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Original Research Article

Comparison of Intracuff Pressure Changes Using Air Versus 2% Lidocainein the Cuff of the Endotracheal Tube

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Abstract

Background: Use of nitrous oxide during general endotracheal anaesthesia is associated with increase in cuff pressure and its consequences. Our aim is to study the cuff pressure changes when lidocaine is used as cuff inflating agent and emergence phenomena following general endotracheal anaesthesia using nitrous oxide.

Materials and methods: Sixty adult participants of ASA 1 and 2 undergoing elective surgeries under general endotracheal anaesthesialasting more than 90 min were included in this prospective randomised study. All patients were premedicated with IV dexamethasone 8 mg. They were divided into 2 groups of 30 patients each. Group A - endotracheal tube cuff was inflated with air and Group L - endotracheal tube cuff was inflated with 2 % preservative free plain lidocaine till the cuff pressure was 20 cm H_2O. Endotracheal tube cuff pressure was recorded by cuff manometer at cuff inflation, 5 min, 15 min and then at every 15 min interval till the completion of surgery. Emergence phenomena like sore throat, coughing, hoarseness, nausea/vomiting, dysphasia and dysphagia were noted at extubation and at 1 hr., 6 hr. and 24 hrs. postoperatively.

Results: The mean cuff pressure in group A was 26.81±4.04 cm H_2O and in group L was 18.67 ± 0.81 cm H_2O at the end of 90 mins of anaesthesia which was statistically highly significant. At 1 hour 33.3% of patients had sorethroatin group A, 10% in group L. At 6 hours and 24 hours, 16.6% and 20% of subjects had sorethroat in group A and 6.67 % subjects in group L at 6 and 24 hours. Incidence of coughing and hoarseness of voice were also more in group A than in group L. Incidence of nausea and vomiting was almost same in both the groups.

Conclusion: Minimal cuff pressure changes and fewer incidences of sorethroat, hoarseness and coughing were noted when cuff of the endotracheal tube was inflated with lidocaine than with air during endotracheal anaesthesia using nitrous oxide. Adding prophylactic

dexamethasone intravenously as a premedicant further reduces the incidence and severity of post-intubation morbidities in both the groups.

Keywords: Cuff pressure, Lidocaine, Air, Sorethroat.

Introduction

Establishment and maintenance of a patent airway by cuffed endotracheal tube (ETT) is still a gold standard principle of modern anaesthesia. Cuffed ETT was introduced by Waters and Guedel for providing positive pressure ventilation using carbon-di-oxide absorption technique. It also protects the airway from macroaspiration of regurgitated gastroesophageal contents. But the procedure can traumatise the airway mucosa leading to varying degree of postoperative sore throat (POST), hoarseness and cough.[1] Although these complications are minor and a patient may have one or more of these morbidities, they are more distressing in the immediate postoperative period. This may lead to patient dissatisfaction and prolonged hospital stay with delayed discharge of the patient.

The injury to the tracheal mucosa may be due to the traumatic injury by the tube, local irritation, inflammation and also by the pressure effects of the cuff of endotracheal tube.[1] Air is commonly used by most of the anaesthesiologist as an inflating agent in the cuff of the ETT during general endotracheal anaesthesia. Using nitrous oxide during general anaesthesia may diffuse across the cuff membrane increasing the cuff volume and pressure with increased incidences of tracheal lesions.[2,3,4] This may cause increased incidences of sore throat, coughing and hoarseness postoperatively. Nowadays, monitoring and adjustment of the cuff pressure of the ETT is becoming a routine practice in an effort to minimize the pressure effects on tracheal mucosa, thereby reducing the incidence of emergence phenomena.

