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Original Research Article

Changes in endotracheal tube cuff pressure during the open and laparoscopic surgery

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ABSTRACT

Introduction: Endotracheal tube is an airway catheter inserted in the trachea to assure patency of the upper airway. ETT cuff seals the trachea to facilitating positive-pressure ventilation and to prevent aspiration. The cuff pressure of an endotracheal tube depends on various patient-related factors like obesity, old age, environmental circumstances and therapeutic interventions. Physiological changes in laparoscopic surgery under general anesthesia, due to pneumoperitoneum and change in patient position can affect ETT cuff pressure. These changes in ETT cuff pressure can lead to significant peri-operative adverse outcome.
Aims and Objectives: To evaluate the changes in ETT cuff pressure between open and laparoscopic cholecystectomy under general anesthesia.
Materials and Methods: 80 ASA grade I/II patients, aged 20-50 years, undergoing laparoscopic or open cholecystectomy, under GA were included in this prospective observational study. Patients were divided in two equal sized groups (N=40) for laparoscopic and open cholecystectomy. ETT cuff pressures were recorded with ETT manometer, at 5 min intervals until extubation. Patients were followed 6 hourly, for 24 hours to record any postoperative complications.
Results: The changes in hemodynamic parameters were more in laparoscopic surgery than open surgery. Abdominal insufflation in laparoscopic surgery causes significant increase in cuff pressure due to altered thoracic compliance. Change in position, during laparoscopic surgery, also affects endotracheal tube cuff pressure.
Conclusion: The pneumo-peritoneum and positional changes during laparoscopic surgery cause significant increase in endotracheal tube cuff pressure and thus associated with an increased incidence of post-operative complications.

1. Introduction

The Endotracheal tube (ETT) is a device that, isolates the trachea from oesophagus and protect the lung from inhalation of foreign material.[1] Endotracheal tube cuff to seal the trachea and bronchial tree against air leakage and aspiration of gastric contents, blood, secretions, and other fluids & facilitating positive-pressure ventilation. Normal cuff pressure should be between 20-30 cm H_2O, cuff pressure above 50 cm H_2O completely obstructs the tracheal wall blood flow. The pressure exerted on the tracheal wall depends on the compliance of the trachea and the pressure measured at the pilot balloon of an ETT cuff, which can be considered as a good estimate of the pressure exerted on the tracheal mucosa.[2]

The cuff pressure of an endotracheal tube varies according to patient-related factors like obesity, old age, environmental circumstances and therapeutic interventions. General anesthesia with endotracheal intubation and controlled ventilation is considered as a safe technique of anesthesia for laparoscopic surgery. Physiological changes due to pneumoperitoneum in laparoscopic surgery can affect ETT cuff pressure. Different type of patient positions is required for different type of laparoscopic surgeries. After intubation change in patient position can also increase or

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decrease cuff pressure.[3] These changes in ETT cuff pressure can lead to significant peri-operative adverse outcome.

In this situation, the conventional method for ETT cuff inflation and pressure measuring is unreliable.[4] So, to prevent these complication, ETT cuff pressure should be monitor with standard cuff manometer device.[5,6], With this idea, this study has been planned to compare the changes in ETT cuff pressure between open and laparoscopic cholecystectomy.

2. Materials and Methods

This was a prospective, comparative, observational study. After obtaining Institutional Ethical Committee clearance as well as written informed consent from all patients, a total 80 patients, ASA I & II of either sex, age 20-50 years undergoing open or laparoscopic cholecystectomy were enrolled in the study.

We divided the patients(n=80) into two groups-

Group ‘OC’ Patient (n=40) includes forty patients planned for open cholecystectomy.

Group ‘L’ Patient (n=40) includes forty patients planned for laparoscopic cholecystectomy.

Inside operation theatre, patients were connected to multichannel non-invasive monitor (DragerFabius plus) to record continuous heart rate (HR) electrocardiogram (ECG), hemoglobin oxygen saturation (SpO2), $EtCO_2$, systolic blood pressure (SBP), diastolic blood pressure(DBP), mean arterial pressure (MAP).

