, the ability to and extent of mandibular protrusion, lack of dentition, limited cervical spine motion, or a history of obstructive sleep apnea were noted.

Written informed consent was taken from all patients. Once patient was taken inside the operation theatre an intravenous canula was secured and monitors were attached. Monitoring included heart rate (HR), electrocardiogram (ECG), Non-invasive Blood Pressure (NIBP), pulse oxymetry (SpO_2), end tidal CO_2 ($ETCO_2$). Patients were placed supine, with their head in a sniffing position using standard pillows. Patients with a body mass index > *30 kg/m*$^{-2}$ were given ramp position.

All the patients were given premedication Inj Glycopyrollate (*0.05 mg/kg*) and Inj Ondansetron (*0.08 mg/kg*). Inj Midazolam (*0.03 mg/Kg*) and Inj Fentanyl (*1 ug/kg*) was given as sedation and analgesic before induction.

Preoxygenation was done with 100% O_2 by tidal breathing *8–10 litres* for *3 min*. General anesthesia was induced with Inj propofol *2 mg/kg* IV slowly. Dragger Primus anesthesia work station was used for recording and anesthesia delivery purpose in all 100 cases. The ventilator was set to deliver volume controlled ventilation with tidal volume of *6 ml/kg*, respiratory rate *12 per minute*, inspiratory-expiratory ratio of 1:1, Positive End-expiratory Pressure (PEEP) of 3 *cm* H_2O and a fresh gas flow of *6 L/min*. Once we achieved loss of eyelash reflex,

Peak Inspiratory Pressure (PIP) in cm H_2O, expired tidal volume (TV) in *ml*, minute ventilation (MV) in litres and ease of ventilation of the patient were noted. Ease of ventilation was described as easy, moderate or difficult for the anesthesiologist.

After *one minute* Inj Succinyl-choline (*2 mg/kg*) IV was given as skeletal muscle relaxant. Face-mask ventilation was continued with 100% oxygen on ventilator. PIP, expired TV, MV and ease of ventilation were noted on anesthesia ventilator again after *1 minute* of administration of succinyl-choline.

Patient was intubated with appropriate size endotracheal tube. General anesthesia was maintained with mixture of oxygen (50%), nitrous oxide (50%), isoflurane as an inhalation anesthetic agent and long acting neuromuscular blocker vecuronium (0.08 mg/kg) as a part of standard anesthetic protocol. At the end of the procedure patients were extubated, after adequate reversal of neuromuscular blockade and recovery of tone, power and reflexes.

Facemask ventilation was defined as impossible mask ventilation if during ventilation delivered tidal volume was <2 *ml/kg*, no adequate chest rise was observed, no end-tidal CO_2 was observed or oxygen saturation measured by pulse oximetry decreased <90%. In such situation, patient was excluded from the study and rescue plan was followed which included securing an airway.

Statistical Anaylysis

Preliminary sample size estimation using previous studies showed that approximately 50 patients should be included in each group, assuming alpha error of 0.05 (95% confidence interval) in order to obtain power of study > 80%.

Comparison of expired TV, MV and PIP was done using paired *t* - test. Comparison of ease of ventilation was done using Wilcoxon sign rank test. $p < 0.05$ was considered significant, $p > 0.05$ not significant and $p < 0.001$ highly significant. Data analysis was done using SPSS (Statistical Package for Social Science) version 17.0 (SPSS inc., Chicago II, USA).

Results

We studied 100 patients. The baseline characteristic of patients is shown in Tables 1 and 2.

In our study we included different risk factors for difficult mask ventilation. Distribution of patients according to number of risk factors for difficult mask ventilation is shown in table 3. They were grouped as patients with no risk factor, with one risk factor, with two risk factors and with three or more risk factors for difficult mask ventilation.

Table 1: Distribution of patients according to age

Age group	Number of patients	Percentage (%)
≤ 20	2	2.0
21–30	13	13.0
31–40	25	25.0
41–50	23	23.0
51–60	24	24.0
> 60	13	13.0
Total	100	100.0

Table 2: Distribution of patients according to sex

Gender	Number of patients	Percentage (%)
Male	55	55.0
Female	45	45.0
Total	100	100.0

Table 3: Distribution of patients according to number of risk factors for difficult mask ventilation.

Number of risk factors	Number of patients	Percentage (%)
0	21	21.0
1	25	25.0
2	26	26.0
≥ 3	28	28.0
Total	100	100.0

Prevalence of risk factors for difficult mask ventilation in study population is shown in Table 4.

