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CHANGES IN ENDOTRACHEAL TUBE CUFF PRESSURE DURING LAPAROSCOPIC SURGERIES IN DIFFERENT POSITIONS: A DESCRIPTIVE COHORT STUDY

Anaesthesiology

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ABSTRACT

Background: The pneumoperitoneum and surgical positioning in the laparoscopic surgery have been reported to result in an increase of airway pressure. However, as ociated effects on changes of endotracheal tube cuff pressure are not well established.

Methods:110 patients were included in this study. In 55 patients, the laparoscopic surgery was performed in Trendelenburg position while in 55 patients the surgery was performed in reverse Trendelenburg position. Changes in endotracheal tube cuff pressure after pneumoperitoneum and surgical positioning were analysed and compared.

Results: The endotracheal tube cuff pressure increased by approximately 5 cm of H2O after pneumoperitoneum in Trendelenburg position and by 2 cm of H2O in the endotracheal tube cuff pressure after pneumoperitoneum in reverse Trendelenburg position. After pneumoperitoneum the cuff pressure increased from 25 to 27.44 + 0.50 and 28.02 + 0.80 cm of H2O respectively for Trendelenburg and reverse Trendelenburg position. This difference was statistically significant in both the groups. There was a stastically significant increase in airway pressure from baseline after pneumoperitoneum in both groups however the difference was statistically not significant between the two groups with a p value > 0.05 using Fisher's exact test.The incidence of post-operative tracheolaryngeal morbidity was significantly higher in Trendelenburg position group which correlated with higher cuff pressures

Conclusions: The endotracheal tube cuff pressure gets affected by creation of pneumoperitoneum and patient position. There is significant increase in the endotracheal tube cuff pressure in laparoscopic surgery performed in Trendelenburg position

KEYWORDS

Endotracheal tube cuff pressure, Laparascopic surgery, Trendelenburg position, Reverse Trendelenburg position

INTRODUCTION:

Aims: To study the changes in endotracheal tube cuff pressure during laparoscopic surgeries performed in Trendelenburg position and reverse Trendelenburg position. The secondary objective of the study was to observe the incidence of sore throat, hoarseness and emergence coughing (laryngo-tracheal morbidity) immediately after extubation & at 24 hours.

Settings and Design: Descriptive Analytical Cohort study

With increase in the number of day care surgeries, prevention of laryngo- tracheal morbidity following airway management is of great importance as it can prolong recovery and home readiness. Most laparoscopic procedures such as cholecystectomy and gynaecological laparoscopies are done as day care procedures with General endotracheal anaesthesia as the preferred mode of anaesthesia.

The effect of endotracheal tube cuff pressure and the duration of intubation on the incidence and the severity of Laryngo-tracheal morbidity are well studied and documented. However the effect of patient position during laparoscopic procedures on the cuff pressure is not known. Hence, in this study we assessed the changes in endotracheal tube cuff pressure during laparoscopic surgeries in Trendelenburg and reverse Trendelenburg position and its effect on laryngo-tracheal morbidity.

METHOD:

This study was conducted at a tertiary health care center during the period of January 2015 to December 2016. After obtaining permission from the institutional ethics committee and written informed consent, all patients scheduled for laparoscopic surgeries were considered for the study. The patients were later classified into 2 groups(55each) depending upon the position given for the proposed surgery: Group I: Reverse Trendelenburg Position & Group II: Trendelenburg Position.

110 ASA Physical status I and II patients of either sex, between 18 – 60 years of age, weighing 40-80kg with BMI < 25 and MPC Grade I & II were included in the study. Patients with history of smoking/COPD, active URTI, hoarseness of voice, dysphagia, laryngeal disease or surgery were excluded from the study. Pregnant patients, patients who refused to give consent and any patient in whom the duration of surgery exceeded 4 hours were also excluded from the study. The surgical procedures conducted in Reverse Trendelenburg position. were: Laparoscopic cholecystectomy and Laparoscopic Vagotomy while the procedures conducted in Trendelenburg Position. were Laparoscopic Hyster ectomy, Laparoscopic ovarian cystectomy and Laparoscopic inguinal hernia repair.

The aim and primary objective of the study was to assess and compare the effect of surgical position on endotracheal tube cuff pressure during laparoscopic procedures.