Patients were given premedication in form of Injection ranitidine 1mg/kg, Injection metoclopramide 0.15 mg /kg, Injection glycopyrrolate 0.004mg/kg, Injection dexamethasone 0.1mg/kg & Injection midazolam 0.05 mg/kg and injection nalbuphine 0.4 mg/kg. Injection Paracetamol infusion 100ml given intravenously before incision.

Following preoxygenation with 100% oxygen, patients were induced with Injection propofol 1.5 - 2mg/kg and muscle relaxant Injection rocuronium 1mg/kg. They were intubated with a cuffed (high volume low pressure) ETT of inner diameter 7.5 mm for male, and 7.0 mm for female. The cuff was inflated by the standard technique, with approx 5 cc air, position in trachea was confirmed visually by chest rise and five-point auscultation method and EtCO2. Patients were mechanically ventilated by volume-controlled ventilation with 50% of oxygen & 50% nitrous oxide with Isoflurane (0.2-0.8), tidal volume and respiratory rate was set at 8 ml/kg and of 8-12 cycle/min, to maintain normo-capnia with end-tidal carbon dioxide tension between 35 to 45 mmHg.

The following parameters were studied

1. Hemodynamic Parameter- SBP, DBP, MAP, HR, SpO2, ECG as baseline and thereafter at an interval of 5 minutes.
2. Changes in ETT cuff pressure in open and laparoscopic procedure – ETT cuff pressure was recorded just after intubation and then after every 5minutes to maintain cuff pressure between 20-30 cm H2O.
3. Changes in ETT cuff pressure on changing position.

In group ‘OC’, first ETT cuff pressure was recorded after intubation with ETT manometer and then after every 5 minutes, last ETT cuff pressure recorded just before extubation. In group ‘L’ patients, First, ETT cuff pressure was recorded with ETT manometer after intubation and then after every 5 minutes. In these patients pneumo-peritoneum was created by CO_2insufflation in supine position with intra-abdominal pressure to be kept between 12-14 mm Hg. Intra abdominal pressure was recorded intraoperatively at every 5 minutes to be kept between 12-14 mm Hg. After that patients were placed in head up and right up position.

Patient were given injection Diclofenac aqueous 1-1.5mg/kg intravenously infusion in100 ml NS & Injection Ondansetron 0.15mg/kg intravenously before extubation. For post operative pain management after completion of surgery 20 ml of 0.25% of Bupivacaine instilled intraperitonially with skin infiltration with 10 ml of 0.25% lignocaine. Patient extubated following Injection Neostigmine 0.05mg/kg &Injection Glycopyrrolate 0.01 mg/kg, after proper suctioning. After extubation 100% oxygen was provided with Oxygen flow mask.

After extubation, in postoperative area all patient was asked for presence of any complication like sore throat or hoarseness. Patient were followed every 6hourly for twenty-four hours after extubation.

2.1. Statistical analysis

The data was entered into the Microsoft excel and the statistical analysis was performed by statistical software SPSS version 21.0The student t-test was used for comparing the mean values between the two groups whereas chi-square test was applied for comparing categorical variables. The p-value was considered to be significant when less than 0.05.

3. Results

Patients in both the groups were comparable in respect to their demographic characteristics. It was observed that there was a significant difference in mean duration of anaesthesia between the two groups (105.18 ± 15.22 Group L; 119.95 ± 13.74 Group ‘OC’) (p value of <0.001).

The comparison of mean heart rate between the two groups (Group’ L’ and Group ‘OC’) across various time points, showed that there was a significant difference in mean heart rate between the two groups at 20, 25, 30, 35, 40, 45, 50, 55, 60 minutes (extubated) and 65 minutes (immediate post operatively) (Figure 1).

