Changes in Endotracheal Tube Cuff Pressure in Open and Laparoscopic Cholecystectomy - A Comparative Study

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Abstract: ***Background and Aims**: Various complications arise due to under or over inflation of endotracheal tube cuff pressure. This study aims to compare the changes in endotracheal tube cuff pressure and the incidences of post-operative laryngotracheal complaints in patients undergoing Open and Laparoscopic cholecystectomy. **Methods**: 90 patients with ASA grade I/II between the age of 18-65 years undergoing Open cholecystectomy (Group I) or Laparoscopic cholecystectomy (Group II) under general anaesthesia were included in this Hospital based Observational study. Patients were divided in two equal sized groups (n = 45). The cuff of the endotracheal tube was inflated to 20-30 mm Hg after intubation. Endotracheal tube cuff pressures via a standard cuff pressure manometer and haemodynamic parameters were recorded just after intubation, at 5, 10, 15, 20, 30, 40, 50, 60 and 70 minutes. Incidences of sore-throat, hoarseness and dysphagia were also observed post-operatively. **Result**: Increase in cuff pressure was significantly higher in patients undergoing laparoscopic cholecystectomy compared to those undergoing open cholecystectomy at 10, 15, 20, 30, 40, 50, 60, 70 mins (p-value<0.05). The changes in hemodynamic parameters were found to be more in laparoscopic cholecystectomy than open cholecystectomy. The incidences of sorethroat, hoarseness and dysphagia just after surgery, at 12 and 24 hours post-operatively were higher in patients undergoing Laparoscopic cholecystectomy compared to those undergoing open cholecystectomy. **Conclusion:** Pneumoperitoneum and change in patient's position during laparoscopic surgeries may increase ETT cuff pressure and lead to postoperative complications. Measurement of cuff pressure should be incorporated as a routine practice intraoperatively specially in laparoscopic surgeries.*

Keywords: Endotracheal tube cuff pressure, Laparoscopic cholecystectomy, post-operative complications

1. Introduction

Endotracheal intubation plays a crucial role in anaesthetic management and critical care of patients since its first use by Rowbotham and Magill in 1921.[1] The endotracheal tube (ETT) is a device which isolates the respiratory tract from the oesophagus and therefore protects the lungs from aspiration.

With the introduction of ether in the 1840s, undertaking surgical procedures became more common.[2] Since then, its use in surgical procedures under general anaesthesia has gained immense popularity. In 1871, Friedrich Trendelenburg [3] developed an anaesthetic technique for surgeries that involved the oral cavity, which aimed at preventing the aspiration of blood and other contents intra-operatively. He is also given the credit of designing the first cuff with the primary aim of creating a tight seal to prevent aspiration during the process of surgery and anaesthesia.

In 1893, Eisenmenger was the first to use a cuffed endotracheal tube which consisted of a wide-bore semi-rigid orotracheal tube carrying an inflatable cuff and a pilot balloon to reflect the pressure in the cuff.[4] After passing the endotracheal tube into the trachea, the balloon cuff present at the distal end of the tube is inflated to help secure it in place, to help facilitate positive-pressure ventilation, to seal the trachea and bronchial tree against air leakage and prevent aspiration of gastric contents, blood, secretions, and other contents during the intra-operative period.

A number of studies have highlighted the morbidities of overinflating or underinflating the endotracheal tube cuff. Therefore, the need to monitor the endotracheal tube cuff pressure throughout the process of surgery and anaesthesia is felt.

Open and Laparoscopic cholecystectomy can be performed under general anaesthesia with controlled ventilation using a cuffed Endotracheal tube (high volume, low pressure) with a sealing cuff pressure in the range of 20 to 30 cm $H2O$ aimed at achieving a proper seal and avoidance of over-inflation intra- operatively.[5] A spectrum of complications may occur as a result of over or under-inflation of endotracheal tube. Overinflation may lead to sore throat, hoarseness, dysphagia, cough with blood-streaked expectorations, tracheal stenosis, necrosis, and even rupture. On the other hand, under-inflation may put the patient at risk for intraoperative air leakage, aspiration and aspiration pneumonitis[6].

