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Original Research Article

Comparative study of endotracheal tube cuff inflation with air versus alkalinized lidocaine on hemodynamic response during extubation

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ABSTRACT

Background: The increased use of cuffed endotracheal tube during general anaesthesia has been associated with increased incidences of hemodynamic stress leading to tachycardia and hypertension during emergence from general anaesthesia. Hence it is planned to conduct a study inflating the endotracheal tube cuff with air as compared to inflation with 2% alkalinized lidocaine during intubation to observe the changes in hemodynamic stress response during extubation.

Aims and Objective: This study aimed to compare the effects of endotracheal tube cuff inflation with air versus 2% alkalinized lidocaine on hemodynamic stability during extubation (primary outcome) and to assess associated side effects (secondary outcome).

Materials and Methods: This Randomised prospective observational study was done on 40 patients between the age group of 18 to 65 years of both gender belonging to American Society of Anaesthesiologists (ASA) physical status 1 and 2 undergoing elective surgeries requiring general anaesthesia. They were separated into Group A – cuff inflated with air and Group L – cuff inflated with alkalinized lidocaine prepared by taking 9cc of 2% lidocaine and adding 1cc of sodium bicarbonate and using approximately 4-5 cc to inflate the cuff. Hemodynamic changes at baseline, induction, intraoperatively, during extubation and post-extubation were recorded.

Results: Haemodynamic responses were monitored at extubation & 2,4,6,8,10,15 minutes after extubation showed better hemodynamic stability in Group L than Group A.

Conclusion: The study suggested that endotracheal tube cuff inflated with alkalinized lidocaine have shown better hemodynamic stress response during extubation and post-extubation.

1. Introduction

Cuffed endotracheal tubes are essential in general anaesthesia for ensuring controlled ventilation. It also decreases the consumption of medical gases, prevent aspiration, reduce pollution of the operating room environment, and maintains the tube midline in the trachea.[1–4] However, cuff inflation, typically with air, can lead to significant hemodynamic stress during extubation, manifesting as tachycardia and hypertension. The incidence of coughing after extubation from general anaesthesia in some cases reaches up to 96%.[5]

Previous studies have explored various agents, including lidocaine, to mitigate these effects. Alkalinized lidocaine, in particular, may offer enhanced permeability through the cuff membrane, leading to better mucosal anaesthesia and reduced hemodynamic response.

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Lidocaine can be administered intravenously, intracuff, topical and through tracheal routes,[6] Other drugs can be used are dexmedetomidine,[7] fentanyl[8] and remifentanil.[9] Amongst these, lidocaine is the most widely used drug in anaesthetic set-ups and so it is being frequently used by anaesthetic professionals for decreasing the pressure response during extubation. It has been shown that lidocaine have reduced postoperative sore throat and coughing in 50 -70% cases over other drugs.[10–12]

In general anaesthesia ETT cuff are inflated by air which exerts pressure on adjacent mucosa. Monitoring of cuff pressure is usually done by manometer and when pressure is elevated, exerts pressure on adjacent mucosa of trachea leading to decrease blood supply which can lead to serious consequences such as ulcer formation, loss of cilia, inflammation, bleeding, tracheal stenosis and sometimes even tracheo-esophageal fistula.[13,14] Keeping ideal cuff pressure maintained for the entire duration of the surgery is also challenging as it is governed by the anaesthetic gas used such as nitrous oxide, the agent used to inflate the cuff, and the material and type of cuff.[15,16] Nitrous oxide is very commonly used in conjunction with other anaesthetic gases, but it readily diffuses into air-filled cavities such as cuff of ETT leading to a slowly rise in volume of cuff and which in turn increases cuff pressure of ETT, consequently leading to more hemodynamic changes during and post extubation.[13,17]

Lignocaine is liquid in nature so it does not allow entry of nitrous oxide into the cuff. It also permeates through the semipermeable membrane of cuff into tracheal mucosa and gives direct anaesthetic effect.[18–21] Making Alkalinised lignocaine with sodium bicarbonate ($NaHCO_3$) increases the non-ionised form of lignocaine which remarkably increases the permeability of lignocaine through polyvinyl cuff walls by approximately 63 folds.[22,23] Thus, small amount of lignocaine can also provide rapid and prolonged anaesthetic effect over mucosa. So, a randomised study was conducted on endotracheal tube inflated with air compared to cuff inflated with 2% alkalinized lidocaine to observe the attenuation of pressure response during extubation.

