Original Research Article

COMPARISON OF CHANGES IN INTRACUFF PRESSURE IN ENDOTRACHEAL TUBE AND LARYNGEAL TUBE

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Abstract

Laryngeal tube is a supraglottic device that is used effectively for managing the airway either as rescue device or device through which intubation can be done. The present study was conducted to compare the changes in intracuff pressure in the patients with endotracheal tube (ETT) and laryngeal tube (LT). Also, postoperative complications (ST and PH) caused by changes in intracuff pressure of ETT and LT.

After approval from Institutional ethics committee, the authors randomly selected 60 patients scheduled for surgery under general anesthesia (expected to last maximum 2 hours) in supine position, belonging to either sex, aged 18-60 years and who belonged to ASA physical status I or II.

After exclusions and inclusions, the patients were divided into two groups, each comprising of 30 patients. In one group the trachea was intubated with appropriate sized ETT (ETT group) and cuff was inflated to a pressure of 24-25 cm H2O; in the other group, the airway device used was LT (LT group) and cuff was inflated to a pressure of 60 cm H2O using hand held cuff inflator with pressure gauge. All patients were premedicated with Inj. Glycopyrrolate, Inj. Fentanyl and Inj. Ondansetron. Anaesthesia was induced with Inj. Propofol 2-3 mg/kg IV. Airway device was inserted after achieving neuromuscular blockade with inj. Vecuronium 0.1 mg/kg. Anaesthesia was maintained using O2 /N2O/ Iso and Inj. Vecuronium for muscle paralysis. At the end of surgery, anaesthesia was reversed using appropriate doses of Neostigmine (50-70μg/kg) and Glycopyrrolate (10μg/kg).

Standard monitoring was instituted along with peak airway pressure and intracuff pressure of the respective airway used (measured every 15 min. starting from cuff inflation to 1 hour). Patients were also assessed for features of airway obstruction, gastric regurgitation and any evidence of airway/oropharyngeal trauma at the time of extubation (visual inspection of device for presence of blood and inspection of oral cavity for evidence of trauma); postoperatively for evidence of sore throat (ST), postoperative hoarseness (PH) and tongue numbness in PACU (2 hours) and in ward (1 day postoperatively). Appropriate statistical tests were applied.

The demographic profile was similar in both groups and all the patients in both the groups could be ventilated adequately with their respective airway device throughout the study period as indicated by end tidal CO2 measurements, SPO2, Peak Airway pressures and Mean airway pressures at various points of times. The hemodynamics i.e. Heart rate, Systolic Blood Pressure, Diastolic Blood Pressure, Mean Arterial Pressure, Oxygen saturation and EtCO2 were also comparable (Table 2-7).

The peak airway pressures and mean airway pressures were comparable. In both the groups 3 patients had blood on the equipment as observed after extubation. No patient had dysphagia in any of the groups and 4 patients in each group had hoarseness in immediate postoperative period. Three patients had felt sore-throat in immediate postoperative and 2 hours in ETT group and 4 patients in LT group at immediate postoperative period and 2 patients after 2 hours.

It was concluded that both ETT and LT can be effective used for controlled ventilation, during general anaesthesia; the intracuff pressure increases in both these devices to similar levels and might contribute to LPM; the incidence of PH is decreased by use of LT instead of an ETT, hence LT can be an effective alternative to ETT.
Key Words : Laryngeal tube; ETT, Intracuff pressure.

INTRODUCTION:

Intubation of trachea is an important practice of protection of airway and maintenance of patent airway while delivering positive pressure ventilation.1 With the advent and increasing availability of supraglottic devices (SGD), these devices have become very popular for maintenance of airway and means of providing ventilation.2-5 Laryngeal tube (LT) is one of the class of SGD that was introduced few years back. LT has been successfully used in anaesthesia practice for PPV and also during CPR. However, all these devices including ETT have their complications. Laryngopharyngeal morbidity (LPM), including sore throat and hoarseness is one of them. Increase in cuff pressure with use of N2O besides other factors has been implicated as one of the causes of LPM.6-7

The present study was conducted to compare the degree of rise in cuff pressure over time in ETT and the LT and to compare the incidence of LPM (ST and PH) with the use of these devices.

The aims of the study were to evaluate and compare the changes in intracuff pressure of ETT and LT in routine surgeries under general anaesthesia and to compare the incidence of postoperative complications (ST and PH) caused by changes in intracuff pressure of ETT and LT.

