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A COMPARATIVE EVALUATION OF EFFICACY OF AIR VERSUS NITROUS OXIDE:OXYGEN MIXTURE AS ENDOTRACHEAL TUBE CUFF INFLATING AGENT

KEY WORDS: Cuffed endotracheal tubes, Air, Nitrous oxide, ETT cuff pressure, Post-operative sore throat

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ABSTRACT

Cuffed endotracheal tubes have been effectively used to deliver anaesthetic gases in general anaesthesia. Air is routinely used as cuff inflating agent. The objective of this study was to compare air (Group A) and a nitrous oxide-oxygen mixture (Group N) as agents for inflating the endotracheal tube cuff, with respect to their tendency to increase endotracheal tube cuff pressure and the resultant incidence of postoperative sore throat. Postoperative sore throat was assessed for the next 24hrs. This was a prospective randomized comparative study. Out of a total of 200 patients, 100 were enrolled in each group. The mean age was 42.73±10.06 and 43.00±10.13 years of the Group A and Group N respectively. Both groups were comparable with respect to demographic parameter, pre-operative vitals, intra-operative HR, SBP, DBP, MAP; except for few clinically irrelevant variations in preoperative HR and intraoperative DBP . There was statistically significant increase in ETT cuff pressure at 5th ,30th and 60th minutes in Group A compared to Group N ($p<0.001$). The incidence of postoperative sore throat at 4-8 hrs interval was almost four times higher in group A compared to group N and difference was statistically significant ($p=0.005$). To conclude, we advocate the use of nitrous oxide oxygen mixture (1:1 ratio) as cuff inflating agent because its efficiency in maintaining endotracheal tube cuff pressure within desirable levels is far superior to that of air. The incidence of postoperative sore throat owing to raised intracuff pressure can also be reduced commendably by using nitrous oxide oxygen mixture as cuff inflating agent.

INTRODUCTION:

Cuffed endotracheal tubes have been effectively used to deliver anaesthetic gases in general anaesthesia. The cuff helps in accurate placement of endotracheal tube within trachea, which is an important factor for maintaining ventilation in an anesthetised patient. Air is the most commonly used cuff inflating agent.

Though nitrous oxide is being used as a volatile agent for long because of its notable analgesic action and ease of usage, its tendency to diffuse into air filled cavities has been kept under watch ever since. An increase in endotracheal tube cuff pressure is seen during anaesthesia incorporating nitrous oxide as an inhalational agent if air is used to inflate the cuff.[1] This increase in pressure can be attributed to its nature of diffusing into the endotracheal tube cuff, thereby increasing the complications due to the same.

Keeping the cuff inflated for a long time can result in tracheal ischemia and further complications such as postoperative sore throat, hoarseness of voice, tracheal ulceration, tracheal stenosis, tracheo-esophageal fistula.[2] Monitoring the cuff pressure and taking necessary actions to keep it under control can be practiced to avoid these complications. The cuff pressure above 30cm of H_2O (22mmHg) compromises tracheal mucosal capillary perfusion.[3] Keeping this in mind we have set an optimum pressure range for endotracheal tube cuff to be between 20-30cm of H_2O.

Several methods have been used to reduce the pressure exerted on the tracheal mucosa by decreasing the diffusion of N_2O into the cuff. Checking of cuff volume and pressure regularly and cuff deflation if indicated, use of the same gas mixture inhaled by the patient to inflate the cuff , use of normal saline or distilled water to prevent increase in pressure, the use of special tubes such as the Brandt tube in which the pilot balloon allows rediffusion of nitrous oxide thereby preventing pressure increase, and devices that control cuff pressure ,are some of the methods recommended and followed.[4]

Giving due attention to raised cuff pressure, researchers compared the efficiency of different cuff inflating mediums in keeping cuff pressure within desired limits. postoperative sore throat owing to raised cuff pressure was significantly reduced by inflating cuff with various concentration (2%,4%) of lignocaine.[5,6] While comparing with air as cuff inflating agent, the incidence was much lower in cases which used lignocaine.[5] Studies have also compared the incidence of postoperative sore throat while using air,saline and lignocaine.[6] The postoperative tracheal morbidity was found to be lesser when saline was used as the medium when compared to air. It was lowest when lignocaine was used.[6] Alkalinized lignocaine is yet another medium used to inflate cuff. 6 ml 2% lignocaine + 0.5 ml 7.5% sodium bicarbonate was used to inflate cuff and the incidence was compared with that of distilled water and air.[7] Extubation was smoother in the lignocaine group, uncharged base form of the drug, blocks cough receptors on tracheal mucosa. While using liquid as an inflating agent researchers found difficulty in initial adjustment of cuff pressure.[8]