2. Materials and Methods

This Randomised prospective observational study was conducted in the operation theatre of a tertiary health care centre under the department of Anaesthesiology after obtaining approval from the Institutional Ethical Committee (SVIEC/UN/MEDI/SRP/JULY/23/128). A total of 40 patients of either sex aged between 18 to 65 years belonging to ASA 1 & 2, posted for elective surgeries, undergoing general anaesthesia were included in this study. Patients on anticonvulsants, known case of hypertension, known allergic to trial drug or not willing to participate were excluded from the study (Figure 1).

Detailed preanaesthetic check-up was carried out a day prior to surgery. General examination, physical and systemic examination and airway assessment were carried out. All routine investigations were done. The procedure was explained and written informed consent was taken in their native language.

Parameters monitored were heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and pulse oximetry (SpO2) recorded at baseline.

The sample size was calculated with the incidence of post operative coughing that was observed in the post-anesthesia care unit after tracheal extubation.[5] For this study, with a Type I error rate set at 0.05 and a Type II error rate of 0.2, corresponding to a power of 80% and a 95% confidence interval, a total sample size of 40 patients was determined, with 20 patients allocated to each group. The patients were evenly divided into two groups. Group A had their endotracheal tube (ETT) cuffs inflated with air, while Group L had their ETT cuffs inflated with alkalinized lidocaine. Alkalinized lidocaine was prepared by taking 9cc of 2% lidocaine and adding 1cc of sodium bicarbonate and using approximately 4-5 cc as required to inflate the cuff.

On arrival to operation theatre, intravenous access was taken and crystalloid inj. Ringar Lactate was started. Baseline parameters were recorded. Patient was premedicated with Inj glycopyrrolate 0.004mg/kg IV, Inj ondansetron 0.1mg/kg IV, Inj midazolam 0.02mg/kg IV and Inj tramadol 1mg/kg IV. Patient was then preoxygenated with 100% oxygen via face mask for 5 minutes. General anaesthesia was induced by standard technique of intravenous induction with Inj propofol (2mg/kg) along with Inj succinylcholine (2mg/kg) given to facilitate the intubation, after confirming check ventilation. Trachea was intubated with a cuffed portex endotracheal tube of appropriate size and bilateral air entry was confirmed. Cuff was then inflated either with air (Group A) or with 2% alkalinized lidocaine (Group L) depending on the allocated groups. Maintenance of anaesthesia was done with oxygen and nitrous oxide at 1:1 ratio and isoflurane as an inhalational agent by circle system. Inj atracurium 0.5mg/kg IV was administered as a loading dose and then maintained with 0.1mg/kg IV. Patients were mechanically ventilated with volume Control mode to maintain eucapnia.

Extubation was done at the end of surgery and patients were shifted to post-operative recovery room for post op monitoring. Primary outcomes were monitoring of vitals parameters (HR, SBP, DBP, MAP) was done at 30 minutes after induction, 30 minutes before extubation, after administration of reversal agent, during extubation, at 2, 4, 6, 8, 10 and 15 minutes after extubation. Secondary outcomes were any side effects like nausea, vomiting, sore throat, coughing, or dysphonia observed during study.