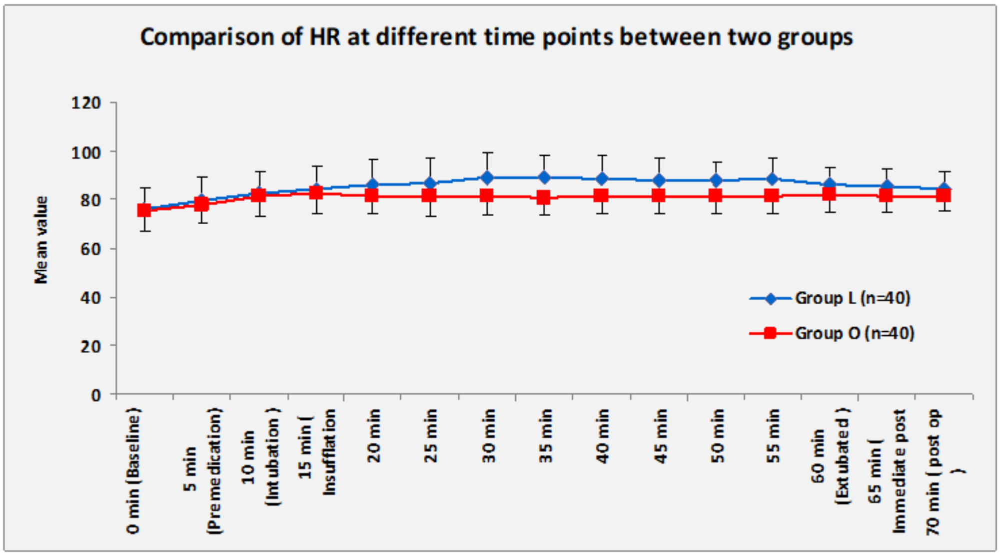

Fig. 1: Comparing the mean heart rate between the two groups (Group 'L' and Group 'OC') under the study across various time points

While comparing the mean systolic blood pressure between the two groups (group L and group OC) across various time points. It was observed that there was a significant difference in mean systolic blood pressure between the two groups at 25, 30, 45 and 50 minutes(Figure 2).

As far as mean diastolic blood pressure was compared between the two groups (Group L and Group OC) under the study across various time points, it showed a significant difference in mean diastolic blood pressure between the two groups at 25, 30, 35, 45, 50 minutes and 60 minutes(extubated)(Figure 3).

When we compared the mean ETCO2 between the two groups (Group L and Group OC) under the study across various time points. It was observed that there was a significant difference in mean ETCO2 between the two groups at 15 minutes. (Insufflation completed), 20, 25, 30, 35, 40, 45 and 50 minutes (Figure 4).

While comparing the mean of ETT CUFF PRESSURE between the two groups (Group L and Group OC) under the study across various time points. It was observed that there was a significant difference in mean ETT CUFE PRESSURE between the two groups at 20, 25, 30, 35, 40, 45, 50, 60 minutes (extubated) and 65 minutes (Immediate post- operative) (Figure 5).

3.1. Comparison of complications in both the groups

It was observed that sore throat was absent in 100% of the patients for both the groups at after 6, 12 and after 24 hrs.

The comparison of presence of hoarseness between the two groups across various time points. At the post operative ward, it was observed that 30% of the patients had hoarseness in group L; in group OC, hoarseness was absent in 100% of the patients. Further it was observed that hoarseness was absent in 100% of the patients for both the groups at after 6, 12 and 24 hours with a significant difference in distribution of hoarseness between the two groups at the post operative ward (p value of <0.001).

The comparison of presence of stridor between the two groups across various time points. At 6 hours, it was observed that 12.5% of the patients had stridor in group L while it was absent in group OC. Further it was observed that stridor was absent in 100% of the patients for both the groups at post operative ward, after 12 hours and after 24 hours. But, there was no significant difference in distribution of stridor between the two groups at 6 hours (p value of 0.055).

While comparing the presence of change in voice between the two groups across various time points. At the post operative ward, it was observed that 15% of the patients had change invoice in group L while it was absent in 100% of the patients in group OC. Further it was observed that change in voice was absent in 100% of the patients for both the groups at after 6, 12 and 24 hours. There was a significant difference in distribution of change in voice between the two groups at the post-operative ward (p value of 0.026).

