Original Article

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Comparison of Air, Normal Saline and Lignocaine for Inflation of Endotracheal Tube Cuff

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Abstract

The study design was a prospective, randomized, double blind. Ninety patients of either sex, ASA I and II were randomly divided into three groups according to the medium used for inflation of endotracheal tube cuff. The study was conducted to correlate the changes in intra-cuff pressure and post-operative incidence of tracheal morbidity in form of hoarseness, sore throat and dysphagia. We observed close relationship between rise in intracuff pressure and incidence of tracheal morbidity. The present study concluded that incidence of postoperative sore throat, hoarseness & dysphagia was significantly less (p 0.05) when Normal Saline & Lignocaine were used as medium for an endotracheal tube cuff inflation as compared to air.

Keywords: Lignocaine 2%; Endotracheal Tube (ETT) Cuff Inflating Medium; Intracuff Pressure of Endotracheal Tube; Post Intubation Tracheal Morbidity.

Introduction

The intubation with cuffed endotracheal tube is a gold standard in long term airway care and surgery under general anesthesia. It provides 100% airway protection against aspiration because of inflated cuff. However, the lateral pressure exerted by an inflated cuff on the tracheal mucosa may cause a range of complications like loss of mucosal cilia [1], inflammation, ulceration [2,3,4,5] , hemorrhage [3,5,6], tracheal stenosis [3,4,5,7], tracheo-esophageal fistula[3,8] and ischemic mucosal necrosis[9,10,11]. More often patients complain of symptoms like sore throat [2,8] hoarseness[2,8] and dysphagia[2] in the immediate postoperative period [12,13]. These complications or tracheal morbidity can lead to patient dissatisfaction and discomfort, if they last few days after operation. This significantly influences satisfaction as well as delays patient's return to normal routine activities.

Although the exact patho-physiology of post intubation airway symptoms is not fully elucidated, mucosal damage occurring at the cuff level is thought to be an important causative factor for tracheal morbidity. Decrease in tracheal mucosa perfusion occurs when the cuff exerts pressure greater than 30 cmH2O. This is probably the first step in the development of mucosal damage [14,15] . The magnitude of cuff pressure related complications depend on the amount of pressure exerted by the cuff on tracheal mucous membrane, duration of intubation and the area of cuff trachea contact [11,16,17]. Ideally pressure exerted against the tracheal wall by a cuff should be low enough to allow adequate tracheal capillary mucosal blood flow and prevent tracheal dilation, yet high enough to avoid aspiration and eccentric positioning of endotracheal tube in trachea. Hence, it is essential that a correct size of cuffed endotracheal tube is chosen with optimal diameter and circumference which will affect a seal with minimal in folding of excess cuff material [18]. An endotracheal tube in situ (i.e. in trachea) & cuff inflated with air represents a gas filled pocket in the body and the cuff wall acts as a diffusion area for nitrous oxide used for general anesthesia. This leads to increase in volume of cuff, ultimately resulting in rise of intra-cuff pressure.

Different methods have been recommended for controlling the intra-cuff pressure during balanced general anesthesia especially when nitrous oxide is a component. These include regular cuff pressure measurement and adjustment, Lanz pressure

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regulating system[19] , Brandt anesthesia tube [20] , but all these techniques and devices are complicated, cumbersome or expensive. Hence these are not routinely accepted methods. Various other studies advocated the use of liquid medium like normal saline [2,9,22] or 2% lignocaine [21, 22] for inflating the cuff as it prevents significant rise in intra-cuff pressure and gives greater endotracheal tube tolerance and lowers the incidence of postoperative sore throat.

Present study was carried out to study Air, Normal Saline and 2% Lignocaine as a medium for inflation of endotracheal tube cuff & to compare the changes in intra-cuff volume, intra-cuff pressure and post intubation tracheal morbidity e.g. hoarseness, sore throat and dysphagia.

Materials and Methods

Institutional ethical committee approval was sought. The study was conducted on 90 patients of either sex, age 18- 65 years, ASA grade I & II. The written informed consent was taken from all the patients. This was a prospective, randomized double blind study carried out at tertiary care centre of Central India.