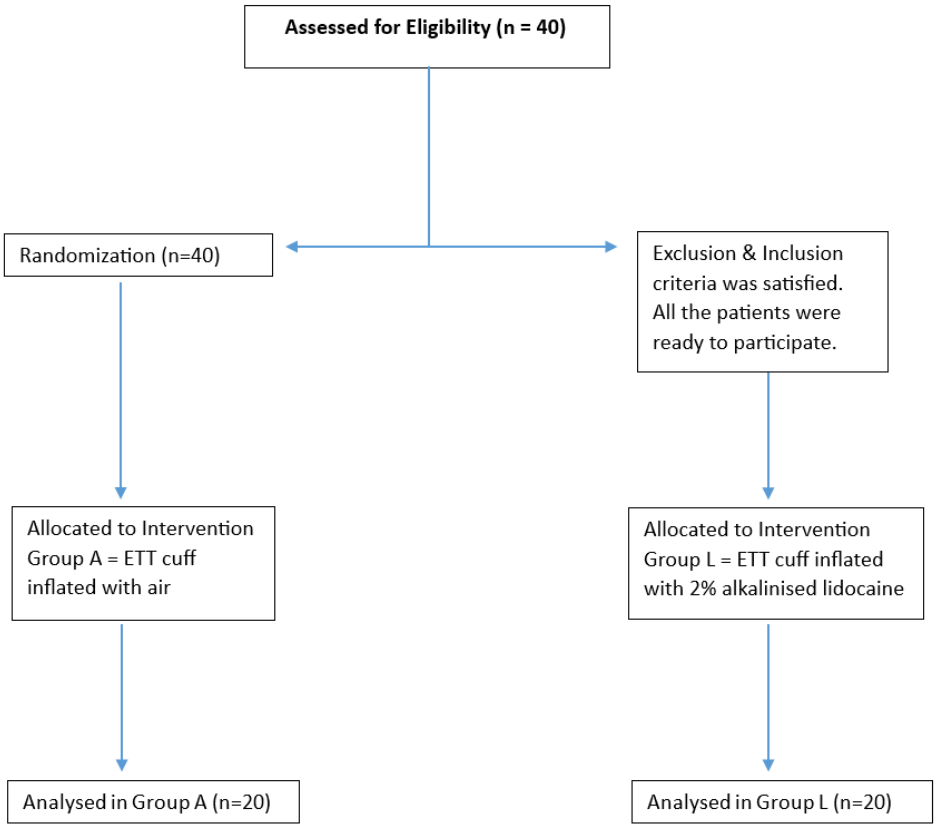

Figure 1: Consort flow diagram

2.1. Statistical analysis

The data was collected and entered using the Epi-Info version 7.0 and clean-up has been made to check accuracy, consistency, and errors. Errors identified were corrected and finally, the data was transported to SPSS Version 20 for analysis and presented as tabulated form. Numerical variables were demonstrated as mean and standard deviations (SD) while categorical variables were demonstrated as frequency and percentage. For comparison between both the groups, unpaired student-t test was used for numerical variables and for categorical variables, chi-square test was used. A difference of $p<0.05$ was considered statistically significant.

3. Results

A total of 20 patients in each group, Group A and Group L, were compared. The demographic data, including age, gender, weight, and ASA grading, were found to be comparable between the two groups (Table 1).

The results indicated that inflating the ETT cuff with air was significantly less effective in reducing heart rate during extubation and at 2, 4, 6, 8, 10, and 15 minutes post-extubation compared to inflation with alkalinized lidocaine. This difference was statistically significant, with a p-value of less than 0.0001 (Table 2).

As shown in (Table 3), ETT cuff inflation with air was less effective than alkalinized lidocaine in reducing systolic blood pressure during extubation and at 2, 4, 6, 8, 10, and 15 minutes post-extubation. This difference was statistically significant, with a p-value of less than 0.001.

In this study, the use of an endotracheal tube (ETT) cuff filled with 2% alkalinized lidocaine was found to be statistically significantly more effective in controlling diastolic blood pressure during extubation, as well as at 2, 4, 6, 8, 10, and 15 minutes post-extubation, compared to an ETT cuff inflated with air (Table 4, $p<0.001$). Diastolic blood pressure can be more sensitive to changes in vascular tone and systemic resistance, which might be influenced more significantly by the irritation and discomfort associated with extubation. Lidocaine's anesthetic properties could help mitigate these responses.