At the post operative ward, it was observed that 27.5% of the patients had cough in group L while in group OC, cough was present in 2.5% of the patients. At 6 hours, it was observed that 7.5% of the patients had cough in group L while in group OC, cough was absent in 100% of the patients. Further, it was observed that cough was absent in 100% of the patients for both the groups after 12hours and 24 hours. Further, it was observed that there was a significant difference in distribution of cough between the

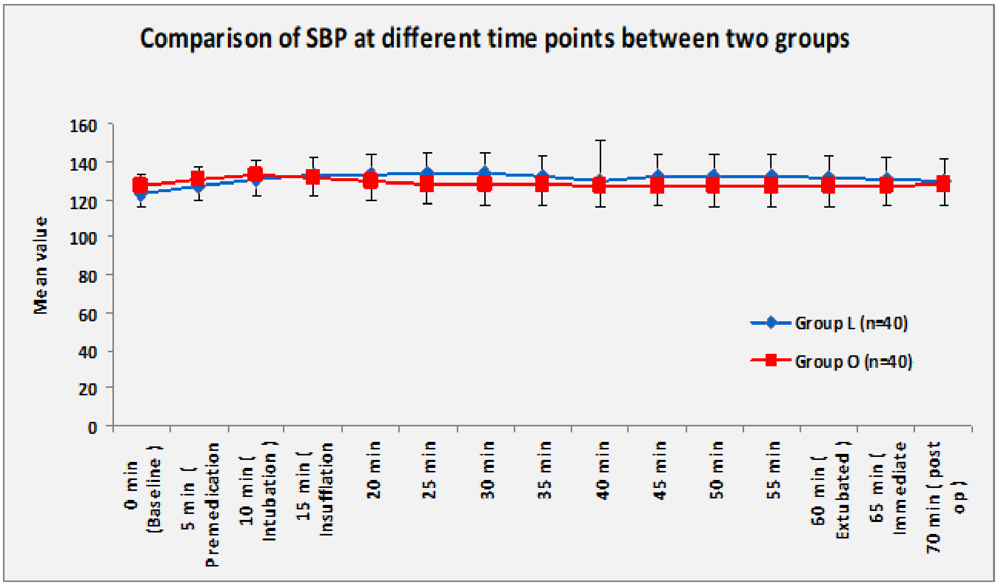

Fig. 2: Comparing the mean systolic blood pressure between the two groups (group L and group OC) under the study across various time points