Patients were randomly allocated in to three groups of 30 patients in each group according to medium used for inflation of cuff of endotracheal tube. Air in group 'A', normal saline in group 'NS and Lignocaine 2% in group 'L' was used as medium for inflation of endotracheal tube cuff. Each time new pre-packed, pre- sterile high volume and low pressure cuff type endotracheal tube (size of endotracheal tube 7-8 F in women; 8.5-9.5 F in men) was used in all the cases under study. The patients posted for surgery below neck, surgery lasting for more than 60 minutes and surgeries of elective as well as emergency nature were included in the study. Patients with history of smoking, laryngo-tracheal disease or anomalies, naso-gastric tube in situ, oropharyngeal airway introduced preoperatively, more than one trial of intubation, surgery in any position other than supine and patients at risk for pulmonary aspiration were excluded from the study. Detailed pre-anesthetic check up and relevant investigations were done.

Preoperatively, all patients were kept fasting for 6 hours prior to surgery. In the operation theatre, monitors were attached to patient and vital parameters like heart rate, NIBP, ECG and SpO_2 were note d before premedication.

Intravenous access was set up and maintenance fluid dextrose normal saline (DNS) was set up. All patients were premedicated with intravenous inj. Ranitidine 50 mg, Glycopyrrolate 0.2 mg, Midazolam 1 mg and Pentazocine 0.5 mg/ kg. Before induction of anesthesia, endotracheal tube was tested for any leakage in the cuff. In Lignocaine group, cuff of endotracheal tube was prefilled with Lignocaine 2% for a period of 90 minutes prior to procedure to enhance diffusion of drug across the cuff and the then cuff was deflated just before intubation. Anesthesia was induced with injection Propofol 2 mg/ kg and Succinyl choline 2 mg/kg intravenously. Gentle endotracheal intubation was done with adequate size Polyvinyl chloride (PVC) portex cuffed endotracheal tube by experienced anesthesiologist. After intubation, tube cuff in all the three groups was inflated with adequate quantity of air just sufficient to prevent paratubal leak. This was checked by palpation method i.e. keeping the fingers over trachea & giving positive pressure ventilation. After fixing the endotracheal tube, it was connected to closed circuit and general anesthesia was maintained with on O_2 (50%) + N_2O (50%) + Sevoflurane and IV intermittent doses of inj. Vecuronium.

After 10 minutes of intubation, cuff pressure monitor was attached to the endotracheal tube through extension tubing containing three way. Three way was attached to the pilot balloon of endotracheal tube. 10 cc syringe was attached to third end of three way. After withdrawing all the air from endotracheal tube, cuff pressure was checked by cuff pressure monitor (Hansraj cuff pressure monitor) which was supposed to be 0 cmH2O. Later on the cuff of endotracheal tube was inflated with the medium as per allotted group. The cuff inflation medium used to inflate cuff of endotracheal tube was air for group 'A', normal saline for group 'NS' and Lignocaine for group 'L'.

Following Observations were Noted

- Initial volume of medium required for re-inflation of cuff.
- Final volume of medium aspirated from cuff just before extubation.
- Initial intra cuff pressure value at re-inflation.
- Every hour intra-cuff pressure value monitoring.
- Final intra-cuff pressure value just before reversal.
- Duration of intubation (From time of intubation to extubation).

At the end of surgery, after adequate recovery, reversal of residual neuromuscular block was done with inj. Neostigmine 0.05 mg/ kg and Glycopyrrolate 0.01 mg/ kg. On regaining consciousness, adequate skeletal motor tone & spontaneous respiration, patient was extubated.

Endotracheal tube cuff was checked for any damage. Patients were observed for 24 hours for symptoms of tracheal morbidity e.g. hoarseness, sore throat and dysphagia.

Hoarseness: - graded in to 4 points. Grade 0:- none, Grade 1:- noted by patient, Grade 2:- obvious to observer, Grade 3:- aphonia. Sore throat : - graded in to 4 points. Grade 0 - none, Grade 1 – mild (scratchy throat), Grade 2 – moderate (similar to that noted with cold), Grade 3 – severe (more severe than with cold). Dysphagia: - Difficulty or pain in swallowing which was recorded as absent or present.

The person keeping record of intra-cuff pressure and post operative tracheal morbidity was blind about the medium used for inflation of cuff of endotracheal tube.

Statistical Analysis

All the observations of the study were subjected to statistical analysis. Continuous parameters were presented as mean ± S.D. and categorical variables were expressed in percentages. Continuous variables were compared in three groups by analysis of variance (ANOVA) with multiple comparisons by Bonferroni test. Categorical variables were compared by chi square analysis. Volume of cuff inflation and deflation and intra-cuff pressure initial and final were compared in 3 groups by paired t-test for each group. Mean changes of these parameters were compared among 3 groups by ANOVA. P-Value < 0.05 was considered as statistically significant.