Mean arterial pressure measurements taken at extubation and at 2, 4, 6, 8, 10, and 15 minutes afterward revealed that the endotracheal tube (ETT) cuff inflated with air was significantly less effective than the cuff filled with alkalinized lidocaine in controlling mean arterial pressure ($p<0.001$) (Table 5). Patients in Group L, who received

Table 1: Demographic variables of both the groups

Variable	Group A Mean ± SD	Group L Mean ± SD	P-value
Age (years)	38.35 ±7.1	48.05 ±13.03	0.058 (NS)
Weight (kg)	59.25 ±8.26	61.2 ±7.11	0.4286 (NS)
Gender	N%	N%	
Male	55%	45%	0.7518 (NS)
Female	45%	55%	

(*NS– Not significant)

Table 2: Comparison of heart rate (beats/min)

Time	Group A (Heart rate) Mean ±SD	Group L (Heart rate) Mean ±SD	t	P-value
Baseline	79.8 ±8.41	80.3 ±10.06	0.171	0.8655 (NS)
30 min after induction	64.8 ±6.66	68.1 ±7.55	1.466	0.1509 (NS)
30 min before extubation	66.2 ±6.45	67.6 ±7.07	0.654	0.5169 (NS)
After administration of reversal agent	68.1 ±7.18	70.2 ±7.13	0.928	0.3592 (NS)
During extubation	90.7 ±6.69	79.5 ±7.1	-5.134	P < 0.0001 (HS)
2 min after extubation	92.1 ±6.31	81.1 ±6.94	-5.245	P < 0.0001 (HS)
4 min after extubation	92.7 ±5.81	81.3 ±8.47	-4.964	P < 0.0001 (HS)
6 min after extubation	92.8 ±6.88	81.4 ±7.49	-5.013	P < 0.0001 (HS)
8 min after extubation	92.1 ±7.38	81 ±7.75	-4.639	P < 0.0001 (HS)
10 min after extubation	91 ±7.36	81 ±7.44	-4.273	P < 0.0001 (HS)

(*HS-significant & *NS-not significant)

Table 3: Comparison of systolic blood pressure(mmHg)

Time	Group A (SBP) Mean ±SD	Group L (SBP) Mean ±SD	t	P-value
Baseline	120.2 ±7.76	119.8 ±8.1	-0.159	0.8741 (NS)
30 min after induction	108.1 ±7.66	107.7 ±9.21	-0.149	0.8821 (NS)
30 min before extubation	108.3 ±7.57	108.1 ±8.25	-0.080	0.9367 (NS)
After administration of reversal agent	109.4 ±6.02	109.4 ±8.41	0.000	1.0000 (NS)
During extubation	149.5 ±6.55	133.1 ±7.52	-7.354	P < 0.0001 (HS)
2 min after extubation	150.5 ±4.81	133.4 ±7.79	-8.353	P < 0.0001 (HS)
4 min after extubation	150.9 ±5.41	133 ±7.8	-8.433	P < 0.0001 (HS)
6 min after extubation	150.1 ±6.03	132.8 ±7.12	-8.292	P < 0.0001 (HS)
8 min after extubation	148.1 ±4.88	131 ±7.27	-8.734	P < 0.0001 (HS)
10 min after extubation	147.4 ±4.73	130.6 ±7.74	-8.283	P < 0.0001 (HS)
15 min after extubation	146.2 ±4.76	129.6 ±8.45	-7.655	P < 0.0001 (HS)

(*NS- Not significant *HS- Highly significant)

the alkalinized lidocaine treatment, exhibited notably better hemodynamic stability during and after extubation compared to those in Group A, who had air-filled cuffs ($p < 0.0001$).

Furthermore, 5 patients in Group A reported coughing and sore throat post-extubation, while no such complaints were observed in Group L. The coughing in Group A was associated with increased tachycardia and hypertension, which were more pronounced in these patients due to the use of air in the ETT cuff.

4. Discussion

Cuffed endotracheal tubes are used extensively to secure airway in patients undergoing general anaesthesia.[5,13] The lateral pressure exerted by the inflated cuff of ETT can be transmitted to the tracheal mucosa. When the ET cuff pressure becomes greater than tracheal capillary perfusion pressure of $30cmH_2O$[22,24,25] it can lead to tracheal ischaemia and complications during emergence such as coughing, agitation and primarily increased hemodynamic stress response.[26,27] This has led to the use of various techniques such as intracuff instillation of drugs such as lidocaine to decrease this response.