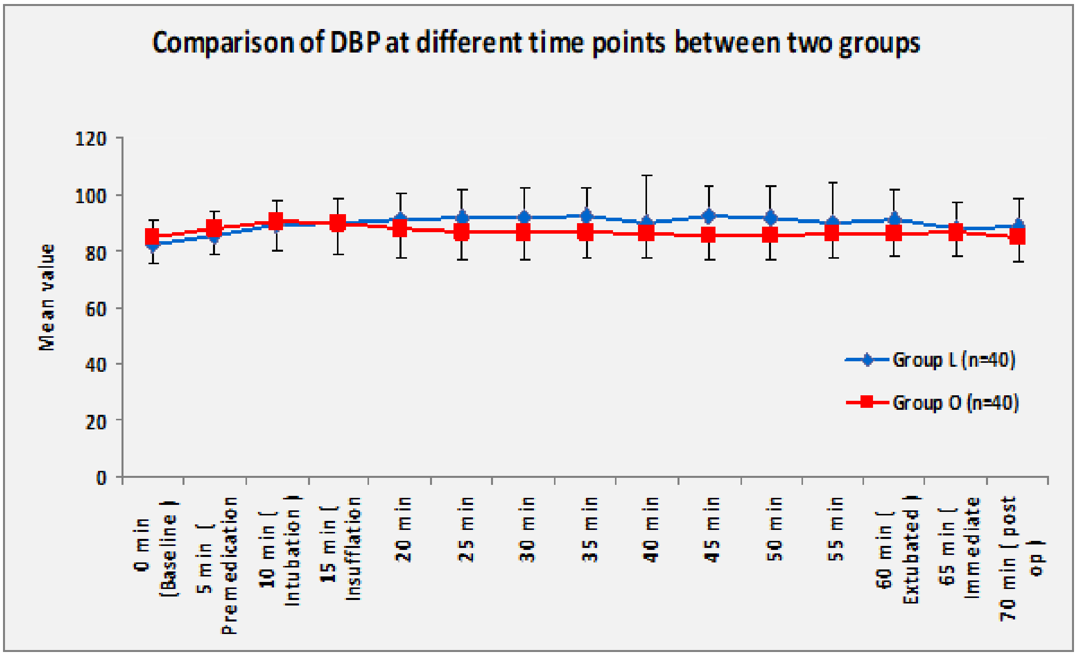

Fig. 3: Comparison of mean diastolic blood pressure between the two groups (group L and group OC)

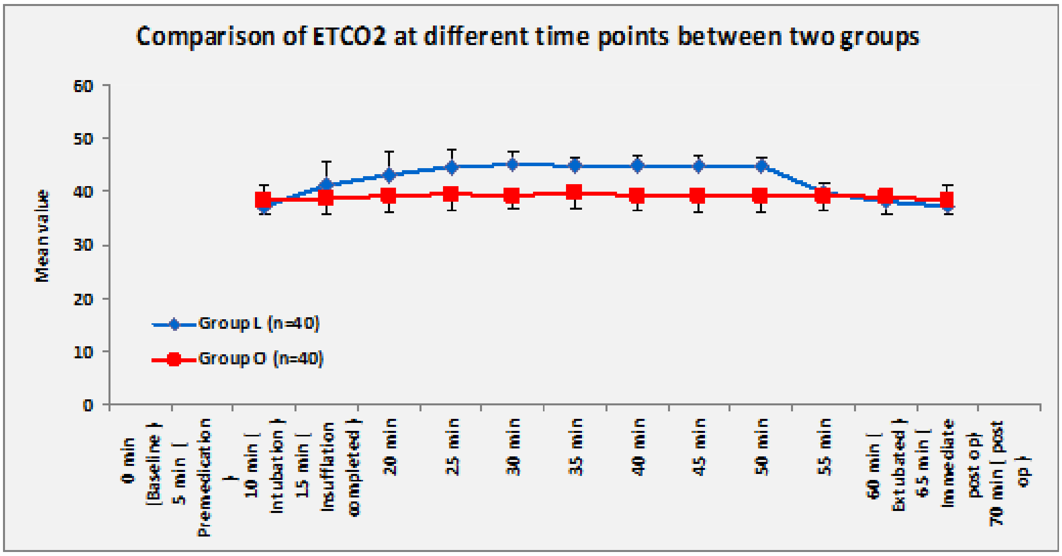

Fig. 4: The comparison of mean ETCO2 between the two groups (group L and group OC) under the study across various time points