MATERIAL AND METHODS

The present study was conducted in the tertiary hospital of north India and after an approval from departmental research and institutional ethics committee. Total 60 ASA physical status I or II patients, belonging to either sex, aged 18-60 years were randomly selected for patients who were scheduled for surgery under general anesthesia (expected to last max 2 hours) in supine position. All the patients weighed between 30-70 kg and measured 150-180 cm in height. Procedure was explained to the patients and informed written consent was obtained from all who participated. Patients who were full stomach or were considered at risk of pulmonary aspiration of gastric contents (including obese and pregnant patients); those having restricted mouth opening (<3 cm), pathology in neck / upper respiratory tract / upper alimentary tract, history of recent sore throat / hoarseness were excluded from the study.

The patients were divided into two groups, each comprising of 30 patients. In one group the trachea was intubated with appropriate sized ETT (ETT group) and cuff was inflated to a pressure of 24-25. cm H2O; in the other group, the airway device used was LT (LT group) and cuff was inflated to a pressure of 60 cm H2O using hand held cuff inflator with pressure gauge (VBM Medizinteknic).

All patients were premedicated with Inj. Glycopyrrolate 5 µg/kg IV, Inj. Fentanyl 2 µg/kg IV and Inj. Ondansetron 0.1 mg/kg IV. Anaesthesia was induced with Inj. Propofol 2-3 mg/ kg IV. Airway device was inserted after achieving neuromuscular blockade with inj. Vecuronium 0.1 mg/kg. Anaesthesia was maintained using O2 /N2O/ Isoflurane and Inj. Vecuronium for muscle paralysis as determined by NMB monitoring. At the end of surgery, anaesthesia was reversed using appropriate doses of Neostigmine (50-70µg/kg) and Glycopyrrolate (10µg/kg).

The patients were monitored for continued ECG, pulse oximetry, NIBP, EtCO2, NMB, temperature, peak airway pressure and intracuff pressure of the respective airway used (measured every 15 min. starting from cuff inflation to 1 hour) using the hand-held cuff inflator with pressure gauge. Patients were also assessed for features of airway obstruction, gastric regurgitation any evidence of airway/ oropharyngeal trauma at the time of extubation (visual inspection of device for presence of blood and inspection of oral cavity for evidence of trauma);

postoperatively for evidence of sore throat (ST) , postoperative hoarseness (PH) and tongue numbness in PACU (2 hours) and in ward (1 day postoperatively).

PH and ST were graded as follows7:

Grade	PH	ST
0	No PH (answered in negative by patient)	No ST (answered in negative by patient)
1	Noticed by patient	Mild (pain with deglutition)
2	Obvious to observe	Moderate (constant pain, increase with swallowing)
3	Aphonia	Severe (interferes with eating, needs analgesics)

Statistical Analysis

Our sample size was based on the results of previous studies,8 the sample size was 26 patients per group with a power of 90% and a confidence interval of 95%. Thirty patients in each group were recruited to compensate for a dropout rate of 20%.

The data was analyzed using IBM SPSS STATISTICS (version 26.0). Discrete categorical data were represented by number or percentage (%); continuous data, assumed to be normally distributed and it has been written either as its mean and standard deviation or as its median and interquartile range, as necessary. The normality of quantitative data was verified by measurements from the Kolmogorov-Smirnov normality tests. Student t-test or Mann Whitney U test was applied to compare 2 groups depending upon normality of the data. Proportions were compared using Chi square or Fisher's exact test, depending on their applicability for 2 groups. For comparison (time related variables) of hemodynamic repeated measure ANOVA was applied. Wilcoxon Signed rank test was used for skewed data (time related variables). All the statistical tests were two-sided and was performed at a significance level of α=0.05.

Results

The demographic profiles of the patients in the two groups were similar (Table 1).

Table 1: Table showing various demographic variables with frequency distribution and mean ± SD along with p-values.

DEMOGRAPHIC VARIABLES	Group ETT (n=30)	Group LT (n=30)	p-value
Sex Distribution M/F (n%)	14 / 16 (48% / 52%)	14 / 16 (48% / 52%)	**1.000***
Age (in years)	36.00 ± 10.57	39.14 ± 11.57	**0.165##**
Weight (in kg)	65.32 ± 9.34	66.44 ± 8.75	**0.537#**
Height (in cm)	163.76 ± 10.10	164.08 ± 8.80	**0.866#**
BMI (in kg/m²)	24.42 ± 3.36	24.79 ± 3.58	**0.746##**
ASA Category I/II (n%)	15 / 15 (50% / 50%)	10 / 20 (33% / 67%)	**0.295***

* chi-square test; # Independent t-test, ## Mann-Whitney 'U' test

All the patients in both the groups could be ventilated adequately with their respective airway device throughout the study period as indicated by end tidal CO2 measurements at various points of times, SPO2, Peak Airway pressures and Mean airway pressures. The hemodynamics i.e. Heart rate, Systolic Blood Pressure, Diastolic Blood Pressure, Mean Arterial Pressure, Oxygen saturation and EtCO2 were also comparable (Table 2-7).

