Changes in endotracheal tube cuff pressure with the changes in peak airway pressures during total laparoscopic hysterectomy and pelvic surgeries. A prospective and observational study

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ABSTRACT

Background: The abdominal insufflation and changes in endotracheal tube (ETT) cuff pressure due to creation of pneumoperitoneum and changes in patient positioning during laparoscopic abdominal surgeries have not been explored thoroughly. Aims and Objectives: The aim of our study was to see the changes in ETT cuff pressures during creation, maintenance, release of pneumoperitoneum, and during surgical positioning. Materials and Methods: A total of 60 patients were finally taken for study. Written informed consent was taken for participation in the study as well as consent for surgery. Inclusion criteria were patients of age above 30 years, American society of anesthesia physical status 1 and 2, patients undergoing total laparoscopic hysterectomy requiring trendelenburg positioning. Exclusion criteria were patients with pre-existing pulmonary or cardiac disease, patients with pre-existing vocal cord palsy, goitre or any other airway or thoracic pathology, pregnant or lactating females, BMI more than 25 or <18.5. Changes of cuff and airway pressures before and after abdominal insufflation in supine position and after head-down or head-up positioning were analyzed and compared. Results: Baseline cuff pressure after manual inflation was 28.85 ± 11.4 cm H₂O. Significant correlation was observed between change in cuff pressure and increase in peak airway pressure at the end of the surgery (P<0.05). Serial measurements of ETT cuff pressure, peak airway pressure, and ETCO₂ were significantly increased compared to baseline (P<0.05). Conclusion: Pneumoperitoneum in Trendelenburg position increases ETT cuff pressure probably due to increase in airway pressure. Therefore, it seems advisable to include routine monitoring of ETT cuff pressure. Objective adjusted measurement of cuff pressure and airway pressures is recommended for such surgeries.

Key words: Endotracheal tube cuff pressure; Laparoscopic hysterectomy; Trendelenburg positioning; Pneumoperitoneum

INTRODUCTION

Laryngotracheal complications are common after endotracheal intubation.¹ Tracheal arterial capillary perfusion decreases when cuff exerts pressure >30 cm of H₂O, causing tracheal ischemia.²

Now a days, laparoscopic surgery is becoming popular as it is a minimal invasive surgery with multiple advantages.³ Laparoscopic surgery is performed under general anesthesia with mechanical ventilation. Pneumoperitoneum is created.⁴ (IAP 10–12 mmHg) there are several significant respiratory system changes during laparoscopic surgery.
Pneumoperitoneum and head low position elevate intrathoracic pressure changes pulmonary compliance and causes increase in airway pressure. Sustained over inflation of endotracheal tube (ETT) cuff increases risk of post-operative complications.

During elective surgeries, due to changes in ETT cuff pressures, it may lead to pressure on recurrent laryngeal nerve and tracheal mucosa which can cause ischemia, mostly in longer duration of surgeries. This may lead to symptoms like sore throat, hoarseness of voice, ulceration, nerve palsy, and subglottic stenosis. Using cuff manometer (AG CUFFILL), a range of 20–30 cm H₂O is considered to be safe although in many hospitals, this is still done by manual palpation and “feel” of the pilot balloon.

Studies have shown that when inflated manually, it leads to higher cuff pressures as compared to use of cuff pressure monitors or automated pressure controllers with less pressure side effects. Laparoscopic pelvic and hysterectomy surgeries involve long duration of pneumoperitoneum and tendelenburg position. These changes lead to increase in cuff ETT pressures. It has been found that there is direct effect between cuff pressure changes and increase in airway pressure. Numerous other factors have also been studied in relation to patient positioning, body mass index, duration of pneumoperitoneum, and use of nitrous oxide.

The aim of our study was to see the changes in ETT cuff pressures during creation, maintenance, release of pneumoperitoneum, and during surgical positioning. The primary objective was to assess the effect of change in ETT cuff pressure with the increase in peak airway pressure and with End tidal CO₂ during total laparoscopic hysterectomy (TLH) and pelvic surgeries.

Aims and objectives
The aim of our study was to see the changes in ETT cuff pressures during creation, maintenance, release of pneumoperitoneum, and during surgical positioning.

MATERIALS AND METHODS
A prospective and observational study was conducted on patients posted for elective TLH and pelvic surgeries. A total of 60 patients were finally taken for study. Written informed consent was taken for participation in the study as well as consent for surgery. Inclusion criteria were patients of age above 30 years, American society of anesthesiology physical status 1 and 2, patients undergoing TLH requiring tendelenburg positioning. Exclusion criteria were patients with pre-existing pulmonary or cardiac disease, patients with pre-existing vocal cord palsy, goiter or any other airway or thoracic pathology, pregnant or lactating females, and BMI more than 25 or <18.5.