To prevent these complications, monitoring the ETT cuff pressure with a standard cuff manometer device should be incorporated into routine anaesthetic practice. The conventional method for endotracheal tube cuff inflation and monitoring of pressure are proved to be unreliable[7]. The cuff

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pressure should ideally be maintained within a range of 20 to 30 cmH2O[8].

Hence this study is undertaken to measure the endotracheal tube cuff pressure during open and laparoscopic cholecystectomy and aims to compare the cuff pressure changes in the patients undergoing these procedures.

2. Materials and Methods

2.1 Patients and study design

This study includes 45 patients in each group, who underwent either open (Group I) or laparoscopic (Group II) cholecystectomy, who fulfilled the inclusion and exclusion criteria. The study was carried out under the department of Anaesthesiology, Jorhat Medical College and Hospital, Jorhat in the study period of one year from July 2021 to June 2022 with permission and approval from the Institutional Ethical Committee. The study design was a hospital based observational study. The sample size was calculated using sample size calculation formula. The inclusion criteria includes Patients who were able to provide written informed consent, ASA Physical status I and II patients, Patients of either sex, between 18-65 years of age scheduled for elective cholecystectomy, Patients with MPS class I/II. Exclusion criteria includes ASA grades III and higher, Age less than 18 years and more than 65 years, baseline heart rate<60/min, Baseline blood pressure<100/50 mmHg, Bleeding diathesis, Any hypersensitivity or contraindication to drugs used for anaesthesia, Patients with history of significant neurological, psychiatric, or neuromuscular disorders, Pregnant or lactating mother. The operative procedures were performed following standard protocols, principles and approaches. An informed consent was taken from all the patients who underwent this study.

2.2 Data collection

The patients who underwent laparoscopic or open cholecystectomy that fulfilled the inclusion and exclusion criteria were included in this study. Their demographic profile and history was collected. Endotracheal tube cuff pressure was measured and recorded just after intubation, at 5 minutes, 10 minutes, 15 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 60 minutes and 70 minutes after intubation. Study parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and SpO2 were recorded at baseline, at 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 60 minutes and 70 minutes after intubation, and at the end of surgery. After extubation, in postoperative ward, all patients were asked for presence of any complication like sore throat, hoarseness and dysphagia. Patients were followed every 12 hourly for twenty four hours after extubation.

2.3 Statistical analysis

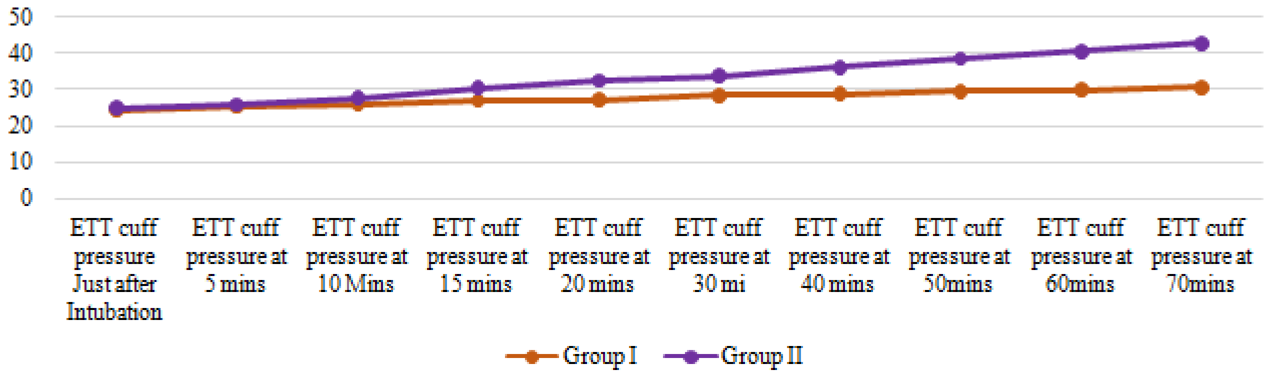
The statistical analysis of data was performed using the computer program, Statistical Package for Social Sciences (SPSS for Windows, version 20.0.Chicago, SPSS Inc) and Microsoft Excel 2010. Results on continuous measurements are presented as mean ± standard deviation and compared using Student t-test. Discrete data are expressed as proportion and percentage and are analysed using Chi-square test or Fisher's exact test. For all analysis, the statistical significance was fixed at 5% level (p value<0.05). Charts and bar diagrams were prepared using appropriate tools.