Among the emergence phenomena, sore throat has been considered as the most common undesirable outcome in the immediate postoperative period occurring in 30% -70% of patients under general endotracheal anaesthesia.[5] The wide variation in these figures is due to different skills and techniques of intubation used by the anaesthesiologists. And also, the assessment of sore throat is mainly a subjective response of the patient to varying method of questioning by the assessor. Alternatively, to endotracheal intubation, other methods of airway management like the use of supraglottic airway devices such as laryngeal mask airway and I-gel are becoming more popular now-a-days to minimize these effects on tracheal mucosa.

Various techniques have been studied by various authors in an effort to minimise the incidence of these emergence phenomena. The cuff of endotracheal tube has been filled with saline, distilled water, plain or alkalinized lidocaine or various gels containing lidocaine, betamethasone or water-soluble gel have been applied on the surface of the cuff of ETT or intravenous steroids and lidocaine have been studied with varying results. In vitro and in vivo studies have shown that when lidocaine is used as ETT cuff inflating agent, it diffuses across the semipermeable cuff membrane and cause local anaesthetic action on the tracheal mucosa minimising emergence phenomenon[5,6,7]. So, the aim of our study was to study the intracuff pressure changes at the end of 90 minutes (min) using air versus 2% lidocaine in the cuff of the endotracheal tube under general endotracheal anaesthesia using nitrous

oxide. And also, to study the development of sorethroat, hoarseness and coughing postoperatively for 24 hours.

Materials and methods:

We conducted a prospective randomised study on 60 adult patients after obtaining approval from Institutional Research Ethical Committee. Patients were aged between 18-65 years belonging to American Society of Anaesthesiologists (ASA) physical status 1 and 2 who were posted for elective surgeries under general anaesthesia and who gave a valid written informed consent were included in the study. Participants with ASA physical status 3 and 4, Cormack and Lehene grading 3 and 4, surgeries on head, neck and airways and those who had preexisting sorethroat or hoarseness, predicted difficult airway, had nasotracheal intubation were excluded from the study. Patients needing rapid sequence induction with Sellick's manoeuvre, duration of surgery lasting for more than 4 hours and requiring mechanical ventilation after surgery were also not considered for the study.

In the operating room, patients were randomly allocated to either one of the 2 groups.

Group A - endotracheal tube cuff was inflated with air

Group L - endotracheal tube cuff was inflated with 2 % preservative free plain lidocaine.

Baseline vital parameters like pulse rate (PR), non-invasive blood pressure (NIBP), electrocardiogram (ECG) and oxygen saturation (SpO_2) were noted using a multi-para monitor.

All the patients received general anaesthesia; were premedicated with intravenous (IV) midazolam 0.02 mg / kg, IV fentanyl 1 µg / kg, IV ondensetron 0.1 mg / kg, IV dexamethasone 8 mg and pre-oxygenated with 100 % oxygen for 3 minutes (min). Patients were induced and intubated with IV Propofol 2 mg / kg and IV Vecuronium 0.1 mg / kg with cuffed endotracheal tube (7 - 7.5 mm in females, 8 - 8.5 mm in males). After confirmation of ET tube position, in group A, cuff of the ET tube was filled with air so that the cuff pressure was 20 cm H_2O. In group L, first the cuff was filled with air and then removed, and the same amount of 2 % preservative free plain lidocaine was inflated slowly into the cuff using a 3-way stop clock to achieve the same pressure of 20 cm H_2O. Anaesthesia was maintained with 50:50 oxygen: nitrous oxide and 0.5-1 % isoflurane with intermittent doses of vecuronium for muscle relaxation. Monitoring of PR, NIBP, ECG and SpO_2 were done every 5 min throughout the surgery. Endotracheal tube cuff pressure was recorded by non-invasive cuff manometer at 0 min (at cuff inflation), 5 min, 15 min and then at every 15 min interval till the completion of surgery.