Results

The mean age of patients in Group 'A' was 38.63 ± 7.16 years, in Group 'NS' was 35.36 ± 10.19 years and in Group 'L' was 33.32 ± 11.63 years. Sex ratio (male: female) of Group 'A' was 15:15, Group 'NS' was 21: 9 and Group 'L' was 18:12. There were no statistically significant differences among the three groups regarding characteristics of the patients (Table 1).

Table 2 and Figure 1 showed comparison of initial volume of cuff inflation medium, final volume of medium at cuff deflation and total change in intra-cuff volume of medium of the three groups. Mean intra-cuff volume at inflation to make the cuff just leak proof was 5.05 ± 0.66 ml in Group 'A', 5.63 ± 0.73 ml in Group 'NS' and 5.58 ± 0.63 ml in Group 'L'.

There was no statistically significant difference in intra-cuff volume amongst three groups (p value-0.384). There was rise in total change in intra-cuff volume in Group 'A' (4.08 ± 1.12 ml) as compared to Group 'NS' and Group 'L'. There was a fall in intra-cuff volume in Group 'NS' and Group 'L' as -0.096 ± 0.14 ml and -0.35 ± 0.23 ml respectively. It was observed that medium volume at deflation of cuff in Group 'A' was significantly more than the medium volume used for inflation (p value - 0.000).

Similarly, intra-cuff pressure was increased in Group 'A' (7.2 ± 2.35 cm H_2O) as compared to Group 'NS' and 'L', (0.65 ± 0.77 and 0.5 ± 0.77 cm H_2O respectively). Rise in intra-cuff pressure was maximum in Group 'A' at first, second and third hour of inflation of cuff. Figure 2 represent the progressive rise in intra-cuff pressure than the baseline intra-cuff pressure in all the three groups. It was found to be statistically significant, (P value-0.0261) when compared with Group 'NS' and Group 'L'. The comparison of initial intra-cuff pressure, final intra-cuff pressure and total change in intra-cuff pressure in three groups were shown in Table 3 and Figure 3. It was observed that final intra-cuff pressure in Group 'A' was significantly more than the initial intra-cuff pressure (p value- 0.000).

The incidence of hoarseness of voice, sore throat and dysphagia were lowest in 'Lignocaine' group as compared to air and normal saline groups. Incidence of hoarseness of voice- Grade 1 was maximum in Group 'A' (70%) as compared to Group 'NS' (16.6%) and Group 'L' (10%). The incidence of sore throat of Grade 1 in Group 'A' was much higher i.e. 83.3%. In Group 'NS' & Group 'L' the incidence of sore throat was 20% and 10% respectively. None of the patient had developed hoarseness of voice and sore throat of grade 2 and grade 3. Dysphagia was observed significantly in more number of patients in Group 'A' (86.6%) as compared to only 2 patients (6.6%) in Group 'NS' and Group 'L' each. This was statistically significant (p value- 0.000) (Table 4).

The mean rise in intra-cuff pressure and the incidence of hoarseness, sore throat and dysphagia was more in Group 'A' as compared to Group 'NS' and Group 'L'.

Thus there was a significant correlation between

Table 1: Demographic data of patients

Group	Age (years) Mean ± S.D.	Sex wise distribution of patients Male	Female
Air (Group A)	38.63 ± 7.16	15 (50%)	15 (50%)
Normal Saline (Group NS)	35.36 ± 10.19	21 (70%)	9 (30%)
Lignocaine (Group L)	33.32 ± 11.63	18 (60%)	12 (40%)

Table 2: Comparison of Initial volume of CIM at cuff inflation, Final volume of CIM at cuff deflation & Total change in intra-cuff volume

Group	Volume at inflation of cuff (ml)	Volume at deflation of cuff (ml)	Change in volume (ml) Increase	Decrease
Air (Group A)	5.05 ± 0.66	9.13 ± 1.38	4.08 ±1.12	-
Normal Saline (Group NS)	5.63 ± 0.73	5.53 ± 0.71	-	-0.096 ± 0.14
Lignocaine (Group L)	5.58 ± 0.69	5.23 ± 0.63	-	-0.35 ± 0.23

Cuff inflation medium(CIM) Data are Mean ± SD.