Table 4: Comparison of diastolic blood pressure (mmHg)

Time	Group A Mean ±SD	Group L Mean ±SD	t	P-value
Baseline	77.8 ±4.72	79.8 ±5.84	1.191	0.2410 (NS)
30 min after induction	70.3 ±3.26	72.1 ±5.33	1.288	0.2054 (NS)
30 min before extubation	69.6 ±3.35	71.3 ±5.04	1.256	0.2167 (NS)
After administration of reversal agent	70.6 ±3.25	72.3 ±5.28	1.226	0.2277 (NS)
During extubation	91.2 ±6.1	81.6 ±5.79	-5.105	P < 0.0001 (HS)
2 min after extubation	92.5 ±6.12	82.5 ±4.58	-5.851	P < 0.0001 (HS)
4 min after extubation	92.3 ±4.78	82.2 ±4.49	-6.887	P < 0.0001 (HS)
6 min after extubation	92.4 ±4.84	81.7 ±4.82	-7.005	P < 0.0001 (HS)
8 min after extubation	92.2 ±5.5	81.3 ±4.27	-7.001	P < 0.0001 (HS)
10 min after extubation	92.1 ±4.7	80.1 ±4.7	-8.074	P < 0.0001 (HS)
15 min after extubation	90.5 ±4.44	78.6 ±5.03	-7.932	P < 0.0001 (HS)

(*NS– Not significant *HS – Highly Significant)

Table 5: Comparison of Mean arterial pressure

Time	Group A (MBP) Mean ±SD	Group L(MBP) Mean ±SD	t	P-value
Baseline	91.95 ±5.02	93.05 ±5.15	0.684	0.4981(NS)
30 min after induction	82.95 ±3.82	84 ±5.66	0.688	0.4958(NS)
30 min before extubation	82.65 ±4.23	83.65 ±5.35	0.656	0.5160(NS)
After administration of reversal agent	83.65 ±3.56	84.75 ±5.72	0.735	0.4666(NS)
During extubation	110.05 ±5.53	98.9 ±4.7	-6.871	P < 0.0001 (HS)
2 min after extubation	111.5 ±4.41	99.5 ±4.24	-8.772	P < 0.0001 (HS)
4 min after extubation	111.4 ±3.78	98.95 ±4.88	-9.020	P < 0.0001 (HS)
6 min after extubation	111.05 ±3.72	98.45 ±4.68	-9.425	P < 0.0001 (HS)
8 min after extubation	110.5 ±4.11	97.45 ±4.74	-9.302	P < 0.0001 (HS)
10 min after extubation	110.25 ±3.77	96.55 ±4.68	-10.195	P < 0.0001 (HS)
15 min after extubation	108.8 ±3.76	95.95 ±4.76	-9.474	P < 0.0001 (HS)

(mmHg) (*NS– Not significant *HS – Highly significant)

With the use of alkalinized lidocaine, the pH of the prepared solution changes from 6.92 to 7.43, increasing the non-ionized fraction of the lidocaine and the cuff acts as a storage for releasing local anaesthetic to the underlying tracheal tissue through the cuff.[21,24–28] With the current focus being on "balanced anaesthesia", N_2O is a common conjunct to other inhaled gases. In 1965, Eger & Saidman found that nitrous oxide is 34 times more soluble in blood than inspired nitrogen[29] hence can lead to increased diffusion of nitrous oxide into the cuffs. In the study done by Navarro LH, they determined that in the group with air inflated ETT cuff, even though the initial pressure of the cuff was set below the critical pressure of tracheal mucosa of 30cmH_2O, after 30 min of administering N_2O, the cuff pressure almost equalled to 30cmH_2O.[23] This may be due to the fact that highly soluble gases dissolving in liquid does not lead to the expansion of the liquid.[14]