At the end of surgery, endotracheal cuff pressure was recorded followed by administration of neostigmine 0.05 mg / kg with glycopyrrolate 0.01 mg / kg IV for reversal of muscle relaxation. Once the extubation criteria were met, patients were extubated in the operating room after thorough oral and throat suctioning. Patients were questioned about sore throat and its severity immediately after extubation, 1 hour (hr.), 6 hr. and 24 hr. postoperatively and were graded as follows [8]: 0 - No sore throat; 1 - Mild (less than common cold) ; 2 - Moderate (as seen with common cold) ; 3 - Severe (more than common cold). Additional emergence phenomena like coughing, hoarseness, nausea/vomiting, dysphasia and dysphagia were also noted at extubation and at 1 hr., 6 hr. and 24 hr. postoperatively.

Results:

All sixty patients who participated in the study were intubated in the first attempt. Both the groups did not differ in

demographic profile like age, sex, height and weight as shown in table 1. The mean duration of anaesthesia in group A was 116.50±20.64 min and in group L was 117.80±19.06 min with insignificant 'p' value of 0.605.

Table 1: Showing Demographic data

Characteristics	Group A	Group L	P value
Age in years (Mean ± S D)	39.0 ± 9.85	35.5 ± 8.38	0.173(NS)
Sex (Male: Female)	14:16	14:16	1.000(NS)
Body weight in kg (Mean ± SD)	55.23 ± 10.65	54.06 ± 9.40	0.655(NS)
Height in cm (Mean ± SD)	164.6 ± 5.37	162.2 ± 6.58	0.128(NS)
ASA grade (1: 2)	18:12	19:11	0.791(NS)
Duration of surgery in minutes	116.50 ± 20.64	117.80 ± 19.06	0.786(NS)

NS- not significant

The mean cuff pressure in group A was 26.81±4.04cm H_2O and in group L was 18.67±0.81cm H_2O at the end of 90 min of anaesthesia. The 'p' value showed to be statistically highly significant between the groups at various time intervals after inflation of cuff as shown in table 2.

Table 2: Cuff pressure changes throughout anaesthesia

Time in minutes	Group A (Mean ± SD)	Group L (Mean ± SD)	P value
At inflation	20	20	0.155(NS)
5	20.13±0.50	20	0.000(HS)
15	21.33±1.76	20	0.000(HS)
30	22.73±2.19	20.06±0.36	0.000(HS)
45	24.00±3.01	19.80±0.40	0.000(HS)
60	24.60±3.11	19.40±0.67	0.000(HS)
75	25.73±3.59	19.06±0.78	0.000(HS)
90	26.81±4.04	18.67±0.81	0.000(HS)
105	28.35±4.37	18.52±0.62	0.000(HS)
120	29.80±6.07	18.08.±0.28	0.000(HS)

NS- not significant, HS- highly significant

Table 3: Incidence and severity of postoperative sorethroat (POST)

POST		0hr	1hr	6hr	24hr
Group A	Grade 0	24 (80%)	20 (66.6%)	25 (83.3%)	24 (80%)
	Grade 1	6 (20%)	9 (30%)	4 (13.3%)	4 (13.3%)
	Grade 2	0	1 (3.3%)	1 (3.3%)	2 (6.67%)
	Grade 3	0	0	0	0
Group L	Grade 0	27 (90%)	27 (90%)	28 (93.3%)	28 (93.3%)
	Grade 1	3 (10%)	3 (10%)	2 (6.67%)	2 (6.67%)
	Grade 2	0	0	0	0
	Grade 3	0	0	0	0

Incidence and severity of POST was less in group L compared to group A at all times in the 24 hours postoperative period as shown in table 3. At 1 hour 33.3 % of patients had sorethroat in air group, 10 % in lidocaine group. At 6 hours and 24 hours, 16.6 % and 20 % of subjects had sore throat in group A compared to 6.67 % of subjects in group L at 6 and 24 hours.

Incidence of coughing was more in group A than in group L. Hoarseness of voice was also more in group A than in group L. Incidence of nausea and vomiting is almost same in both the groups as shown in table 4.