Many studies have reported different concentrations of nitrous oxide (N_2O) in the endotracheal tube cuff to provide stable cuff pressures during general anaesthesia with N_2O.[4] Features like ease of use, easy availability and cost efficiency makes nitrous oxide oxygen mixture an attractive alternative compared to its liquid counterparts. 40% of nitrous oxide inside cuff was found to keep cuff pressure within optimum limits while 67% N_2O was used as inhalational agent.[4] Hazards associated with filling the cuff with nitrous oxide oxygen have also been studied. Errors in collection of the right concentration of nitrous oxide can even result in diffusion of the gas from the cuff, out into the trachea, or vice versa according to the concentration gradient. Cuff deflation is a risk that must be anticipated in such cases.[8] This mandates cuff pressure monitoring while using alternative agents. The diffusion into cuff is maximum during first hour of N_2O anaesthesia. So monitoring the cuff pressure at least at the end of first hour after intubation can be helpful in bringing down the incidence of post intubation complications.

Several studies have been conducted regarding the significance of monitoring endotracheal tube cuff pressure and maintaining an optimum cuff pressure by using alternative cuff inflating agents indicating its relevance in bringing down the post intubation complications to patients undergoing general anaesthesia using nitrous oxide as a volatile agent.

The objective of this study is to compare the effect of Air (group A) and Nitrous oxide Oxygen mixture(group N) as an agent to

inflate endotracheal tube cuff, in raising cuff pressure in patients undergoing general anaesthesia using nitrous oxide as inhalational agent. The cuff pressure was recorded during 0^{th},5^{th},30^{th},60^{th} minute post intubation to know about the optimal time taken for the cuff pressure to increase and cause significant complications. postoperative sore throat was assessed for the next 24hrs in intervals of 0-4hrs,4-8hrs,8-12hrs and 12-24hrs.

MATERIALS AND METHOD:

This was a prospective randomized comparative study. The study was conducted on 200 ASA I and II patients aged 18-70 years who were scheduled to undergo elective surgery under general anaesthesia lasting for 60-120 min using endotracheal tube intubation from 1^{st} April 2017 to 31^{st} May 2018. Study was conducted at Ananthapuri Hospitals and Research Institute, Trivandrum with approval from Institutional Ethics Committee and Written Informed Consent from all patients who had participated in the study. N- Sample size was calculated according to the formula,

$$N = \frac{2(Z_{\alpha} + Z_{\beta})^2 \sigma^2}{d^2}$$

According to the study conducted by Manissery et al [9] on "Endotracheal tube cuff pressures during general anaesthesia while using air versus a 50% mixture of nitrous oxide and oxygen as inflating agents." Hence minimum sample size was 40 in each group, minimum total sample size of the study was 80.

As per the criteria mentioned above, 200 patients posted for elective surgeries were included in the study. About 100 patients each was randomly allotted to two groups- Group A and Group N. Group A had Air as the cuff inflating agent and group N had nitrous oxide oxygen mixture(1:1) as cuff inflating agent. A thorough pre-operative evaluation was done on the day before surgery to select patients satisfying the criteria. Pre-operative investigations were done according to patient's requirement and essential parameters were optimised. Patients were nil per oral for 6 hrs prior to surgery. After being shifted to operation theatre, i.v. access was secured using appropriate sized cannula in the non-dominant hand and i.v. fluid infusion was started.Non-invasive blood pressure, ECG and SpO_2 monitors were attached and baseline values recorded. Datex Ohmeda cardiocap monitor was used for monitoring all the patients. The patients were then preoxygenated with 100% O_2 for 3 minutes and premedicated with 0.03mg/kg of midazolam i.v. , 10mcg/kg of glycopyrrolate i.v and 2 mcg/kg of fentanyl i.v. anaesthesia was induced with inj. Propofol i.v 2mg/kg., dose titrated to the loss of verbal response. Neuromuscular blockade was achieved with i.v.inj. atracurium 0.5mg/kg. After 3 minutes of assisted ventilation and direct laryngoscopy, vocal cords were visualised, cuffed endotracheal tube of appropriate size was inserted. If direct laryngoscopy takes >30 seconds or multiple attempts of intubation were required, study was deferred owing to exclusion of cases with difficult intubation.