Table 3: Comparison of Initial intra-cuff pressure, Final intra-cuff pressure & Total change in intracuff pressure in three groups

Group	Initial intracuff pressure (cm H2O)	Final intracuff pressure (cm H2O)	Change in intracuff pressure
Air (Group A)	21.2 ± 3.03	28.4 ± 3.97	7.2 ± 2.35
Normal Saline (Group NS)	20.46 ± 2.48	21.36 ± 2.74	0.65 ± 0.77
Lignocaine (Group L)	20 ± 2.21	20.5 ± 2.31	0.5 ± 0.77

Data are Mean ± SD.

Table 4: Correlation between Rise in intra-cuff pressure & Incidence of post-operative tracheal morbidity

Group	Rise in intracuff pressure	Hoarseness (%)		
		Gr 0	1	>1
Air (Group A)	7.2 ± 2.35	30	70	0
Normal Saline (Group NS)	0.65 ± 0.77	83.3	16.6	0
Lignocaine (Group L)	0.5 ± 0.77	90	10	0
Group	**Rise in intracuff pressure**	**Sore throat (%)**		
		Gr 0	**1**	**>1**
Air (Group A)	7.2 ± 2.35	16.6	83.3	0
Normal Saline (Group NS)	0.65 ± 0.77	80	20	0
Lignocaine (Group L)	0.5 ± 0.77	90	10	0
Group	**Rise in intracuff pressure**	**Dysphagia (%)**		
		Present	**Absent**	
Air (Group A)	7.2 ± 2.35	86.6	13.3	
Normal Saline (Group NS)	0.65 ± 0.77	6.6	93.3	
Lignocaine (Group L)	0.5 ± 0.77	6.6	93.3	

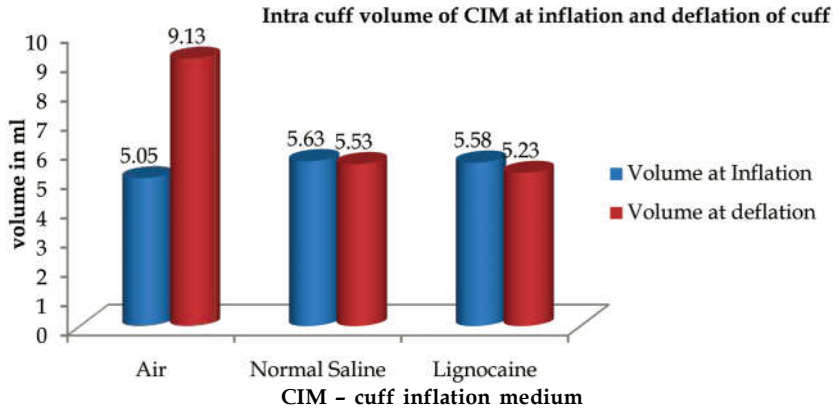

Fig. 1: Diagrammatic presentation of intra-cuff volume of CIM at inflation & Deflation of cuff in three groups