3. Results

In Group I, 8 of the cases were males and 37 were females. In Group II, 11 of the cases were males and 34 were females. The Group I (open cholecystectomy) had a mean age of 35.22±10.41years and the Group II (laparoscopic cholecystectomy) had a mean age of 32.75±9.35years.There were 35 patients of ASA I and 10 patients of ASA II in Group I (open cholecystectomy) and 34 patients of ASA I and 11 patients of ASA II in Group II (laparoscopic cholecystectomy). The mean height in case of Group I (open cholecystectomy) was 165.19±6.24 cm and the mean in Group II (laparoscopic cholecystectomy) was 166.70±6.60 cm. The mean weight in case of Group I (open cholecystectomy) was 62.98±9.35 kgs and the mean in Group II (laparoscopic cholecystectomy) group was 65.20±8.20 kgs. The difference in demographic parameters between the two groups was statistically insignificant.

On comparing the endotracheal tube cuff pressure between the two groups, it is found that cuff pressure was increased significantly in Group II at 10 minutes, and remained highly significant at 15 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 60 minutes and 70 minutes. (Figure 1)

FIGURE 1: VARIATION OF ETT CUFF PRESSURE BETWEEN THE TWO GROUPS.



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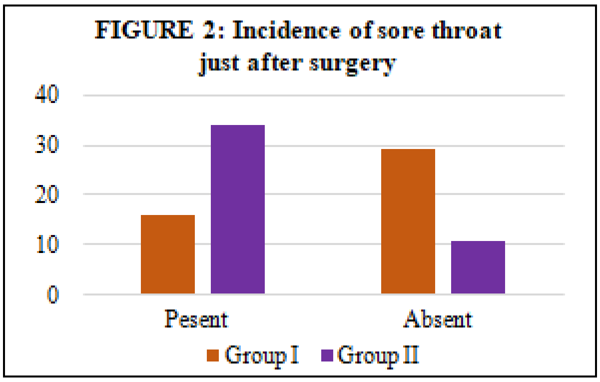
It is found that the rise in mean SBP in Group II is significant at 20, 30, 40, 50 and 60 minutes when compared to Group I. Diastolic blood pressure was increased significantly at 20, 30 and 50 minutes; highly significant at 40, 60 and 70 minutes; not significant in other time intervals when compared to Group I.

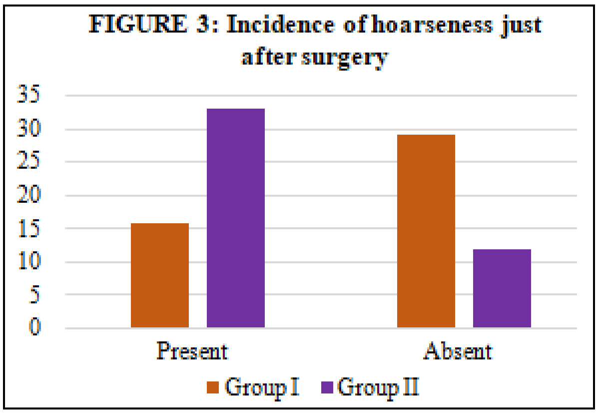
As far as MAP is compared, in Group II MAP was increased significantly at 70 minutes and highly significant at 20, 30, 40, 50, 60 minutes; not statistically significant in other time intervals. Also, in Group II, the increase in Heart Rate was highly significant at 20, 30, 40 and 50 minutes. It was significantly increased at 60 and 70 minutes; not statistically significant in other time.