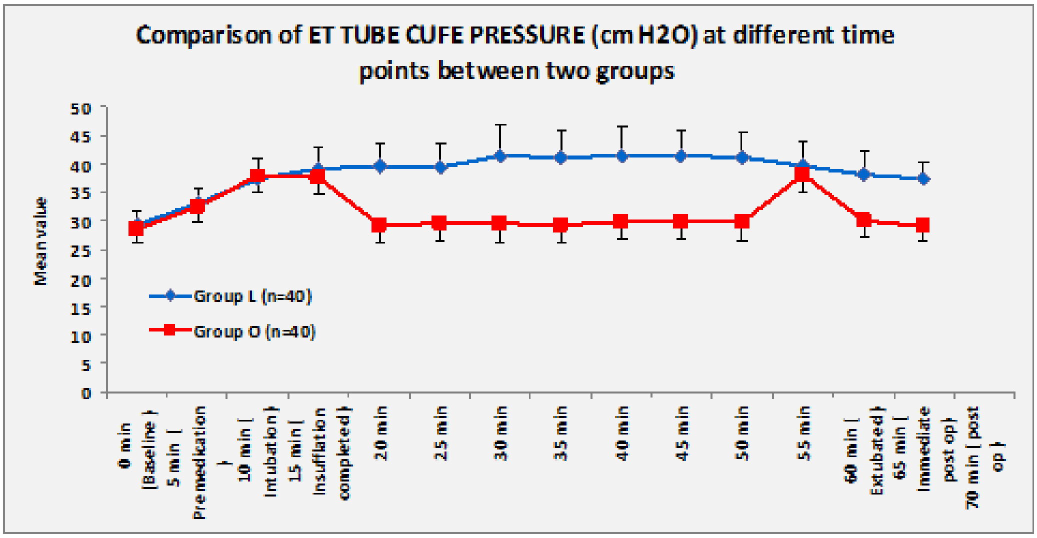

Fig. 5: Comparison of mean ETT CUFE PRESSURE between the two groups under the study across various time points

two groups at the post operative ward (p value of 0.003).

4. Discussion

Normal cuff pressure of ETT should be maintain between 20-30 cm H_2O.A minimal pressure of 20 cm H_2O is recommended to prevent aspiration and ventilator-associated pneumonia. The ETT cuff pressure associated with impaired tracheal capillary perfusion ranges between 30 and 50 cm H_2O. Sustained over inflation of the ETT cuff increases the risk for tracheal damage: subglottic stenosis or scarring, hoarseness, nerve damage, fistula, and damage of the tracheal wall.[7]

Although persistent cuff pressure of ETT have multiple beneficial effect but increase in cuff pressure after a certain limit can result into delete riousintra and post-operative complications in cardiopulmonary compromise patient.

As already mentioned, the cuff pressure of an endotracheal tube varies with patient-related factors like obesity, old age, environmental circumstances and therapeutic interventions. Physiological changes due to pneumoperitoneum in laparoscopic surgery can affect ETT cuff pressure. Different type of patient positions is required for different type of laparoscopic surgeries. After intubation change in patient position can also increase or decrease cuff pressure.[3] These changes in ETT cuff pressure can lead to significant peri-operative adverse outcome.

It was observed that large volume, low pressure endotracheal tube cuffs are claimed to have less deleterious effect on tracheal mucosa than high pressure, low volume cuffs. Low pressure cuffs, however, may easily be overinflated to yield pressures that will exceed capillary perfusion pressure. It was found that these cuffs when over pressurized impaired mucosal blood flow. This impairment of tracheal mucosal blood flow is an important factor in tracheal morbidity associated with intubation. Hence it is recommended that a cuff inflation pressure of 30 cm H2O (22 mm Hg) should not be exceeded. Hence it is recommended that a cuff inflation pressure of 30 cm H2O (22 mm Hg) should not be exceeded.[8]

Di Sebastiano N et al observed in laparoscopic cholecystectomy that during insufflations, peak and pause pressures increased by 6 cm H2O and mean pressure; by 3 cm H2O; Compliance was reduced by 48%; PaO2 decreased evenly with time ($p > 0.05$) irrespective of the airway pressure. PaCO2, PECO2, VCO2 and Vd/Vt after a sharp increase stabilized at 30% (mean value) over the baseline. P(a-ET)CO2 and Vd/Vt fluctuate in the physiological range except for two short but significant changes ($p > 0.05$) at insufflation and desufflation time.[8]

In our study our preliminary data suggest that there is no effect of age sex and weight on ETT cuff pressure supported by Youngsuk Kwon that the change in P_{cuff} was not affected by BMI and was significantly correlated with pneumoperitoneum time.[9]

Asif Umar et al observed that laparoscopic cholecystectomy induces significant hemodynamic changes intra operatively. The majority of pathophysiological changes are related to cardiovascular system and are caused by CO2 insufflation & High intra-abdominal pressure due to CO2 insufflation is associated with more fluctuations in hemodynamic parameters and increased peritoneal absorption of CO2 as compared with low intra-abdominal pressure.[10] In our study we also observed that after abdominal insufflations with CO2 there was significant increase in heart rate in laparoscopic surgery in comparison to open surgery(Figure 1). After 5-10 min of abdominal insufflations there was significant rise in systolic & diastolic blood pressure. (Figures 2 and 3). Although these physiological changes generally do not need any intervention, but it makes continuous intraoperative monitoring mandatory thus low-pressure pneumoperitoneum is ideal for laparoscopic cholecystectomy and minimizes the adverse hemodynamic effects of CO2 insufflation.