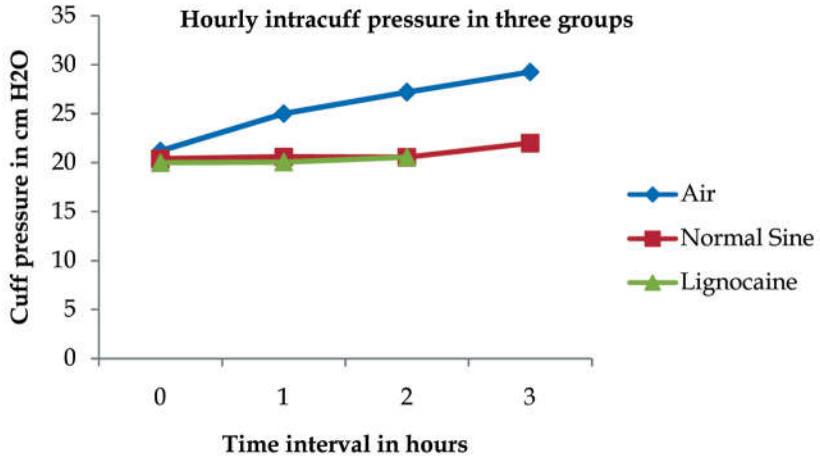

Fig. 2: Represent hourly intracuff pressure in three groups

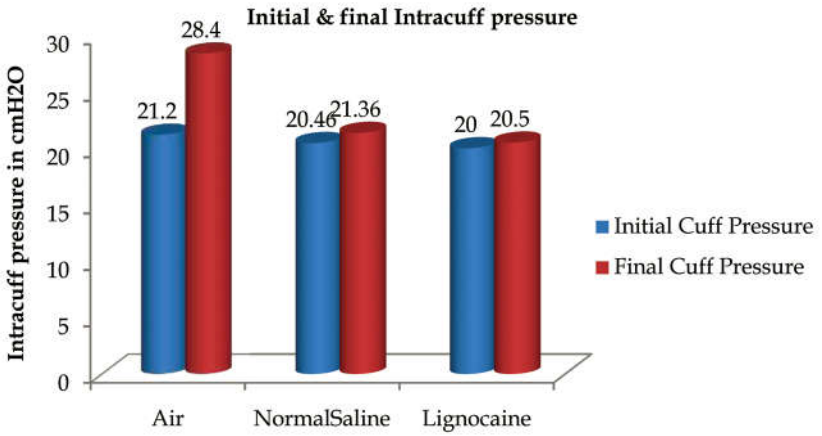

Fig. 3: Diagrammatic presentation of initial and final intracuff pressure in three groups

the rise in intra-cuff pressure and the incidence of post operative tracheal morbidity amongst three groups in relation to the medium used for endotracheal tube cuff inflation (Table 4).

Discussion

The present study was carried out to know whether the use of Normal Saline and 2% Lignocaine as a medium for cuff inflation offers any benefit over routinely used medium i.e. air. Considering possibility of toxicity of local anesthetic the amount of lignocaine used in the present study was less i.e. 2% Lignocaine 5 ml - 7 ml (100-140 mg) for patients weighing between 35 to 60 kg.

In our study, mean intra-cuff volume required for leak proof inflation of cuff was statistically comparable in all three groups (p value 0.384). This finding supports the study of Malhotra S. at al [22]. While Helena L [23] et al demonstrated that the median intracuff volume at inflation of cuff was 5.0 ml in group A and 6.5 ml in group L. The intra-cuff volume at inflation was more in group L as compared to group A. This was not observed in the present study and in the study of Malhotra S et al which may be because in these studies cuff was inflated preoperatively with lignocaine 2% for 90 min. to saturate the receptors which was not followed by Helena L et al [23].

We found statistically significant increase in intra-cuff volume at the time of extubation in group A which was in accordance with study of Malhotra S [22] and Helena L et al [23]. However, the fall in intra-cuff volume at the time of extubation in group 'NS' and 'L' observed in present study can be attributed to diffusion of normal saline and lignocaine from the endotracheal tube cuff which was also seen in study of Sconozo JM [24] , Altintas F et al [25] .This fall in intra-cuff volume at the time of extubation was statistically insignificant. However, Helena L et al [23] also observed fall in intra-cuff volume in group L at the time of extubation which was stastically

significant as they did not practice technique of presaturation of cuff receptors.

Initial intra-cuff pressure in all the three groups of present study was comparable (in range of 20-21.5 cm H2O) as well as with Helena et al [23] . According to Mehta S et al [18], the intra-cuff pressure of 25-30 cm of H_2O prevents aspiration of gastric contents. However in present study as well as in that of Helena L et al [23] the intra-cuff pressure was not adjusted exactly to 25-30 cm of H2O and its mean was in the range of 20-21.5 cm H2O and 20 cm of H2O respectively, still none of our patient had obvious evidence of aspiration.

In our study, we reported statistically significant progressive rise in intra-cuff pressure in group A when measured at hourly intervals (p - value 0.0281) also at the end of surgery (from 21.2 ± 3.03 to 28.4 ± 3.97 cm of H_2O). This finding correlates with the findings of Benette MH et al [26], Nguyen TU et al [27], Malhotra S et al [22] and Helena L et al [23]. This is because air inflated cuff within trachea represents a gas filled pocket in the body. The blood/gas solubility coefficient is 0.468 and 0.013 for nitrous oxide and nitrogen respectively which facilitates the diffusion of nitrous oxide into the cuff. Nitrous oxide diffuses inside an air space faster than nitrogen can escape. This leads to increase in both volume and pressure inside an air filled cuff [28] .