After selection of study participants and obtaining consent, a thorough pre-anesthetic checkup was done. All patients were kept fasting for 6 h as per latest guidelines. On the day of surgery, a safety check list was done. On arrival in the operation theater, all patients were laid on the operating table and after securing intravenous lines, all patients were pre-medicated with Inj. Pantop 40 mg, Inj. Glycopyrrolate (0.01 mg/kg), Inj.Fentanyl (1–2 mcg/kg). Minimum mandatory monitoring (ECG, NIBP, and SPO₂) was started. Anesthesia was induced with Inj. Propofol (1–2 mg/kg), Inj. Atracurium (0.5 mg/kg) and trachea was intubated with 7.5 mm ID (Portex) in all female patients. The ETT cuff (Polyvinyl chloride) was inflated by a theatre technician or a resident guided by AG Cuffill syringe. Baseline cuff pressure was measured and adjusted to 25 cm of H₂O. Other baseline values of peak airway pressures and end tidal CO₂ (ETCO₂) were also measured on Anesthesia workstation Draeger Fabius. Maintenance was with Sevoflurane, air, and oxygen along with maintenance dose of fentanyl and atracurium. Nitrous oxide was not used. Cushioned straps were applied to chest and arms so that the patients were firmly supported on the operating table.

Baseline ventilator parameters were set after intubation before pneumoperitoneum insufflation (tidal volume 8 mL/kg, respiratory rate 16 mL/min, PEEP of 5 cm H₂O. Changes were made in the ventilator settings only when there was increase in ETCO₂ above 45 mmHg and peak airway pressure above 40 cm H₂O. The degree of head down tilt was fixed at 35° and the intra-abdominal pressure was set at 12 mm Hg unless airway pressures exceeded the set limit. Those who required change of set parameters were excluded from the study. All values were recorded (ETT cuff pressure, peak airway pressure and ETCO₂) 5 min after establishing pneumoperitoneum, 5 min after final head down position and lastly, 5 min before releasing pneumoperitoneum and return to normal horizontal position. The trachea was extubated at the end of the operation after patient was fully awake and responding to verbal commands.

Statistical analysis
All statistical calculations were done using computer programs Microsoft Excel 2007 (Microsoft Corporation, Washington, USA) and Statistical Package for the Social Science (SPSS); SPSS Inc., Chicago, IL, USA) version 21. P<0.05 was considered statistically significant. Data were statistically described in terms of mean (±SD), frequencies (number of cases), and percentages when appropriate.
The data were entered in MS Excel and were analyzed using SPSS Version 20 and Epi info version 7.2. Levene’s Test for Equality of Variances was used and equal variances were assumed within the groups. Independent sample test (Unpaired t-test) was used to test equality of means. Post hoc analysis was done using Tuckey’s test by considering 5% margin of error (α). P<0.05 was considered as significant.

RESULTS

Baseline characteristics of all 60 patients undergoing TLH and pelvic surgeries are presented in Table 1 (P>0.05).

Significant increase in cuff pressure, ETCO₂, and peak airway pressure at different time intervals was observed at various time intervals of pneumoperitoneum and head down position across the surgery (P<0.0001) Table 2.

Five of the total 60 patients were complication free postoperatively. In the rest five patients, the only complication found was sore throat immediate in postoperative period which resolved over next 24 h without any active intervention (Table 3).

DISCUSSION

Maintenance of adequate ETT cuff pressure is not only important to avoid ventilatory leak during mechanical ventilation but also important to prevent aspiration especially for patients in head-down position.14,15 Conversely, several postoperative complications such as cough, sore throat, hoarseness, and blood-streaked expectorations are associated with excessive ETT cuff pressure.16,17

In terms of the goals of our study, the primary finding of our study was that the ETT cuff pressure increases with creation of pneumoperitoneum by abdominal insufflation with CO₂ and intraoperative patient position changes, especially the head-down position. The ETT cuff pressure increased from 25±0.2 cm H₂O at the start to a maximum of 33.24±3.5 cm H₂O.