Table 4: Incidence of post-extubation morbidities

		0 hr.	1 hr.	6 hr.	24 hr.
Coughing	Air	10 (33.3%)	6 (20%)	4 (13.3%)	3 (10%)
	Lidocaine	6 (20%)	1 (3.3%)	2 (6.67%)	1 (3.3%)
Hoarseness of voice	Air	3 (10%)	2 (6.67%)	0	1 (3.3%)
	Lidocaine	3 (10%)	0	0	0
Nausea/ vomiting	Air	1 (3.3%)	0	1 (3.3%)	1 (3.3%)
	Lidocaine	0	2 (6.67%)	2 (6.67%)	0
Dysphagia	Air	0	0	0	1 (3.3%)
	Lidocaine	0	0	0	0

Regarding haemodynamic changes there were no significant changes in the parameters between the groups ($p>0.05$) at various time intervals. Variations in mean heart rate, systolic and diastolic blood pressure changes are shown in figures 1, 2 and 3 respectively

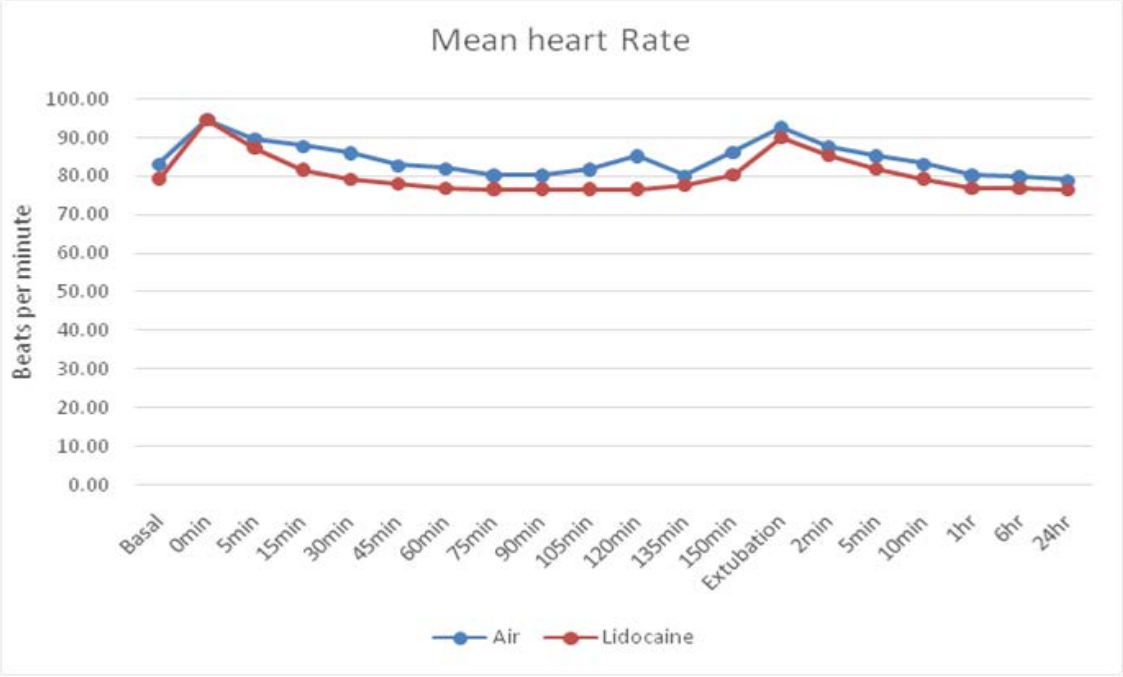

Figure 1: Changes in mean heart rate (in beats per minute) at various time intervals.