Table 4: Prevalence of risk factors

Risk Factors	Number of patients	Percentage (%)
BMI > 30.0	29	29.0
BEARD	25	25.0
Edentulous	9	9.0
MPC grade > 3	23	23.0
History of OSA	18	18.0
Limited mandibular protrusion	16	16.0
Gender Male	55	55.0

From table 5 it can be seen that there is significant increase in tidal volume after administration of succinylcholine ($p < 0.001$). Peak inspiratory pressure shows a significant decrease after succinylcholine < 0.001). Figure 1 shows that expired tidal volume has improved after administration of succinylcholine irrespective of the number of risk factors for difficult mask ventilation. There is no worsening in facemask ventilation in any case.

Table 5: Comparison of expired TV, MV and PIP before and after administration of succinylcholine.

	Before succinylcholine (n = 21)		After succinylcholine (n = 21)		p-value
	Mean	SD	Mean	SD	
PIP	18.31	5.43	14.97	3.59	< 0.001
MV	4.78	1.41	5.01	1.48	0.025
Expired TV	414.60	110.79	442.88	115.23	< 0.001

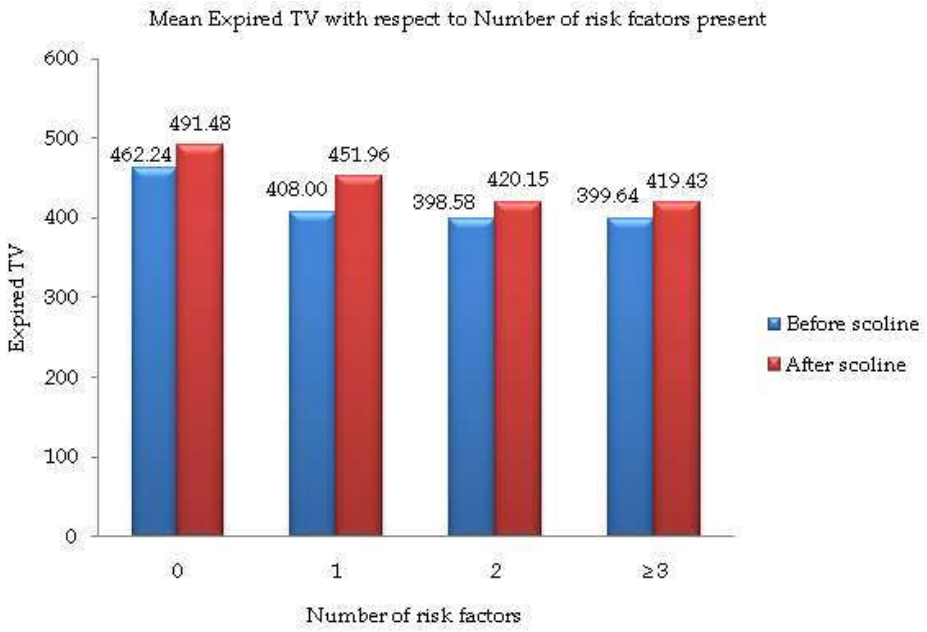

Fig. 1: Comparison of expired TV before and after administration of succinylcholine according to number of risk factors.

It can be seen from table 6 that ease of ventilation improves significantly after giving succinylcholine (p < 0.001).

Table 6: Comparison of ease of ventilation before and after administration of succinylcholine.

Ease of ventilation	Number of patients		p-value
	Before succinylcholine	After succinylcholine	
Easy	39	70	< 0.001
Moderate	28	22	
Difficult	33	8	

Discussion

Ventilation by mask is of utmost important for emergency airway management. It is important to predict which patients may be difficult to ventilate.

Difficult mask ventilation is defined as 'the inability of an unassisted anesthesiologist to maintain the measured oxygen saturation as measured by pulse oximetry > 92% or to prevent or reverse signs of inadequate ventilation during positive pressure mask ventilation under general anesthesia.

There are certain predictors or factors which can make mask ventilation difficult.[15] Thus, whether to administer NMBD before testing facemask ventilation remains a controversy. Our primary outcome was that FMV after administration of NMBD is superior as compared to FMV after induction.

Baseline demographic characteristics and prevalence of predictors of DMV are shown in Tables 1, 2 and 3.