The study by Baysal et al., recorded the ETT cuff pressures in laparoscopic patients to be consistently higher at all points of recording as compared to patients operated openly.18

In the present study, significant increases in cuff pressure were observed at various time intervals of pneumoperitoneum and head down position across the surgery. Similar trends were observed by Wu et al., who conducted their study on patients undergoing elective laparoscopic colorectal tumor resection and laparoscopic cholecystectomy comparing it to open abdominal surgery. The cuff pressure increased from 26±3 to 32±6 cm H₂O in laparoscopic cholecystectomy patients and from 27±3 to 33±5 cm H₂O in laparoscopic colorectal tumor resection after insufflation (P<0.001). The headdown tilt further increased cuff pressure from 33±5 to 35±5 cm H₂O (P<0.001).4 Findings of Rosero et al.,10 are also in keeping with the above findings, in their study on adult obese patients undergoing elective laparoscopic gynecologic procedures. The peak airway pressures significantly increased from 23.2±0.84 cm H₂O before peritoneal insufflations (phase 1) to 32.1±0.46 cm H₂O after peritoneal insufflations and Trendelenburg positioning (phase 2), (P<0.0001). ETT cuff pressures also increased

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Table 1: Baseline characteristics of study population

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean n=70</th>
<th>SD</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>51.21</td>
<td>10.4</td>
</tr>
<tr>
<td>Body height (cm)</td>
<td>158.4</td>
<td>7.1</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>62.5</td>
<td>11.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.1</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Table 2: Comparison of ETT cuff pressure, ETCO₂ and peak airway pressure at different time intervals among the study population

<table>
<thead>
<tr>
<th>Measured parameter</th>
<th>Mean±SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuff pressure (cm H₂O)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline (adjusted to 25 cm H₂O)</td>
<td>25±0.2</td>
<td>0.76</td>
</tr>
<tr>
<td>5 min after pneumoperitoneum</td>
<td>28.8±2.1</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>5 min after head down</td>
<td>33.6±3.1</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>5 min prior to pneumoperitoneum</td>
<td>33.24±3.5</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>Peak airway pressure (cm H₂O)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>15.57±0.1</td>
<td>0.65</td>
</tr>
<tr>
<td>5 min after pneumoperitoneum</td>
<td>24.06±1.4</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>5 min after head down</td>
<td>27.77±2.3</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>5 min prior to pneumoperitoneum</td>
<td>25.25±2.9</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>End tidal CO₂ (mm Hg)</td>
<td>32.82±0.2</td>
<td>0.81</td>
</tr>
<tr>
<td>Baseline</td>
<td>32.82±0.2</td>
<td></td>
</tr>
<tr>
<td>5 min after pneumoperitoneum</td>
<td>34.25±1.8</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>5 min after head down</td>
<td>36.77±2.9</td>
<td>(P&lt;0.0001)</td>
</tr>
<tr>
<td>5 min prior to pneumoperitoneum</td>
<td>35.2±1</td>
<td>(P&lt;0.0001)</td>
</tr>
</tbody>
</table>

Table 3: Incidence of airway related complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sore throat</td>
<td>5</td>
<td>8.33</td>
</tr>
<tr>
<td>Hoarseness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stridor</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Change in voice</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

P=0.453
significantly from 29.6±1.30 cm H\textsubscript{2}O during phase 1–35.6±0.68 cm H\textsubscript{2}O during phase 2, (P<0.0001).

On looking into the correlation between the intraoperative ETT cuff pressure changes and the presence of post-operative complications, we could not find any significant relation between the same. Direct questioning was used to find out the presence or development of any airway related complications such as sore throat and hoarseness of voice at various points of time (immediately after extubation, in the recovery, and in the ward if any complication was present) and follow-up of the patients was done till 24 h after the procedure to detect any complication or its resolution. There was no significant association between the occurrence of complications and the changes in intra cuff pressure (P>0.05).

Limitations of the study
Firstly, duration of surgery was relatively short: inclusion of airway pressures and adjustment of cuff pressure using a manometer is essential and advised, especially for these types of surgeries. Secondly, analysing variables like BMI, degree of head down tilt was not within the scope of the study.

CONCLUSION
Significant increase in ETT cuff pressure is caused by changes in body position like head down and effect of pneumoperitoneum. There exists a significant relation between the change in cuff pressure and increase in airway pressure, which appears to be more significant as the surgery prolongs. In this context, strict monitoring and management of airway pressures and adjustment of cuff pressure using a manometer is essential and advised, especially for these types of surgeries.

ACKNOWLEDGMENT
Government Medical College Srinagar.

REFERENCES


Authors’ Contributions:
SUM: Definition of intellectual content, Literature survey, Prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article.
ST: Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; Design of study, statistical Analysis and Interpretation;
UI: Review Manuscript; Literature survey and preparation of Figures.

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Source of Support: Nil, Conflict of Interest: None declared.