According to different surgical requirement different patient position can be possible like supine, prone, Trendelenburg, reverse Trendelenburg, sitting. In our study we are only concerned with Trendelenburg & reverse Trendelenburg position. Trendelenburg position because diaphragmatic movement reduces FRC and increases a telectasis, lung volumes are impaired by cephalad movement of the abdominal contents. The resulting reduction in functional residual capacity (FRC) is detrimental to gas exchange with an increase in ventilation–perfusion mismatching and decrease in pulmonary compliance. These effects are most significant if the closing capacity of the lung exceeds FRC.

In reverse Trendelenburg position physiological effects include an increase in head and neck venous drainage, reduction in intracranial pressure and reduced likelihood of passive regurgitation. The main complications of this position are hypotension and increased risk of venous air embolism.… cardiovascular system is primarily affected by venous pooling, which can lead to resistant hypotension. Excessive neck flexion/extension may also be associated with obstruction of the neck veins.[11]

There was no change in oxygen saturation in both group.In laparoscopic surgery there was a marked increase in $ETCO_2$ after 5 minutes' abdominal insufflations in laparoscopic surgery (44±2-4) in comparison to open surgery (39±1-2) with significant p value (<0.001) (Figure 4). It was supported by PPELOSI et al in who observed that laparoscopic cholecystectomy, abdominal carbon dioxide insufflation caused marked alterations in lung and chest wall mechanics mainly due to their viscoelastic components.[12] It did not affect oxygenation and arterial to end-tidal carbon dioxide difference and there was no time-dependent effect of the duration of anaesthesia.

In our study ETT cuff pressure was significantly rise in laparoscopic surgery after 5-10 min of CO2 insufflation (37±3-4cm H_2O) & then open surgery (27±2-3cm H_2O) it was continuously raised throughout the peri-operative period till extubation (Figure 5), also supported Dr. Amruta Pooja Kannadkar et al.[13]

It is clearly correlating a relationship between ETT cuff pressure and the incidence of tracheal lesion & demonstrating that tracheal mucosal damage was significantly severe in high ETT cuff pressure group. Many studies showed that high ETT cuff pressure can give rise to postoperative airway complication such as sore throat. Carbon dioxide pneumoperitoneum moves diaphragm upward and increases intra-thoracic pressure. This phenomenon, thereby, results in reduction of pulmonary compliance and elevation of peak inspiratory pressure. In addition, carbon dioxide pneumoperitoneum has been known to cause significant increase in ETT cuff pressure. These results are in favour of our study as we have also higher incidence of post-operative complication in laparoscopic surgery like cough, change in voice & Hoarseness in immediate post-operative area in comparison to open surgery with significant p value (<0.003). Seong-Joo Park observed a correlation between ETT cuff pressure and the incidence of tracheal lesion & demonstrating that tracheal mucosal damage was significantly severe in high ETT cuff pressure group.[14] We had also higher incidence of post-operative complication in laparoscopic surgery like cough, change in voice & Hoarseness in immediate post-operative area in comparison to open surgery with significant p value (<0.003).

5. Conclusion

Although, it was clear from our study that abdominal laparoscopic surgeries were associated with a significant rise in ETT cuff pressure. But, to make this study more authentic we need to do it as multi-centric trial, including extensive surgeries in all types of patients. Simultaneously, measuring the airway pressure and lung compliances is equally important.

Hence, to conduct laparoscopic procedure safely we need to be very vigilant regarding ETT cuff pressure monitoring peri-operatively.

6. Source of Funding

None.

7. Conflict of Interest

None.

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