Group A received air as the cuff inflating agent, while group N received nitrous oxide oxygen mixture which was taken earlier into BD 50 ml, concentric-precise,Luer lock syringe when the FiO_2 as measured by the oxygen analyser at the common gas outlet on the anaesthetic machine was 50% and was sealed with a rubber cork.

Endotracheal tube cuff pressure was set at a value between 20-30 cm of H_2O and noted as pressure at 0^{th} minute, then on, cuff pressure was recorded at 5^{th},30^{th},and 60^{th} minute. General anaesthesia was maintained with nitrous oxide, oxygen (1:1ratio) and sevoflurane 1–2% with controlled ventilation using a closed circuit. Post-induction monitoring included end-tidal carbon dioxide and respiratory gas analyser. After completion of surgery, the residual paralysis was antagonised with i.v. neostigmine and i.v. glycopyrrolate as per patient requirement. The patients were extubated after confirming adequate level of consciousness and intact reflexes. The patients were then shifted to the post anaesthesia care unit.

postoperative sore throat was assessed for 24 hours postoperatively. The presence or absence of sore throat was recorded at the following intervals: 0-4 hours, 4-8 hours, 8-12 hours and 12-24 hours in the postoperative period and statistical analysis was done accordingly. Data was collected into a prestructured proforma for each patient.

The data analysed were endotracheal tube cuff pressures and presence or absence of post intubation sore throat. Comparison of quantitative variables was analysed by independent sample T-Test. Comparison of qualitative variables between the two groups was analysed by chi-square test. A p- value of 0.05 was taken as level of significance. Data analysis was performed using windows SPSS version 17.0.

RESULTS:

Total 200 patients, 100 in each group were enrolled. The mean age was 42.73±10.06 and 43.00±10.13 years of the Group A and Group N respectively. The mean weight of the patient was 67.35± 7.74 and 67.06±7.75 kg respectively of Group A and Group N. Table 1 shows both groups were comparable with respect to all demographic parameter (p >0.05). The test statistics showed that the two groups were comparable in terms of all pre-operative vitals except that of heart rate. (Table 2)

Table 1: Comparison of both groups based on demographic parameter

Demographic Parameter		Group A		Group N		p Value
		Frequency	Percentage	Frequency	Percentage	
Age (Years)	≤ 30	15	15	14	14	0.962
	31 - 40	25	25	24	24	
	41 - 50	35	35	37	37	
	51 - 60	21	21	19	19	
	61 - 70	4	4	6	6	
Gender	Male	56	56	52	52	0.57
	Female	44	44	48	48	
Weight (Kg)	≤ 50	3	3	3	3	0.978
	51 - 60	12	12	14	14	
	61 - 70	51	51	48	48	
	71 - 80	30	30	32	32	
	≥ 81	4	4	3	3	

Table 2: Comparison of both groups based on Pre-operative vitals

Pre-operative data	Group A		Group N		t	p Value
	Mean	SD	Mean	SD		
Pre-op HR	79.63	12.67	84.67	10.78	-3.03	0.003
Pre-op SBP	132.68	8.36	132.06	8.88	0.508	0.612
Pre-op DBP	80.48	7.55	79.6	7.25	0.841	0.401
Pre-op SPO2	98.20	1.44	98.03	1.39	0.851	0.396

Table 3: Comparison of both groups based on heart rate

HR (Beats/Min)	Group A		Group N		t	p Value
	Mean	SD	Mean	SD		
0 minute	91.06	4.28	91.29	3.55	-0.413	0.68
5 minute	78.11	12.05	80.03	12.14	-1.122	0.263
30 minute	75.93	11.19	73.94	11.25	1.254	0.211
60 minute	75.22	10.87	77.74	10.06	-1.702	0.09

Table 3 shows, there is no significant difference in intraoperative heart rate among both groups (p > 0.05). Table 4 shows that, statistically significant reduction in mean systolic blood pressure at 30th minute noted in Group N compared to Group A (p = 0.001). Table 5 shows, there is no significant difference in diastolic blood pressure among both groups (p > 0.05). Table 6 shows, there is no significant difference in mean arterial blood pressures among both groups (p > 0.05). Table 7 shows, there was statistically significant increase in ETT cuff pressure at 5^{th} ,30^{th} and 60^{th} minutes in Group A compared to Group N (p<0.001).