It was observed that the incidence of sore throat in the immediate post- operative period was 75.6% in Group II compared to 35.6% in Group I. The difference is found to be statistically significant between both the groups (p=0.0001). (Figure 2)



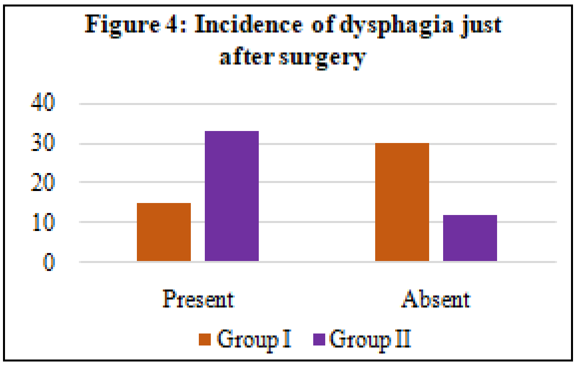
The incidence of sore throat at 12 hours after surgery was 51.1% in Group II compared to 20% in Group I. The difference is found to be statistically significant between both the groups. (p=0.0020). The incidence of sore throat 24 hrs after surgery was 33.33% in Group II compared to 0% in Group I. The difference is found to be highly significant between both the groups. (p<0.0001).

The incidence of hoarseness in the immediate post-operative period was 73.3% in Group II compared to 35.6% in Group I. The difference is found to be statistically significant between both the groups. (p=0.0003). (Figure 3)



The incidence of hoarseness at 12 hours after surgery was 51.1% in Group II and to 4.4% in Group I. The incidence of hoarseness was 31.1% in Group II compared to 0% in Group I at 24 hrs after surgery. The difference is found to be highly significant between both the groups in both the time points.

The incidence of dysphagia in the immediate post- operative period was 73.3% in Group II compared to 33.3% in Group I. The difference is found to be statistically significant between both the groups. (Figure 4)



The incidence of dysphagia at 12 hours after surgery was 51.1% in Group II compared to 2.2% in Group I. The incidence of dysphagia at 24 hours after surgery was 20% in Group II compared to 0% in Group I. The difference is found to be statistically significant between both the groups at both the time points.

4. Discussion

Laparoscopic cholecystectomy is nowadays increasingly preferred over open cholecystectomy. Studies are being undertaken to know and compare the hemodynamic, cardiovascular and pulmonary changes associated with the procedure for better patient care.

It was observed that the demographic parameters of the two groups for this study were comparable. The age, sex, weight, height and the ASA grade differences were statistically insignificant (p value > 0.05) in both the groups.

In our study, ETT cuff pressure was kept between the recommended ranges of 20-30 cm H2O at the beginning of the surgery. ETT cuff pressure kept on increasing till the end of surgery in both the groups. At the end of the surgery, ETT cuff pressure was 30.8±1.97 cm H2O in open cholecystectomy group, while it was 42.98±1.738 cm H2O in laparoscopic cholecystectomy group. However, the increase in the cuff pressure in the patients undergoing laparoscopic cholecystectomy was highly significant as compared to those undergoing open cholecystectomy from 15 mins to the end of the surgery. (p value<0.001).

In 2011, Yildirim et al[9] in a study found similar results where the endotracheal cuff pressures in laparoscopic cholecystectomy group were significantly higher than those in the open cholecystectomy group at all time points studied.

In 2015, Geng G et al[10] in a study found that in patients who underwent laparoscopic gynaecological surgery, the endotracheal tube cuff pressure and peak airway pressure were significantly increased compared to initial pressure at

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all examined time points. These findings were similar to what we observed in our study.