In our study it can be seen that expired tidal volume improved significantly after the administration of NMBD, $p < 0.001$ (Table 5). It was seen that expired tidal volume increased from 414.6 ml (110) before administration of succinylcholine to 442.8 *ml* (115.23) after administration of succinylcholine.

In a study conducted by Ikeda *et al.* in 2012, tidal volume increased significantly from 4.2 to 5.4 *ml/kg* (p = 0.020) after 60 seconds of administration of scoline in 17 patients; however there was no

significant change in tidal volume with rocuronium in 14 patients[16]. We used succinylcholine in all 100 patients.

Similarly in a study by R. Sachdeva, T. R. Kannan *et al.* the tidal volume increased significantly from 525 to 586 *ml* ($p < 0.001$) after administration of rocuronium.[17] Aaron M Joffe, Ramesh Ramaiah *et al*. in 2015 demonstrated an increase in mean tidal volume from 399 *ml* (169) to 428 (166) $p < 0.001$[1]. The results of all these studies were similar to our study.

In our study we included patients with normal as well as difficult airway. We had 28% patients with 3 or more risk factors for difficult mask ventilation and 26% patients with 2 risk factors. So almost half of patients were with difficult airway. Soltezs S *et al*. assessed the effect of neuromuscular blockade on expiratory tidal volume in patients with difficult mask ventilation in all 113 patients.[8] They concluded that the administration of rocuronium improves facemask ventilation in all cases with a potentially difficult mask ventilation and causes clinically relevant increase in tidal volume. These results were similar to our study.

Also there was a significant decrease in peak inspiratory pressure (PIP) after administration of NMBD, $p < 0.001$ (Table 5). None of the patient had deterioration in ventilation or became impossible to ventilate after giving succinylcholine. Ease of ventilation improved significantly after administration of NMBD (Table 6). Our findings are consistent with previous studies.

Warters R. D, Szabo T. A, *et al.* conducted a study in 2011 to prove neuromuscular blockade facilitates mask ventilation and developed a grading scale (Warters scale), based on attempts to generate a standardised tidal volume.[18] They observed that patients with a baseline Warters scale value of > 3 (i.e. difficult to mask ventilate; $n = 14$), the ventilation scores also showed significant improvement (4.2 (1.2) vs 1.9 (1.0), $p = 0.0002$).

In our study, ease of ventilation improved significantly after administration of NMBD. 33 patients were difficult to ventilate before giving succinylcholine which reduced to 8 after administration of succinylcholine. Furthermore 70 out of 100 patients were easy to ventilate after giving NMBD. However no specific grading scale was used in our study.

Amathieu *et al*.[19] assessed 12221 patients for difficult airway management in a two-year prospective study and in 56 of the 90 patients (62 %) with FMV difficulty grade III, the quality of FMV improved by one grade following administration of suxamethonium. Equally important, in none of the 12,003 patients did the quality of FMV worsen following administration of the NMBD. The results of this study were similar to our study. We compared the patients with respect to number of predictors present: with no predictor, with one predictor, with 2 predictors and >3 predictors.

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In 2008, Calder and Yentis questioned the validity, safety and rationale of the practice of demonstrating wheather facemask ventilation is possible before giving a neuromuscular blocking drug (NBD)[20]. Calder and Yentis argued that insistence on checking facemask ventilation, and the subsequent fear of not being able to restore spontaneous respiration should it be difficult, increased the likelihood of 'light anesthesia', which itself caused difficulty with facemask ventilation. Neuromuscular blocking drugs appeared to improve facemask ventilation but evidence was lacking.

Mechanism by which neuromuscular blockade improves facemask ventilation and causes decrease in peak inpsiratory pressure is debatable. Ikeda suggested that pharyngeal fasciculations during suxamethonium administration causes airway dilatation.[16] They performed endoscopic evaluation of airway during suxamethonium administration in 6 patients to demonstrate contractions of both pharyngeal dilators and contractors causing re-opening of airways, no such evaluation was done following rocuronium administration. NMBDs may also improve the FMV by improving chest wall compliance.

Ease of ventilation in our study was a subjective measurement of the anesthesiologist, we did not use any scale for the grading of the same. This is a limitation of our study.

Conclusion

Overall we conclude that, facemask ventilation improves after administration of NMBD with

improvement in expired tidal volume and decrease in peak inspiratory pressure. It also increases ease of ventilation. There is no worsening of face mask ventilation after its administration.

Conflict of interest: None.

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