The final rise in intra-cuff pressure observed in normal saline and lignocaine 2% group was not significant. Our observations support the findings others [22], [25], [26]. Under ideal circumstances, there should be no change in intra-cuff pressure in the normal saline and lignocaine groups. The reason for this minimal rise in intra-cuff pressure could be explained by a small amount of air, which can be present in the PVC tube cuff even after deflation of cuff and when the cuff was inflated with liquid, air bubble was difficult to remove. So, Nitrous oxide gas diffusion into the air bubble may be responsible for small rise in intra-cuff pressure.

Nitrous oxide is 34 times more soluble than nitrogen in blood. The blood/gas solubility coefficient is 0.468 and 0.013 for nitrous oxide and nitrogen respectively which facilitates faster diffusion of nitrous oxide into the cuff especially in air space. The water / gas solubility coefficient of nitrous oxide is 0.435 hence it is obvious that the blood / water solubility coefficient of nitrous oxide (0.468/0.435) is near unity hence there is no net influx of nitrous oxide if liquid is used to inflate the cuff. Hence water or saline can be used to inflate the cuff of the tracheal tubes, the change in cuff volume and pressure would be minimal [9] .The findings in present study support it. Liquid medium with local anesthetic (e.g. 2% Lignocaine) can offer same benefits of stable intracuff pressure [25] and the cuff acts as a potential reservoir for local anesthetic allowing diffusion and subsequent anesthesia of the underlying mucosa [44] .This may help to reduce the incidence of postoperative tracheal morbidity because of diffusion from the cuff.

Postoperatively, after 24 hours the incidence of hoarseness of voice was maximum in group A as compared in group NS and in group L. The severity of hoarseness was grade 1 (noted by the patient). In all the three groups, none of the patient in the present study had hoarseness of grade 2 (obvious to observer) and 3 (Aphonia). When this incidence was correlated with the increase in intra-cuff pressure, it was obvious that the rise in intra-cuff pressure results in more incidence of hoarseness in group A as compared to group NS and group L. This supports the observations of Malhotra et al [22], Helena et al [23] and Ali et al [29].

However, the severity of hoarseness in the present study was less (Grade 1) as compared to Malhotra (Grade 2). The final rise in intra-cuff pressure in Malhotra's study was almost double as compared to present study, which may be responsible for the higher severity of hoarseness in their study.

Similarly, the severity of sore throat was grade 1 (mild-scratchy throat) in all the three groups. None of the patient in the present study had sore throat of Grade 2 (moderate, similar to that noted with cold) and 3 (severe, more severe than with cold). When this incidence was correlated with the increase in intra-cuff pressure, it was obvious that the rise in intra-cuff pressure results in higher incidence of sore throat as in group A compared to group NS and L. This observation in the present study supports the observation of Malhotra S et al [22] and correlate well with the findings of Combes X et al [2], Altintas F et al [25], Ali et al [29] and Navarro RM et al [19].

The occurrence of sore throat even when endotracheal tube cuff pressure was not significantly raised, suggest that this may due to the use of high volume low pressure cuffs. Loeser EA et al [12] in 1980 said that tracheal intubation with either cuffed or uncuffed disposable PVC tube produces a greater incidence and severity of post operative sore throat than mask anesthesia. Their findings support the results of present study.

The maximum number of patients from group A complained of dysphagia postoperatively as

compared to patients from group NS and group L. Thus the incidence of dysphagia also shows a close relation with the rise in intra-cuff pressure in the present study. Malhotra S et al [22] and Combes X et al [2] encountered patients of dysphagia in the post-operative period when they used air, saline as well as lignocaine for inflation of cuff. They were not able to demonstrate any correlation between the rise in intra-cuff pressure and the incidence of dysphagia as observed in the present study.

Conclusions

Inflating cuff endotracheal tube with air causes progressive and significant rise in intra-cuff pressure and volume as the duration of intubation increases.

Considering the findings & observations of the study, Normal saline and 2% Lignocaine seemed to be beneficial than Air for inflation of cuff especially when N2O is used as a part of balanced anesthesia in patients requiring prolonged duration of endotracheal intubation for general anesthesia to reduce the incidence of post operative tracheal morbidity.

If air is used for inflation of cuff, intra-cuff pressure should be monitored at regular interval and should be controlled to reduce the incidence and severity of post operative tracheal morbidity.

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