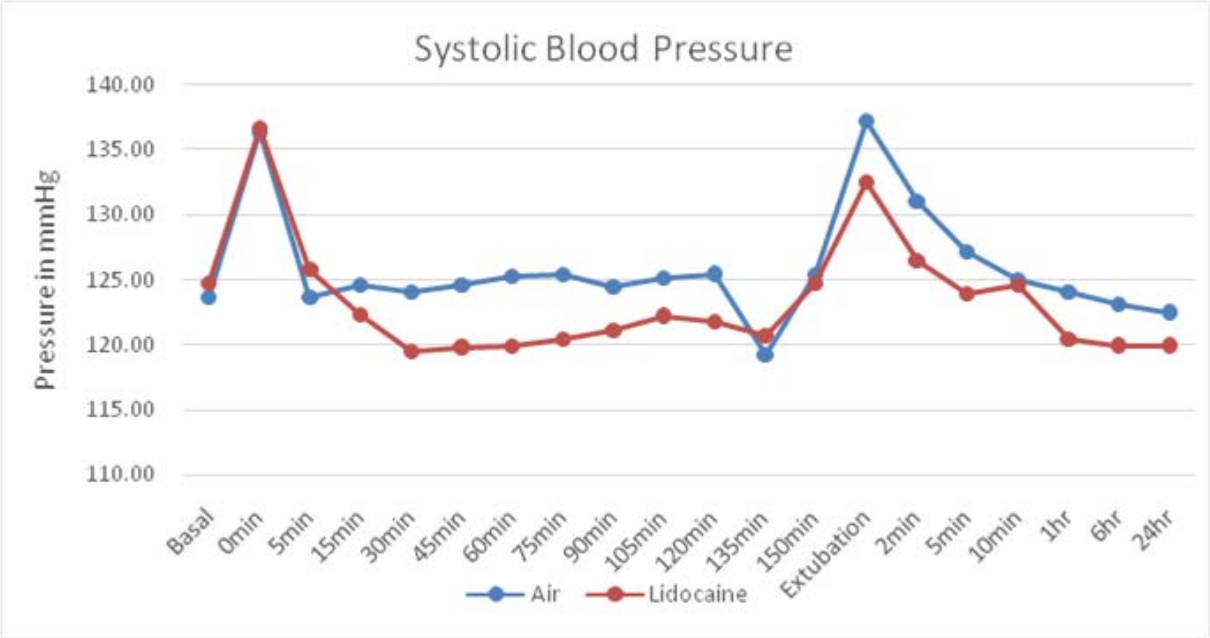

Figure 2: Changes in systolic blood pressure (in mm Hg) at various time intervals