The peak airway pressures and mean airway pressures were comparable. (Table 8-9).

Table 2: Table showing Heart Rate in both groups at different time intervals Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline HR	81.62 ± 13.52	80.72 ± 17.48	0.774
HR after 15 minutes of cuff Inflation	104.02 ± 14.75	9 4.78 ± 1.1	0.064
HR after 30 minutes of cuff Inflation	82.92 ± 14.66	76.22 ± 13.69	0.060
HR after 45 minutes of cuff Inflation	79.94 ± 13.17	74.46 ± 12.21	0.063
HR after 60 minutes of cuff Inflation	77.60 ± 12.17	73.64 ± 13.18	0.722

* Independent t-test

Table 3: Table showing Systolic Blood Pressure in both groups at different time intervals Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline HR	116.84 ± 11.47	119.94 ± 10.31	0.158
HR after 15 minutes of cuff Inflation	117.56 ± 11.83	117.78 ± 10.93	0.923
HR after 30 minutes of cuff Inflation	100.04 ± 9.01	113.36 ± 11.50	0.111
HR after 45 minutes of cuff Inflation	117.48 ± 13.70	119.86 ± 112.06	0.004*
HR after 60 minutes of cuff Inflation	113.44 ± 13.09	109.08 ± 13.20	0.100

* Independent t-test

Table 4: Table showing Diastolic Blood Pressure in both groups at different time intervals Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline DBP	76.08 ± 11.67	78.83 ± 10.55	0.38
DBP after 15 minutes of cuff Inflation	68.08 ± 13.34	68.61 ± 12.02	0.86
DBP after 30 minutes of cuff Inflation	71.06 ± 15.99	69.44 ± 15.01	0.66
DBP after 45 minutes of cuff Inflation	69.64 ± 15.02	65.14 ± 12.02	0.17
DBP after 60 minutes of cuff Inflation	67.33 ± 14.60	67.58 ± 12.85	0.94

Table 5: Table showing Mean Blood Pressure in both groups at different time intervals Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline MBP	96.47 ± 10.98	99.78 ± 12.29	0.23
MBP after 15 minutes of cuff Inflation	84.53 ± 14.24	84.58 ± 13.17	0.99
MBP after 30 minutes of cuff Inflation	87.11 ± 15.57	84.47 ± 14.89	0.46
MBP after 45 minutes of cuff Inflation	85.89 ± 14.44	79.67 ± 12.46	0.06
MBP after 60 minutes of cuff Inflation	82.53 ± 14.19	82.00 ± 12.64	0.87

Table 6: Table showing SPO2 in both groups at different time intervals Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline SPO2	98.64 ± 1.38	98.53 ± 1.21	0.72
SPO2 after 15 minutes of cuff Inflation	99.64 ± 0.72	99.67 ± 0.59	0.85
SPO2 after 30 minutes of cuff Inflation	99.61 ± 0.60	99.61 ± 0.60	1.00
SPO2 after 45 minutes of cuff Inflation	99.56 ± 0.61	99.56 ± 0.80	0.74
SPO2 after 60 minutes of cuff Inflation	99.53 ± 0.74	99.64 ± 0.68	0.51

* Independent t-test

Table 7: Table showing ETCO2 in both groups at different time intervals Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline ETCO2	-	-	-
ETCO2 after 15 minutes of cuff Inflation	34.17 ± 2.84	33.28 ± 3.90	0.05
ETCO2 after 30 minutes of cuff Inflation	33.28 ± 2.51	32.11 ± 2.64	0.06
ETCO2 after 45 minutes of cuff Inflation	32.22 ± 2.14	31.83 ± 2.05	0.43
ETCO2 after 60 minutes of cuff Inflation	32.72 ± 2.42	32.25 ± 1.95	0.36

* Independent t-test

Table 8: Table showing Peak Airway Pressure (PAP) in both groups at different time intervals
Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline PAP	-	-	-
PAP after 15 minutes of cuff Inflation	34.17 ± 2.84	33.28 ± 3.90	0.06
PAP after 30 minutes of cuff Inflation	33.28 ± 2.51	32.11 ± 2.64	0.07
PAP after 45 minutes of cuff Inflation	32.22 ± 2.14	31.83 ± 2.05	0.43
PAP after 60 minutes of cuff Inflation	32.72 ± 2.42	32.25 ± 1.95	0.36