The secondary objective was to assess the incidence of post-operative laryngo-tracheal complications – emergence coughing, post-operative sore throat, dysphagia, and hoarseness.

We tested the hypothesis that the endotracheal tube cuff pressure increases significantly during laparoscopic surgeries in Trendelenburg position and thus associated with increased incidence of laryngotracheal morbidity.

Sample size was calculated on the basis of the anticipated difference in endotracheal cuff pressure between the two different surgical positions, using published data from previous study for a value of α-0.05 & β-0.20 and from a standard formula from the site for mean difference $N = K \times \{\delta/\mu_1 - \mu_2\}^2$ where
K = constant {for a value of α-0.05 & β-0.20} – 7.9
δ = standard error
μ_1 & μ_2 = mean of two groups

The sample size needed was 54 for each group. We included 55 patients with a total of 110 patients.

A convenience sampling method was used to select and classify patients depending upon the position given for the proposed laparoscopic surgery. Group I included patients who were given Trendelenburg position for the proposed laparoscopic surgery and Group II included patients operated in reverse Trendelenburg position. All patients underwent thorough preanaesthesia assessment prior to surgery including a detailed history, general and systemic examination. The anaesthetic procedure was explained to the patient and all queries were answered. All patients were investigated as per the institutional protocol for Complete blood count, Chest X-ray, Random blood sugar, Liver function tests, Renal function tests and ECG in patients above 40 years of age.

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On the day of surgery, Anesthesia trolley and difficult airway cart and crash cart was kept ready. After confirming the Consent and NBM status, Intravenous access was secured. Standard monitoring included pulse oxymeter(SPO2), Non Invasive Blood Pressure monitor(NIBP), Cardioscope for ECG monitoring, Capnometer(ETCO2) and ETT Cuff pressure monitor.

All patients were premedicated with 0.03 mg/kg IV Midazolam hydrochloride and IV Fentanyl 2µg/kg. After preoxygenation for 3 minutes, anaesthesia was induced with Intravenous Thiopentone Sodium 5mg/kg or intravenous Propofol 2mg/kg as per the discretion of the anaesthesiologist conducting the case. After confirming that patient could be mask ventilated, neuromuscular blockade was achieved with Intravenous Vecuronium bromide 0.08mg/kg or Atracurium besylate 0.5mg/kg. Tracheal intubation was performed after clinical assessment of N-M blockade i.e. adequate jaw relaxation. All intubations were done by a qualified anesthesiologist having at least 5 years of experience. Endotracheal tubes with high residual volume, low-pressure cuff, with an inner diameter of 7.0 mm for female and 8.5 mm for male was used as per the standard protocol.

Prior to intubation, endotracheal tube cuff was aspirated as much as possible and after intubation the cuff was inflated with air using a sterile 10cc syringe to achieve intracuff pressure of 25 cm of H2O. The volume used to fill the cuff and the cuff pressure was recorded in each patient using hand-held, Portex aneroid manometer (CE0473, for low pressure cuffs, Germany) by the senior Anaesthesiologist conducting the case. The same anaesthesiologist assessed the tracheal leak by both audible technique and by observing the difference between set and delivered tidal volume. Auscultation over trachea and epigastrium was done for detection of leak at inspiratory pressure not greater than 40 mm of Hg. In case of a leak, additional air in the increment of 1cc was added. Intracuff pressure was not allowed to increase beyond 30 cm of H20. Total air volume to fill the cuff was noted. Same Portex aneroid manometer was used to measure endotracheal tube cuff pressure throughout the surgery and this manometer was calibrated monthly.

Mechanical ventilation was controlled using Penlon AV-S ventilator and adapted to maintain end-tidal carbon dioxide at 30–35 mmHg and optimal saturation of >95%.

A gastric tube was inserted in all patients.

Anaesthesia was maintained either by using inhalational agent or intravenous propofol as per the discretion of the conducting anaesthesiologist to maintain haemodynamic parameters within 20% of the baseline value. N2O was avoided. Oxygen + air 50:50 were used. Neuromuscular blockade was maintained with supplemental dosages of Vecuronium (0.02mg/kg) given at regular intervals. Fentanyl 1 mcg/kg was repeated every hour.