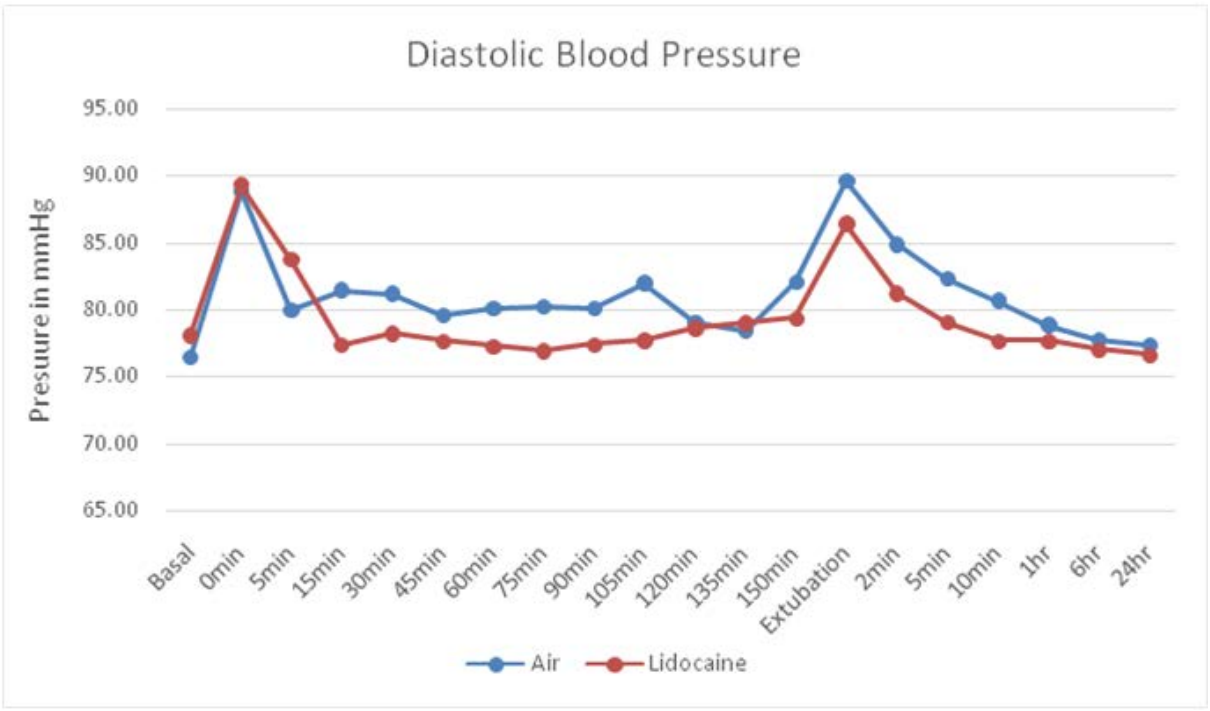

Figure 3: Changes in diastolic blood pressure (in mm Hg) at various time intervals

Discussion:

Endotracheal intubation is a common procedure done during general anaesthesia to provide positive pressure ventilation and also to protect the airway from aspiration. Earlier, red rubber tubes with low volume high pressure cuff were being used. But the disadvantage of these tubes is that the effect of the pressure exerted by the cuff on the tracheal mucosa leading to tracheal mucosal necrosis, stenosis and tracheomalacia on prolonged intubation.[9] Currently, disposable high volume low pressure cuffed ETT made of

polyvinyl chloride and polyurethane are being used to minimize the pressure effects on the trachea. Loeser and co-workers have extensively studied the effect of various types of ETT cuffs and their effects on the tracheal mucosa.[9] They showed that high volume cuffs have a greater area of contact with tracheal mucosa and are associated with more incidences of sore throat. They also recommend that the ideal cuff should have a diameter slightly less than that of trachea to prevent cuff wrinkling and so microaspiration. These high-volume cuffs cause more even distribution of pressure leading to only superficial mucosal damage when the cuff pressure exceeds the tracheal mucosal perfusion pressure of 30cm H_2O. It has been proved that the use of larger sized ETT may cause greater trauma to the airway during insertion and also greater contact with pharyngeal, laryngeal and tracheal lumen. So, it is advisable to use a smaller sized ETT as it has a distinct advantage in reducing the incidence of POST presumably because of decreased pressure at the tube-mucosal interface.[10]

In literature, overinflation or insufficient inflation of ETT cuff leading to catastrophic consequences has been reported which can be harmful to the patient. Overinflation may increase the cuff-tracheal contact area and may predispose the patient for development of POST. Generally, in routine anaesthesia practice, ETT cuff inflation and thereby the pressure is assessed by palpation of the pilot balloon or inflated till the cessation of audible leak around the cuff. The pressure in the pilot balloon is an indirect measure of the pressure exerted by the cuff on the tracheal mucosa. But these conventional methods of assessing cuff pressure are unreliable as they poorly correspond with the measured ETT cuff pressure.[11] The measurement and adjustment of cuff pressure by using a small, simple and inexpensive cuff pressure monitoring manometer device is suggested to be used as a routine in clinical practice to avoid these increased cuff pressure related problems.