It is the use of N2O intra-operatively, pneumoperitoneum and reverse Trendelenburg position during laparoscopic cholecystectomy that increases the endotracheal cuff pressure. Pneumoperitoneum moves the diaphragm upwards and increases intra-thoracic pressure. This phenomenon, thereby results in reduction of pulmonary compliance and elevation of peak inspiratory pressure, causing an increase in the cuff pressure.[11]

We found in our study that the difference in increase in SBP in Group II when compared to Group I was significant (p-value<0.05) at 20, 30, 40, 50 and 60 minutes.

It was also found that the difference in increase in diastolic blood pressure in Group II when compared to Group I was significant (p<0.05) at 20, 30, 50 and highly significant (p<0.0001) at 40, 60 and 70 minutes.

On comparing the mean arterial pressure between the two groups we found the difference to be significantly increased at 30, 40, 50 and 60 and 70 minutes in laparoscopic cholecystectomy group. The findings of our study were similar to those of an earlier study by Kelman GR et al [12] (1972).

We also found the mean heart rate to increase significantly in Group II at 20, 30, 40, 50, 60 and 70 minutes compared to that of Group I.

There are studies which have demonstrated an increase in heart rate during laparoscopy. Hypercarbia (due to absorption of CO2 during insufflation) induces release of catecholamines which might cause tachycardia. In laparoscopic surgery there is a rise in intra-abdominal pressure along with decrease in venous return which may cause a compensatory increase in heart rate.[13]

Critchley LA et al[14] (1993) studied the hemodynamic changes during laparoscopic cholecystectomy and in their studies they found that mean arterial pressure was raised throughout the surgery.

In a study, Dorsay DA et al[15] (1995) demonstrated that the combination of CO2 pneumoperitoneum and the reverse trendelenburg position does adversely affect cardiac output. They found significant rise in heart rate and mean arterial pressure in their study population.

Cenk Y et al[16] in 2015 conducted a study to evaluate the hemodynamic changes during laparoscopic cholecystectomy. They found the heart rate and mean arterial pressure to be significantly increased compared to the baseline following CO2 pneumoperitoneum.

In our study, a direct relationship between ETT cuff pressure and the incidence of post- operative complications is found. This suggests that tracheal mucosal damage was significantly high in the group with raised ETT cuff pressure.

An increase in cuff pressure is found to cause an increase in the incidence of post-opearative laryngo-tracheal complaints. The causative factor is diminished blood flow to tracheal mucosa due to excessive cuff pressure on the tracheal wall. This ischemic injury then produces healing fibrosis months or even years later. High cuff pressures can result in complications ranging from sore throat and hoarseness to tracheal stenosis, necrosis, and even rupture.

In our study also, we observed an increased incidence of post operative airway complications like sore throat, hoarseness and dysphagia in the patients undergoing laparoscopic cholecystectomy compared to those undergoing open cholecystectomy.

In 2010, Liu et al[17] found that the incidence of postprocedural sore throat, hoarseness, and blood-streaked expectoration in the control group was significantly higher in the group with increased ETT cuff pressure. Fiberoptic bronchoscopy was also done in the patients post-operatively, which showed that the tracheal mucosa was injured in varying degrees in both groups, but the injury was more severe in the group with higher Ett cuff pressure.

In 2012, Calder et al[18] had reported that the incidence of postoperative sore throat increased with cuff pressure in paediatric day-case surgery with an average anaesthesia time of 60 minutes.

Lakhe G et al[19] in 2017 found that the incidence of post-operative sore throat followed by an increase in cuff pressure was higher in the patients undergoing laparoscopic cholecystectomy.

5. Conclusion

We can conclude from this study that, there is a significant increase in the endotracheal tube cuff pressure intra-operatively in patients undergoing laparoscopic cholecystectomy when compared to open cholecystectomy. There are significant haemodynamic changes in laparoscopic cholecystectomy group when compared to open cholecystectomy group. The incidence in occurrence of laryngotracheal complaints like sore throat, hoarseness and dysphagia are also higher in patients undergoing laparoscopic cholecystectomy compared to those undergoing open cholecystectomy.

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