Each patient received abdominal insufflation in supine position with the intraabdominal pressure between 10-15 mm Hg. Intracuff pressure was noted after desired intraabdominal CO2 insufflation was achieved. After abdominal insufflation, patients were given position for the surgery. Endotracheal tube cuff pressure was measured after desired position was given and every 30 minutes. Changes in airway pressure were also recorded. All measurements were taken with each patients head and neck in the neutral position and the occiput on 7cm thick head ring and data was recorded 2 minutes after every/any additional abdominal insufflation and positioning adjustments during end expiration.

If intracuff pressure of >30cm of H20 was noted, endotracheal tube position was reconfirmed. Intraabdominal pressure was noted and reduced if possible. The cuff pressure was monitored after correction of position and removal of gas from abdominal cavity. If needed cuff volume was reduced in steps of 1cc air to maintain cuff pressure < 30 cm of H2O.

At the end of surgery, patient was allowed to awaken and neuromuscular block was reversed with Neostigmine 0.05 mg/kg and Glycopyrrolate 8µg/kg and the pharynx was gently suctioned. ETT was removed after the following criteria were met: full reversal of neuromuscular block, spontaneous breathing, Ability to follow verbal commands (hand grip or eye opening) and Demonstration of purposeful movement (attempting self-extubation). Patient was extubated after the endotracheal tube cuff was totally deflated.

The duration of surgery and intubation were recorded. Intravenous paracetamol 15mg/kg was used for postoperative analgesia. Patients were shifted to Post Anaesthesia Care Unit (PACU) for observation for 4 hours. Patients were asked about complaints of sore throat, hoarseness and emergence coughing by the investigating physician at the time of discharge from PACU & 24 hours after extubation.

Data analysis was done with the help of SPSS software Version 21 and Sigma Plot Version 12. Quantitative data was presented with the help of Mean, Standard Deviation, Median and IQR, comparison among study group was done with Unpaired T test. Qualitative data was presented with the help of Frequency and Percentage table, association among study groups was assessed with the help of Chi-Square test and Fisher Exact test (2*2 tables). P value less than 0.05 was taken as significant level.

RESULTS:

A total of 110 patients were studied with 55 patients in each group. Both groups were comparable with regards to age, sex, weight, ASA grade and baseline hemodynamic parameters and there was no statistically significant difference between the two groups with respect to these parameters (Table 1).

Table No. 1 Comparison of ASA grade, Demographic & Haemodynamic Parameters

Variables	Group	Statistics					
		Mean	SD	Median	IQR		
Age (yrs)	I	38.96	9.06	38.00	14.00	Unpaired t test	0.248
	II	37.04	8.31	37.00	13.00	Difference is not significant	
BMI	I	22.85	1.56	23.00	2.00	Unpaired t test	0.654
	II	22.98	1.41	23.00	11.00	Difference is not significant	
ASA Grade	I	ASA I: 34		ASAII: 21		0.844	1.00
	II	ASA I: 35		ASA II: 20		Difference is not significant	
Sex	I	25 Females		30 Males		0.563	0.300
	II	22 Females		33 Males			
Duration of Anaeasthesia	I	117.8182		7.62329		0.2014	
	II	119.7273		7.62329		Difference is not significant	

Cuff pressures baseline, post-pneumoperitoneum, post-surgical position(usually 30 min),60,90 minutes & at final time (MEAN±Std.Dev) were 25±0.00, 27.44±0.50; 28.16±0.37; 29.31±0.47; 30.15±0.52; 30.69±0.50 in Trendelenburg position and in Reverse Trendelenburg position 25±0.00; 26.02±0.30; 27.80±0.73; 27.56±0.83; 27.25±0.82 ; 27.15±0.78 respectively.The cuff pressures were higher in Trendelenburg group than in the reverse Trendelenburg group and the difference was statistically significant (p value < 0.05 using Fisher's exact test) throughout the period of pneumoperit oneum.**(Table 2.)**

Table no.2:Association between study groups between baseline cuff pressure & after pneumoperitoneum,after giving surgical position (usually30 min),60,90 minutes & final pressure at the end of surgery