Table 8 shows, incidence of postoperative sore throat in first 4 hrs was almost twice in group A compared to group N, though the difference was not statistically significant (p 0.093). The incidence of postoperative sore throat at 4-8 hrs interval was almost four times higher in group A compared to group N and difference was statistically significant (p=0.005). The incidence of postoperative sore throat at 8-12 hrs was almost similar in group A and to group N, though the difference was not statistically significant (p 0.700). The incidence of postoperative sore throat at 12-24 hrs was almost similar in group A and to group N, though the difference was not statistically significant (p 0.312).

Table 4: Comparison of both groups based on systolic blood pressure

SBP(mmHg)	Group A		Group N		t	p Value
	Mean	SD	Mean	SD		
0 minute	126.8	11.28	124.76	12.59	1.207	0.229
5 minute	123.72	12.61	125.7	12.11	-1.133	0.259
30 minute	122.64	12.53	117.98	6.179	3.335	0.001
60 minute	126.98	12.57	126.24	11.13	0.441	0.66

Table 5: Comparison of both groups based on diastolic blood pressure

DBP(mmHg)	Group A		Group N		t	p Value
	Mean	SD	Mean	SD		
0 minute	76.02	7.31	75.18	8.14	0.768	0.444
5 minute	75.42	8.82	72.76	6.78	2.391	0.018
30 minute	74.8	8.66	74.88	6.76	-0.073	0.942
60 minute	74.06	7.54	74.4	7.31	-0.324	0.746

Table 6: Comparison of both groups based on mean arterial pressure

MAP (mmHg)	Group A		Group N		t	p Value
	Mean	SD	Mean	SD		
0 minute	92.97	7.34	91.76	8.89	1.05	0.295
5 minute	91.6	9.89	90.52	7.78	0.858	0.392
30 minute	90.81	9.71	89.24	5.15	1.366	0.173
60 minute	91.8	8.35	91.76	7.89	0.035	0.972

Table 7 : Comparison of both groups based on ETT cuff pressure

ETT cuff pressure (cm of H_2O)	Group A		Group N		t	p Value
	Mean	SD	Mean	SD		
0 minute	22.82	1.1	22.98	1.08	-1.035	0.302
5 minute	26.72	2.08	22.52	1.52	16.302	<0.001
30 minute	30.1	2.9	23.44	2.43	17.587	<0.001
60 minute	32.48	4.47	23.58	2.38	17.573	<0.001

Table 8 : Association of sore throat with cuff inflating agent in endotracheal tube

SORE THROAT		Group A		Group N		p Value
		Frequency	Percentage	Frequency	Percentage	
First 4 Hrs	No	83	83	91	91	0.093
	Yes	17	17	9	9	
4-8 Hrs	No	86	86	97	97	0.005
	Yes	14	14	3	3	
8-12 Hrs	No	96	96	97	97	0.700
	Yes	4	4	3	3	
12-24 Hrs	No	97	97	99	99	0.312
	Yes	3	3	1	1	

DISCUSSION:

Nitrous oxide and its effects on air filled cavities were studied in detail since its discovery . Its effect on endotracheal tube cuff should be of prime concern as increased diffusion of nitrous oxide into the cuff has several deleterious effects. Endotracheal tube cuff pressure has to be maintained at an optimum level as both its decrease and increase is detrimental to the patient. Intraoperative cuff pressure monitoring is often neglected as the adverse effects due to improper cuff seal are seldom recognized. The rise of endotracheal tube pressure while using nitrous oxide as an inhalational agent was noticed by several practitioners and several methods were sought out to solve the problem. One of such methods is inflating the cuff with the same concentration of nitrous oxide as that is used in the inhalational mixture. This method reduces the harmful rise in cuff pressure and reduces the incidence of postoperative sore throat due to increased cuff pressure to a great extent.