Nitrous oxide, a still commonly used gaseous anaesthetic in conjunction with other anaesthetic agents can easily diffuse across the semipermeable cuff membrane of ETT causing an increase in the volume as well as pressure in the cuff when air is used as an inflating agent. This raised lateral wall pressure on trachea above 30cm H_2O may impair the tracheal mucosal capillary blood circulation and also the lymphatic drainage. If the cuff pressure exceeds 50 cm H_2O, it may completely obstruct the tracheal mucosal blood flow.[12] This impaired mucosal blood flow for 15min or more has shown to cause damage to the tracheal mucosal columnar epithelium and basement membrane was exposed resulting in sore throat, hoarseness and coughing during and post extubation causing discomfort and restlessness in the patient.[13] Coughing may also lead to tachycardia, hypertension and raised intraocular, intraabdominal, intracranial pressure with increased chances of surgical bleeding.

Some precautions need to be considered while inflating the cuff with a liquid like lidocaine. Before inflating the cuff with lidocaine, cuff should be emptied as fully as possible to remove the air in the inflating system. Sometimes it is difficult to remove all the air bubbles, and then this air bubble may expand during nitrous oxide anaesthesia increasing the cuff pressure and its consequences. So if any air bubble seems to be accumulated in the cuff after inflation, should be removed as much as possible. Alternatively, cuff can be prefilled with lidocaine and all the air bubbles are removed and deflated just before intubation.[6] Another consideration is that, filling the cuff with lidocaine should be done slowly than air as the liquid can flow slowly from the pilot balloon to the cuff and vice versa, and to ensure an equilibrium throughout the

inflating system from pilot balloon to the cuff.

Use of a liquid in the cuff like saline, plain lidocaine or alkalinised lidocaine prevents the diffusion of nitrous oxide into the cuff and thereby pressure within the cuff remains the same or reduces with time.[14] This minimizes the pressure effects on tracheal mucosal microcirculation.

Our study showed the gradual increase in the cuff pressure when air was used for cuff inflation after 15minutes of nitrous oxide anaesthesia using closed circuit. But the cuff pressure remained constant or slightly decreased only after 30min in lidocaine group. These results are in correspondence with the study by Navarro et al, Acharya et al and Gaur et al.[15,16,17]

Plain or alkalinised lidocaine hydrochloride in the cuff prevented increase in cuff pressure during nitrous oxide anaesthesia and the cuff serves as a local reservoir.[18] Lidocaine diffuses slowly along the concentration gradient through the lipophilic plastic semipermeable cuff membrane and act locally, anaesthetising the tracheal mucosa which is in contact with the cuff membrane[18,19,20] leading to improved ETT tolerance and reducing the adverse outcomes like coughing, haemodynamics, hoarseness and sore throat during emergence from general anaesthesia.[6] In vitro studies by Navarro and Estebe have demonstrated that the diffusion of lidocaine depend on the availability of nonionized fraction of lidocaine, temperature, duration of procedure and concentration of local anaesthetic used.[19,20,21] When plain lidocaine is alkalinised using sodium bicarbonate, the concentration of diffusible lipophilic nonionized fraction of lidocaine increased and the drug effect is drastically increased as studied by Navarro et al and Estebe et al.[15,20] In a meta-analysis, Lam et al proved that both alkalinized and non-alkalinized intracuff lidocaine may prevent postintubation related emergence phenomena.[22] Alkalinized lidocaineprestored in the ETT cuff with or without warming was suggested as prestorage, can saturate the cuff membrane and the effect is faster with smoother emergence from anaesthesia.[23,24] Lidocaine has been studied in varying concentrations from 2% to 10%. Using higher concentration of lidocaine is assumed to increase the diffusible fraction of lidocaine across the cuff membrane reducing the incidence of coughing in the initial postextubation period but local anaesthetic toxicity has to be considered if cuff ruptures.[23,25,26,27] But we used 2% plain lidocaine as it can be routinely used in clinical practice by all the anaesthesiologists.