Baseline Parameters (cm of H2O)	Trendelenburg Position				Reverse Trendelenburg Position				Unpaired T test	P Value
	Mean	Std.Dev.	Median	IQR	Mean	Std.Dev.	Median	IQR		
Baseline Cuff Pressure	25.00	0.00	25.00	0.00	25.00	0.00	25.00	0.00		
Post Pneumoperitoneal Cuff Pressure	27.44	0.50	27.00	1.00	26.02	0.30	28.00	2.00	-4.223	0.000
Cuff Pressure after surgical position (30 min)	28.16	0.37	28.00	0.00	27.80	0.73	28.00	1.00	3.288	0.001
60 min	29.31	0.47	29.00	1.00	27.56	0.83	28.00	1.00	13.551	0.000
90 min	30.15	0.52	30.00	0.00	27.25	0.82	27.00	1.00	22.002	0.000
Time Final (before deflation of pneumoperitoneum)	30.69	0.50	31.00	1.00	27.15	0.78	27.00	1.00	28.310	0.000

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The relative increase in the cuff pressure was higher in the Trendelenburg group and the difference was statistically significant at all times.**(Table 3.)**

Table 3: Relative increase in cuff pressures

Changes at time	Trendelenburg Position				Reverse trendelenburgP osition				Unpaired T test	P Value
	Mean	Std.Dev.	Median	IQR	Mean	Std.Dev.	Median	IQR		
After giving surgical position(30 min)	3.16	0.37	3.00	0.00	2.80	0.73	3.00	1.00	3.288	0.001
Change 60 min	4.31	0.47	4.00	1.00	2.56	0.83	3.00	1.00	13.551	0.000
Change 90 min	5.15	0.52	5.00	0.00	2.25	0.82	2.00	1.00	22.002	0.000
Change Final min	5.69	0.50	6.00	1.00	2.15	0.78	2.00	1.00	28.310	0.000

The mean cuff pressures and the mean change in cuff pressure was statistically higher in Trendelenburg position at all intervals.**(Figure 1 & 2)**

Figure 1: Cuff pressures at Various Intervals

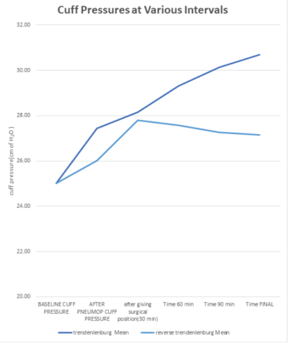
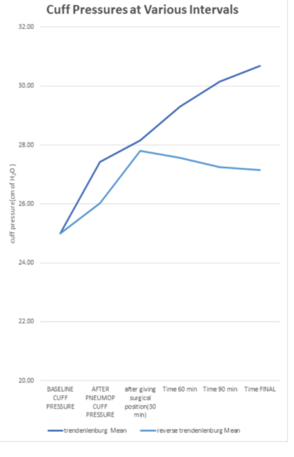


Figure 2: Relative increase in cuff pressure at various time interval

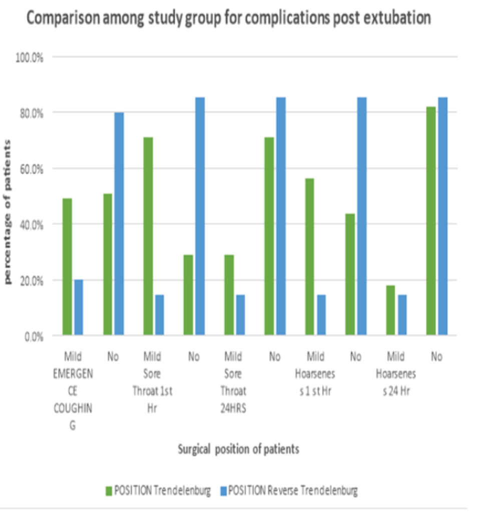


There was statistically significant higher incidence of various Laryngotracheal morbidity indicators in the Trendelenburg group namely: Emergence coughing, Sore throat 1 hour post extubation and Hoarseness of voice 1 hour post extubation. There was no difference between the groups in terms of hoarseness at 24 hours post surgery.**(Table no.4 & figure no.3)**

Table No.4 Comparison of Laryngo-tracheal morbidity

Variables	Group	Incidence (Number of Patients)			
		Mild	None		
Emergence Coughing	**Trendlenburg**	27	28	0.001	0.002
	Reverse Trendlenburg	11	55	Difference is significant	
Sore Throat (1 Hr Post Extubn)	**Trendlenburg**	16	39	0.000	0.000
	Reverse Trendlenburg	8	47	Difference is significant	
Sore Throat (24 Hr Post Extubn)	**Trendlenburg**	16	39	0.065	0.105
	Reverse Trendlenburg	8	47	Difference is not significant	
Hoarseness (1 Hr Post Extubn)	**Trendlenburg**	31	24	0.000	0.000
	Reverse Trendlenburg	8	47	Difference is significant	
Hoarseness (24 Hr Post Extubn)	**Trendlenburg**	10	45	0.606	0.797
	Reverse Trendlenburg	8	47	Difference is not significant	

Figure no.3 comparison among study group for complications post extubation.