* Independent t-test

Table 9: Table showing Mean Airway Pressure (P_{Mean}) in both groups at different time intervals
Data is expressed as mean ± SD

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline P_{Mean}	-	-	-
P_{Mean} after 15 minutes of cuff Inflation	7.22 ± 1.51	7.22 ± 1.27	1.00
P_{Mean} after 30 minutes of cuff Inflation	7.44 ± 1.34	6.97 ± 1.28	0.13
P_{Mean} after 45 minutes of cuff Inflation	7.58 ± 1.42	7.08 ± 1.27	0.12
P_{Mean} after 60 minutes of cuff Inflation	7.75 ± 1.32	7.28 ± 1.26	0.12

* Independent t-test

Table 10: shows mean intracuff pressure (MICP) in both the groups at different time intervals. It was 25.25 cm of H_2O in ETT group when it was inserted and fixed as compare to 60.40 cm H2O when LT was inserted and then measured. From 25.25 it increased to 33 cm of H_2O in one hour duration and from 60.40 cm H_2O to 80.14 cm H_2O. When the percentage of increase was measured from baseline and it was 32.3 % in ETT and 32.7 % in LT group. (Table 11)

	Group ETT (n=30)	Group LT (n=30)	p-value
	Mean ± SD	Mean ± SD	
Baseline MICP (Immediately After insertion)	**25.25**	**60.40**	-
MICP after 15 minutes of cuff Inflation	26.75	64.50	
MICP after 30 minutes of cuff Inflation	29.41	68.30	
MICP after 45 minutes of cuff Inflation	31.16	76.50	
MICP after 60 minutes of cuff Inflation	33.00	80.14	

* Independent t-test

Table 11: Table showing percentage increase of Intracuff pressure (PIMICP) in both groups at different time intervals.

	Group ETT (n=30)	Group LT (n=30)
	Mean ± SD	Mean ± SD
Baseline PIMICP (Immediately After insertion)	-	-
PIMICP after 15 minutes of cuff Inflation	5.9	6.7
PIMICP after 30 minutes of cuff Inflation	14.8	13.07
PIMICP after 45 minutes of cuff Inflation	23.4	26.65
PIMICP after 60 minutes of cuff Inflation	30.3	32.68

Table 12: Postoperative complications

	Group ETT (n=30)	Group LT (n=30)	P VALUE
Presence of blood on equipment	3	3	1.00
Dysphagia			
0 hours	0	0	
2 hours	0	0	
24 hours	0	0	
Hoarseness			
0 hours	4	4	1.00
2 hours	0	0	NA
24 hours	0	0	NA
Sore throat			
O hours	3	4	1.00
2 hours	3	2	0.69
24 hours	0	0	NA

Table 12 shows the postoperative complications. In both the groups 3 patients had blood on the equipment as observed after extubation. No patient had dysphagia in any of the groups and 4 patients in each group had hoarseness in immediate postoperative period. Three patients had felt sore-throat in immediate postoperative and 2 hours in ETT group and 4 patients in LT group at immediate postoperative period and 2 patients after 2 hours.

Discussion

Nitrous Oxide (N_2O) is known to diffuse in air filled cavities including cuffs of airway devices resulting in increase in volume and intracuff pressure. Disposable PVC ETT with high-volume low-pressure cuffs are mostly used now-a-days. In these cuffs the nitrous oxide penetrates and diffuses into it and increases intracuff pressure.

The rise in intracuff pressure of airway devices contributes to laryngopharyngeal morbidity.[7] Intracuff pressure has been shown to be an excellent predictor of mucosal pressure and perfusion. Further pressure exerted on mucosa has been shown to be a causative factor postoperative sore throat and hoarseness.

In the present study all hemodynamic and ventilator parameters were similar and difference in these parameters were statistically insignificant. The mean intracuff pressure was increased in both the groups (Table 10) and the percentage of increase was in both the devices. In 45 minutes of introduction of both devices, percentage of increase of mean intracuff pressure was 5.9 to 30.3 in ETT group and from 6.7 to 32.68 in LT group. The increase was significant from baseline as nitrous oxide might have diffused inside the cuff and increased the pressure. This increased the incidence of sore throat and hoarseness in first few hours in both the groups.