Lidocaine has been used in many other ways like gel for tube lubrication, spray over epiglottis and vocal cords and intravenous lidocaine to minimize POST.[28] Topical lidocaine gel has been used for many years for cuff lubrication for smooth insertion of the tube as well as for blunting of emergence effects after general anaesthesia. Lubrication of the cuff with steroids like 1% hydrocortisone and betamethasone gel has also been studied to decrease the incidence of sore throat.[9,29] Conversely it was found that the incidence of sore throat was more with topical gels than no lubricant at all. Many studies failed to demonstrate that the use of lubricant jelly is beneficial in reducing POST.[28] So, we have not applied any lubricant gel on the cuff for insertion of the ETT.

Lidocaine, used as a spray on vocal cords however increased the incidence of ETT induced emergence phenomena but the mechanism remains unclear.[28] This may be thought to be due to local irritation by lidocaine or by the damage caused by prolonged or repeated laryngoscopy. IV lidocaine was also found to be useful in reducing emergence phenomena although the dose needed was higher 1-2mg/kg so as to achieve a significant serum lidocaine concentration of about 3µg/ml to

effectively suppress the cough, but it may lead to delayed emergence from anaesthesia[28]. So intracufflidocaine was found to be ideal as the drug dose needed is less and it acts locally on the tracheal mucosa which is in contact with the cuff of the ETT. Procedure of intubation may cause injury and activate the nociceptive receptors on the tracheal mucosa and so intracuff lidocaine by blocking these receptors continuously may lead to decreased incidence of POST and coughing. Even though alkalinisation of lidocaine was found to be more effective than plain lidocaine, it is not routinely practiced by all the anaesthesiologists. [14,15,17,20,24,30,31] So we used plain lidocaine in our study to assess the pressure changes and its consequences on post-intubation morbidities.

Our study showed the decreased incidence of postoperative sore throat when lidocaine was used as an inflating agent than air group at different times of recovery after extubation. As compared to other studies, where plain lidocaine has been used, the incidence of sorethroat and coughing were less in our study. These results are almost similar to use of alkalinized lidocaine for cuff inflation.[14,15,17,20,24,30] Our study also showed fewer incidences of coughing and hoarseness immediately after extubation and postextubation in lidocaine group than air group as shown by the study by Navarro et al.[31] Our study also proved that as we assumed, nitrous oxide is the major causative factor for increased cuff pressure and its consequences during balanced anaesthesia. At 6 hours and 24 hours, our study showed to have lesser frequency and severity of sorethroat, coughing and hoarseness as compared to other studies. This may indicate that along with pressure effects, local irritation, inflammation and edema caused by laryngoscopy and endotracheal intubation may also contribute to the increased incidence of laryngotracheal morbidity. Steroids due to their anti-inflammatory effect proved to be effective in modulating tissue edema, pain and also its action on chemoreceptor trigger zone leading to reduced incidence of emergence phenomena particularly after 6 hours. Park et al in their study has shown that the prophylactic use of 0.2mg/kg of IV dexamethasone than 0.1mg/kg IV dexamethasone was effective in significantly reducing the incidence and severity of sore throat and hoarseness at 1hr and 24hr postextubation period after double lumen endobronchial tube use for thoracic surgeries.[32] In our study, the administration of IV dexamethasone 8mg single dose as a premedicant, the incidence and severity of POST was less in both the groups as compared to other studies.[33]

Limitations of our study: Plasma lidocaine levels measurement was not done and so the amount of lidocaine that diffused across the cuff was not assessed. The degree of laryngotracheal mucosal damage has not been assessed.

Conclusion:

Our study demonstrated minimal cuff pressure changes and fewer incidence of sorethroat, hoarseness and coughing when cuff of the ETT was inflated with lidocaine than with air during endotracheal anaesthesia using nitrous oxide. So, we conclude that the use of intra-cuff lidocaine with monitoring of the cuff pressure is needed along with prophylactic use of intravenous dexamethasone in reducing post-intubation laryngo-tracheal morbidities.

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