DISCUSSION:

The incidence of laryngotracheal morbidity reportedly ranges from 15% to 94% after tracheal intubation.[6,8-12] When the cuff pressure exceeds the tracheal mucosal perfusion pressure, the resultant mucosal ischaemia leads to hoarseness, sore throat, emergence coughing and dysphagia[5-6,8-13].

Most laparoscopic procedures are done as day care procedures and prevention of laryngo-tracheal morbidity is of essence in these patients for smooth recovery and early home readiness.

Laparoscopic procedures frequently require different patient positions for better surgical access mainly 'Trendelenburg' and 'Reverse Trendelenburg' position. The aim of our study was to assess the changes in endotracheal tube cuff pressure during laparoscopic surgeries in Trendelenburg and Reverse Trendelenburg position and the incidence of post-operative laryngotracheal morbidity.

Following creation of Pneumoperitoneum, there was an equal increase in cuff pressure of both groups by an average of 2-3 cm of H2O from the baseline in tandem with increased IAP. The cuff pressure increased to 27.44 + 0.50 cm of H2O and 28.02 + 0.80 cm of H2O respectively for Trendelenburg and 'Reverse Trendelenburg' position.

This increase was statistically significant in both the two groups when compared with the baseline cuff pressure (with a p value < 0.05) but not significant when compared between the two groups.

Similarly there was an equal increase in the mean airway pressure of both groups by an average of 6-7 cm of H2O from the baseline in tandem with increased IAP. This increase was statistically significant in both the two groups when compared with the baseline cuff pressure (with a p value < 0.05) but not significant when compared between the two groups.

The creation of pneumoperitoneum invariably increases the abdominal pressure which is transmitted to the thorax. The upward pressure elevates the diaphragm, compresses the lungs, and impedes expansion of the lungs and chest cavity and decreases thoraco-pulmonary compliance. Thus pneumoperitoneum makes controlled mechanical ventilation more difficult and mechanically delivered tidal volume results in higher airway pressures.

There are reports indicating endotracheal shortening in the laparoscopic surgery with cephalad movement of the carina [87,88] and conformational change of the trachea by abdominal insufflation and the gravitational effect of the head-down tilt may be the underlying mechanism behind the elevated cuff pressure. This can lead to complications like endobronchial intubation hence air entry was always checked after giving position.

Yildirim ZB et al observed cuff pressure changes during laparoscopic and open abdominal cholecystectomy surgery (44). The endotracheal cuff pressure was registered every 5 min after tracheal intubation and patients were investigated for laryngo-tracheal complaints such as sore throat, dysphagia, and hoarseness. The results showed that endotracheal cuff pressures in laparoscopy group were significantly higher than in the group open surgery group at all time points studied ($P < 0.05$). The endotracheal cuff pressures exceeded the critical pressure of 30 cm H20 after 5 min in the laparoscopy group at the time of creation of intra-abdominal pneumoperitoneum. The incidence of sore throat was higher in group I than in group II in the PACU and at 12 hours postoperatively. The study concluded that the CO_2 pneumoperitoneum and Trendelenburg position used during laparoscopy increase endotracheal cuff pressure and lead to discomfort in the postoperative patient.

Our study observes a similar finding of increased cuff and mean airway pressure following pneumoperitoneum.

Effect of Position:

The cuff pressure increased further after giving Trendlenburg position but not in the Reverse Trendelenburg position. The cuff pressure measured after surgical position was 28.16±0.37 cm of H_2O in Trendelenburg position. The cuff pressure continued to increase in Trendlenburg position throughout the procedure but not in the reverse Trendlenburg position. The cuff pressures in Trendelenburg position were higher than in Reverse Trendelenburg position at each observation time point. The cuff pressure increased by an average of 5 cm of H_2O after in Trendelenburg position group and an average of 2 cm of H_2O in Reverse Trendelenburg position group. This difference in the cuff pressures was statistically significant at all times during observation period.