Navarro LH[24] conducted a randomised clinical study on 50 patients comparing ETT cuff inflation with 20cmH_2O to ETT cuff filled with 2% lidocaine & 8.4% $NaHCO_3$ to attain the same pressure. They observed that pressures in lidocaine filled endotracheal tube cuffs were significantly lower than the air filled cuffs ($p<0.05$) having lower systolic blood pressure at the time of extubation in lidocaine group ($p<0.05$)

Another prospective randomised controlled study conducted by Pallavi Gaur & Pravin Ubale[13] on 100 patients aged between 18 to 65 years compared ETT cuff inflated with air versus ETT cuff filled with alkalinized lidocaine (2% lidocaine with 7.5% $NaHCO_3$ in the proportion 19:1) and inflated to the pressure required to prevent air leak and measured using pressure manometer. It was seen that volume and pressure measured in the cuff at the end of the surgery were significantly higher in air group as compared to alkalinized lidocaine group ($p<0.05$) with incidence of coughing and post-operative sore throat being significantly higher in air group which is similar to our study.

In 2022, Biniam Assefa[15] conducted a prospective observational cohort study on 56 children aged between 3 to 13 years to compare tracheal tube cuff inflation with air versus alkalinized lidocaine to monitor hemodynamic parameters starting 5 minutes before extubation to 24 hours after extubation of the endotracheal tube. They

observed that mean heart rate and systolic blood pressure at 5 minutes after extubation was significantly lower in alkalinized lidocaine group compared to air group with p<0.001. Hence it was concluded that alkalinized lidocaine showed improved hemodynamic stability in children also.

There were two systematic reviews and meta-analysis of randomised controlled trials. Firstly in 2015 when Lam F[30] reviewed 19 trials comprising 1566 patients. Incidence of coughing and agitation was compared between alkalinized lidocaine filled cuffs, non-alkalinized lidocaine filled cuffs and control groups. It was seen that both alkalinized & non-alkalinized intracuff lidocaine helps to alleviate emergence phenomena compared to control group with significant hemodynamic stability (Confidence Interval 95%).

The second one was done in 2012 by Rizvanovic N[31] with 12 studies involving 1175 participants with age range of 36.71 to 52 years. It was concluded that Intracuff alkalinized lidocaine was associated with less cough compared to Saline group (95% confidence interval) and more effective than air group in decreasing postoperative sore throat & hoarseness (95% confidence interval).

Many Studies have shown that, with lidocaine used in the cuff, patients present lower incidence of bucking at the time of extubation,[29] since there is higher tolerance for both tracheal and tracheotomy tubing[32] and lower incidence of sore throats.[21–24]

In contrast to our study, Budania conducted a randomised study on 104 patients compared the effect of air, saline, anaesthetic gas mixture, or 2% lignocaine for tracheal tube cuff inflation on coughing & laryngotracheal morbidity after tracheal extubation.[33] They concluded that the difference in the post-extubation cough response was not significant in different groups.

In our study it was observed that ETT cuff inflated with air (Group A) was not as effective as alkalinized 2% lidocaine (Group L) in controlling vital parameters such as heart rate, systolic blood pressure, diastolic blood pressure & mean arterial pressure at the time of extubation, 2, 4, 6, 8, 10 & 15 minutes after extubation. Incidence of cough and sore throat was also seen in Group A patients.

5. Recommendation

Cuff inflation with alkalinized lidocaine is very easy to perform, readily available and new emerging trend for smooth recovery from general anaesthesia. It gives further door to various research proposals.

6. Limitations

There are few limitations of this study: First, the lack of a cuff manometer to measure cuff pressure is major limitation of the study. Second, there is no placebo saline group so comparison of Lidocaine and air group cannot be done with saline group. Third, we have included only normotensive patients and the responses may not reflect the effectiveness and safety in hypertensives in whom attenuation of intubation response is more difficult. As this study is conducted in single hospital, its generalisability is limited.

7. Conclusion

Inflation of the endotracheal tube cuff with alkalinized lidocaine significantly attenuates hemodynamic stress during extubation compared to air, suggesting a potential improvement in patient safety.

8. Source of Funding

There is no source of funding.

9. Conflict of Interest

The authors declare no conflict of interest.

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