Splinter and Smallman in 1994 quoted the incidence to be 13% with LMA use and 5% with ETT in children.[9] In both the groups 3 patients had blood on the equipment as observed after extubation. No patient had dysphagia in any of the groups and 4 patients in each group had hoarseness in immediate postoperative period. Three patients had felt sore-throat in immediate postoperative and 2 hours in ETT group and 4 patients in LT group at immediate postoperative period and 2 patients after 2 hours.[9]

In 1997, Reiger et al showed the incidence of dysphagia to be 23.8% after LMA use and 12.5% after ETT use. Various factors have been implicated in causation of post-operative ST like depth of anaesthesia, method of insertion of airway device, number of attempts made for placements of the

device, presence of HME filter in circuit, sex of the patient, and duration of anaesthesia and postoperative analgesia. In our patients, device could be placed in single attempt in all the patients, we did not use an HME filter, and duration of anaesthesia was almost the same in all the patients. Patients were well anaesthetized before airway manipulation and adequate analgesia was provided to all patients in postoperative period.[10]

Factors implicated in causation of PH are ETT size and cuff designs, airway humidity and trauma during insertion and suction, the placement of device was atraumatic in all patients, airway humidity played similar role in both groups, obviously patients in LT group were not exposed to any maneuvers below the glottis which might account for lesser incidence of PH in this group of patients.

Reiger et al showed the incidence to be 46.8% with ETT and 25.3% with LMA. The authors noted the incidence of PH to be 33.3% with ETT and 13.3% with LT ($p<0.05$).[10] The severity of ST and PH was mild in most of the patients except 3 patients in ETT group and 4 in LT group, who had moderate (grade 2) ST and 3 patients in ETT group has moderate (grade 2) PH while all 4 patients in LT group had mild PH. Neither ST nor PH persisted beyond 24 hours in any of the patients. Intracuff pressure has been shown to correlate to pressure exerted on mucosa and consequent mucosal perfusion, Asai and Kawachi in 2001 showed that in LT at intracuff pressure of 60 cmH_2O pressure exerted on mucosa is 29 (24-36) cmH_2O and at intracuff pressure of 70 cmH_2O, pressure exerted on mucosa is 37 (26-60) cm H_2O 12, Brimacombe J showed in 2005 that at intracuff pressure of 124 cmH_2O the exerted mucosal pressure was 46 cmH_2O.[12] Seegobin and colleagues showed in 1984 that tracheal mucosal perfusion begins to decrease when mucosal pressure exceeds 30 cm H_2O and begins to cease when mucosal pressure exceeds 50 cm H_2O.[12]

Brimacombe on the other hand, correlated pharyngeal mucosal pressure with mucosal perfusion by direct measurement of pharyngeal mucosal pressure with mucosal perfusion by direct measurement of pharyngeal mucosal pressure and showed that patients mucosal blood vessels (BVs) begin to compress at mucosal pressure at 34 cm H2O and their BVs begin to collapse at mucosal pressure at 73 cm H_2O.[13] According to Asai & Shingu's work in 2004, the intracuff pressure rises to 77 cmH2O 60 min with use of N_2O and may go upto 102 cm H2O after 110 min, while the pressure remains stable if air is used instead of N_2O.[12]

Various methods have been advocated to limit the increase in cuff pressure during anaesthesia delivery, some of which are – avoidance of N_2O during anaesthesia and use of air instead of it; use of saline to inflate the cuff, the cuff may be inflated with anaesthetic gas mixture instead of air; intermittent release of pressure can also limit the increase in pressure; use of tubes with foam cuffs can be tried, tubes with Profile-soft-seal cuffs (PSSC); Brandt anaesthesia tube also limits N_2O related increase in intracuff pressure, pharmacological methods can be tried to prevent postop ST such as transdermal ketoprofen, ketamine gargles, gargling with sodium azulene sulfonate, lubrication of tube with betamethasone gel, pre-op use of dexamethasone iv have been shown to decrease incidence of ST.[14]

The blood on the supraglottic or the ETT shows the insertion difficulties in the experienced hands. Its incidence is comparable in the present study. Experienced anaesthesiologists perform well in the airway procedures and incidence of complications decrease with them.

Conclusions

It is concluded that both ETT and LT can be effectively used for controlled ventilation, during general anaesthesia. The intracuff pressure increases in both these devices similarly and might contribute to laryngopharyngeal morbidity. The incidence of postoperative hoarseness is decreased in patients where LT was used.

Continuous monitoring of intracuff pressure is necessary so as to decrease the incidence of pharyngeal mucosal ischemia. Hence, the present study concludes that LT can be an effective alternative to ETT .

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