Our study was done with an aim to compare the efficacy of nitrous oxide oxygen mixture in maintaining endotracheal tube cuff pressure within a desirable range and thereby reducing the incidence of postoperative sore throat. The average endotracheal tube cuff pressure after 5 minutes of intubation was 26.72±2.08 in group A which when compared to 22.52±1.52 in group N was significantly high. This finding implies that cuff pressure increase commences as early as 5 minutes after intubation in group A compared to group N. The mean cuff pressures in group A during the 30^{th} and 60^{th} minute were 30.10±2.90 and 32.48±4.47 respectively. This finding shows that there has been a significant rise in cuff pressure at 30^{th} and 60^{th} minute from the baseline cuff pressure of 22.82±1.10 soon after intubation in group A. Not only were these values greater than the baseline value but they were also significantly higher than that group N. In group N cuff pressures at 5^{th},30^{th} and 60^{th} minutes were 22.52±1.52, 23.44±2.43, 23.58±2.38. Thus it can be inferred from these values that there was no significant rise of cuff pressure in group N during intraoperative period. These values were commendably lower than the values in group A, implying that cuff pressure values had risen significantly during intraoperative period in group A compared to group N. While we assessed patients postoperatively, a total of 54 of them complained of sore throat, of which 38 patients were of group A, and only 16 belonged to group N. It can be inferred from the results that the incidence of postoperative sore throat in group A is more than twice as that of group N. In group A 17 patients complained of sore throat during the first 4 hrs postoperatively, while only 9 of group N complained of the same. It is evident from these data that incidence of sore throat due to raised cuff pressure presented as early as during the first 4 hrs postoperatively and its incidence gradually decreased thereafter .This difference in occurrence was not statistically significant during the first 4 hrs which may be due to the small sample size of the study. There could also be erroneous reporting of pain by patients in the early recovery phase of anaesthesia.

We observed out that during the interval of 4-8hrs of postoperative period, 14 patients in group A complained of sore throat while only 3 in group N complained of sore throat. During this interval, patients were communicating better than during the early phase of recovery. The results were thus statistically significant during this interval postoperatively. During the 8-12hr and 12-24hr interval,4 and 3 patients of group A complained of pain respectively; only very few, 3 and 1 respectively of group N complained of sore throat during these time intervals. These reporting of pain are subjective to varying threshold of pain among patients, as it is unlikely for postoperative sore throat caused by raised cuff pressure to present during these intervals. These could also be the reason why these results were not statistically significant.

Our results matched with the conclusion made by JJ Manissery et al[9] who found in their study that inflation of the cuff of the endotracheal tubes with a 50%N_2O:O_2 rather than air maintains a stable intra cuff pressure. This study was aimed at assessing the efficacy of filling a 50% mixture of nitrous oxide:oxygen (50%N_2O:O_2) in the endotracheal tube cuff to provide stable cuff pressures during general anaesthesia. The endotracheal tube cuff pressures with air (control) as the inflating agent in the tubes were found to have a total mean pressure of 62.60±12.33 at the end of one hour of general anaesthesia. The endotracheal tube cuff pressures with 50%N_2O:O_2 as the inflating agent showed a total mean

pressure of 27.63 ± 3.221 at the end of one hour of general anaesthesia. They concluded that inflation of the cuff of the endotracheal tubes with a 50%N_2O:O_2 rather than air maintains a stable intra cuff pressure.

Modern anaesthesia practitioners have to be aware of the effects of raised endotracheal tube cuff pressure intraoperatively as the adverse effects are numerous if it goes unnoticed. Regular monitoring and maintenance of an optimum cuff pressure can be ensured with devices like Cufflator™ which can measure cuff pressure and if high can also release it. Alternative cuff inflating agents like buffered lignocaine, saline or specialized tubes for maintaining stable cuff pressure can also be put into practice.

CONCLUSION:

To conclude, we advocate the use of nitrous oxide oxygen mixture (1:1 ratio) as cuff inflating agent because its efficiency in maintaining endotracheal tube cuff pressure within desirable levels is far superior to that of air. Air is the conventionally used cuff inflating agent and as nitrous oxide easily diffuses into air filled cuff thereby raising the cuff pressure, alternative cuff inflating agents should be kept in mind. Other methods to maintain optimum cuff pressure are numerous, but what makes nitrous oxide oxygen mixture more desirable is that it is easily available to anaesthesia practitioners in the operation theatre and its ease of use compared to its liquid counterparts. Using newer tubes may be more effective, but these tubes are costly and are not easily available.

We also found out that incidence of postoperative sore throat owing to raised intracuff pressure can also be reduced commendably by using nitrous oxide oxygen mixture as cuff inflating agent. Other cuff inflating agents like buffered lignocaine have also reduced the incidence of postoperative sore throat as it diffuses out of the cuff and acts locally on the tracheal mucosa. As it is one of the most common complaints in the postoperative ward, due attention should be given to decrease its incidence.

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