Wu CY et al [89] studied changes in endotracheal tube cuff pressure during laparoscopic surgery in head-up or head-down position. They studied 70 patients undergoing elective laparoscopic colorectal tumor resection (head-down position, n = 38) and laparoscopic cholecystecomy (head-up position, n = 32) and compared them to 15 patients undergoing elective open abdominal surgery. Changes of cuff and airway pressures before and after abdominal insufflation in supine position and after head-down or head-up positioning were analysed and compared. They found no significant cuff and airway pressure changes during the first fifteen minutes in open abdominal surgery. After insufflation, the cuff pressure increased from 26 ± 3 to 32 ± 6 and 27 ± 3 to 33 ± 5 cmH_2O in patients of laparoscopic cholecystecomy and laparoscopic colorectal tumour resection respectively (both $p < 0.001$). The head-down tilt further increased cuff pressure from 33 ± 5 to 35 ± 5 cmH_2O ($p < 0.001$). There was no significant correlation between increase of cuff pressure and either the patient's body mass index or the common range of intra-abdominal pressure (10-15 mmHg) used in laparoscopic surgery. They concluded that increase of endotracheal tube cuff pressure occured during laparoscopic surgery especially in the head-down position. Our study results are similar with cuff pressure increasing in response to pneumoperitoneum as well as Head Down or Trendelenburg position.

Laryngotracheal Morbidity:

The incidence of emergence coughing was stastically higher in patients of Trendlenburg position most probably due to higher intracuff pressure.

The patients in Trendlenburg group were more susceptible to sore-throat in PACU as compared to patients from Reverse Trendlenburg group. The difference in the incidence of sore-throat in PACU at 1st hour was statistically significant between the 2 groups. The severity of sore throat was mild to moderate probably due to strict attention to maintaining the intra cuff pressure < 30 cm of H_2O throughout the surgery in all patients. At 24 hours post extubation, although more number of patients from Trendlenburg position complained of sore throat, the difference between the groups was not statistically significant and the sore throat was mild degree in all patients.

In Trendlenburg position, the incidence of hoarseness at 1st hour was statistically higher than in Reverse Trendlenburg position. This can be attributed to increased intracuff pressure observed in Trendlenburg position. At 24 hours postextubation, there was no statistically significant difference between the incidence of sore-throat between the two groups.

Thus the incidence of post-operative Tracheolaryngeal morbidity was significantly higher in Trendlenburg position group correlating with increased cuff pressures.

Apart from injury to the teeth, the most common complications of endotracheal intubation are emergence coughing(at the time of extubation), postoperative sore throat and hoarseness . The incidence of these two varies between 10% and 64%. [45-52]

Mucosal damage occurring at the cuff level is thought to be an important causative factor for tracheal morbidity. Tracheal arterial capillary pressure decreases when the cuff exerts pressure greater than 30 cm H_2O, causing tracheal ischemia proportional to the pressure exerted by the cuff and to the duration of exposure.

Postoperative sore throat is at its peak in the early postoperative period, 2 to 6 hours after extubation, but the incidence decreases rapidly with time. It can sometimes be long-lasting, and after 96 hours, it has been reported that as many as 11% can have residual symptoms.

Thus from this study we observed that the incidence of post-operative tracheolaryngeal morbidity was significantly higher in Trendlenburg Position which correlated with higher cuff pressures observed in the group. Monitoring of endotracheal tube cuff pressure is important in intubated patients, specifically in patients undergoing laparoscopic surgeries in Trendlenburg Position. Endotracheal cuff pressure manometer a cheap, simple to use, handheld device which will help detect increased cuff pressure so that preventive measures can be carried out to reduce post-operative laryngotracheal morbidity associated with endotracheal intubation.

Limitations of the study:

Our study has several limitations. The power of study is less and hence the sample size is small. Since the investigator could not be blinded about the patient position for surgery, the study is unblinded. Thus there is a possibility of researcher bias.

CONCLUSION:

In this study of effect of patient position for surgery on the cuff pressures and laryngotracheal morbidity, we found that Trendlenburg or Head down position increases cuff pressure and increases incidence of laryngo tracheal morbidity as compared to reverse Trendlenburg position.

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