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ORIGINAL RESEARCH

The effect of endotracheal tube cuff pressure change during gynecological laparoscopic surgery on postoperative sore throat: a control study

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Abstract Postoperative respiratory complications related to endotracheal intubation usually present as cough, sore throat, hoarseness. The aim of the study was to examine the effects of endotracheal tube cuff pressure changes during gynecological laparoscopic surgery on postoperative sore throat rates. Thirty patients who underwent gynecological laparoscopic surgery and 30 patients who underwent laparotomy under general anesthesia with endotracheal intubation were included. After induction of general anesthesia and endotracheal intubation, the cuff was inflated to 25 mmHg. At 5, 15, 30, 45 and 60 min after endotracheal intubation, cuff pressure and peak airway pressure were recorded. At 2 and 24 h after surgery, the patients were assessed for complaints of a sore throat. In patients who underwent laparotomy, cuff pressure and peak airway pressure did not change significantly at different time points after intubation. In patients who received laparoscopic surgery, cuff pressure and peak airway pressure were significantly increased compared to initial pressure at all examined time points. In both groups, the endotracheal tube cuff pressure and peak airway pressure were significantly correlated ($R = 0.9431$, $P < 0.01$; $R = 0.8468$, $P < 0.01$). Compared to patients who had undergone laparotomy, patients who had undergone laparoscopic surgery showed significantly higher sore throat scores at both 2 and 24 h after surgery ($P < 0.01$). Pneumoperitoneum and Trendelenburg position may increase airway pressure and cuff pressure, resulting in increased incidence of postoperative sore throat.

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1 Introduction

Sore throat is a common complication of endotracheal intubation. In severe cases, it can affect the eating behavior of the patient and reduce satisfaction with the hospital stay. Local mucosal injury caused by increased endotracheal tube cuff pressure is the main cause for a sore throat. It has been reported [1, 2] that a cuff pressure greater than 30 cmH_2O (1 cmH_2O = 0.098 kPa), significantly reduces perfusion of local tracheal mucosa. Compared to open procedures, laparoscopic surgery is less invasive, results in reduced postoperative pain, and leads to quicker recovery. With wide application of laparoscopic surgery, its influences on the pathophysiology of the patients have also been increasingly recognized.

Carbon dioxide pneumoperitoneum can reduce lung compliance and increase airway pressure, the question remains as to whether this will lead to increase in endotracheal tube cuff pressure and postoperative sore throat in patients. Although Yildirim et al. [3] report that high tracheal cuff pressure during laparoscopic cholecystectomy was an important factor in the development of postoperative sore throat. How did pneumoperitoneum affect the tube cuff pressure? Is the tube pressure related with peak airway pressure? To address these questions, we examined change in endotracheal tube cuff pressure during gynecological laparoscopic surgery and laparotomy and its effect on postoperative sore throat. We hypothesized that increased peak airway pressure during laparoscopy would increase tracheal tube cuff pressures.

Table 1 Comparison of general information of patients from the two groups ($x \pm s$, $n = 30$)

Group	Age (year)	Weight (kg)	Height (cm)	BMI (kg/m^2)	Operative time (min)
Group L	35.4 ± 9.6	56.9 ± 5.8	153.3 ± 10.4	25.2 ± 4.1	82 ± 14
Group O	36.5 ± 7.7	53.8 ± 8.3	155.5 ± 12.3	24.1 ± 3.9	79 ± 15
t value	0.48	0.85	0.81	0.72	0.64
P value	0.71	0.18	0.26	0.39	0.45

2 Materials and methods

Ethical approval for this study (Ethical Committee No. FDFCK 17) was provided by the Ethical Committee of the Obstetrics & Gynecology Hospital of Fudan University, China (Chairperson Prof Xu CJ) on 10 August 2012. After obtaining written informed consent, we included 30 patients who underwent gynecological laparoscopic surgery and 30 patients who underwent gynecological laparotomy under general anesthesia with endotracheal intubation at our hospital from March to July 2012. The inclusion criteria were as follows: age 25–50 years old; weight 45–70 kg; body mass index (BMI) >20 and <30 kg/m^2; American Society of Anesthesiologists (ASA) grade I–II. The exclusion criteria were as follows: a history of chronic throat disease; upper respiratory tract infection within 2 weeks before surgery; and history of mental illness or communication barriers. Patients who underwent laparoscopic surgery were in group L, and those who underwent open surgery were in group O. Comparison of general information of patients in the two groups is shown in Table 1.

No patient received medications prior to surgery. After the patient was taken to the operating room, routine vital sign monitoring of non-invasive arterial blood pressure, ECG and pulse oximetry was performed and an oxygen mask was connected. For induction of general anesthesia, 0.5 μg/kg sufentanil, 2 mg/kg propofol and 0.6 mg/kg rocuronium were administered intravenously. After intubation using an endotracheal tube of ID = 7 mm, the transducer was connected to the cuff through a t-connector, and the cuff was inflated to 25 mmHg (1 mmHg = 0.133 kPa). The number of intubations as well as need for cricoids pressure and bucking were recorded. During the operation, hemodynamic readings were recorded every 5 min, and operative time was also recorded. After successful intubation, mechanical ventilation was initiated using tidal volumes of 8 ml/kg and respiratory rates of 10 per min. All patients were ventilated with air/O_2 (FiO_2 = 50 %). Anesthesia maintenance was achieved through administration of 6 mg/(kg h) propofol and 0.25 μg/(kg min) remifentanil. In addition, rocuronium was added throughout the operation as needed. For patients in group L, after carbon dioxide pneumoperitoneum was established, the patients were positioned in Trendelenburg with the head lower than the feet by 20°–30°. The pneumoperitoneum pressure was maintained at 14 mmHg. Patients in group O were kept in the supine position. Cuff pressure and peak airway pressure were recorded at 5, 15, 30, 45 and 60 min after endotracheal intubation.

To relieve the incision pain, all patients received incision infiltration with 0.2 % ropivacaine and intravenously injection with 200 mg tramadol and 50 mg flurbiprofen axetil before the end of the surgery. After operation, 50 mg tramadol was injected intravenously when the patient's VAS >3.

At 2 and 24 h after surgery, an observer who had no knowledge of the grouping of the patients assessed their conditions regarding sore throat. Visual analog scale (VAS) was adopted, with 0 being painless and 10 being the most pain ever experienced. The patients' sore throat in both quiet and swallowing states was evaluated.

We performed a pilot study with 10 patients from the O group to assess the size of our study. The mean value of cuff pressure was 26.7 mmHg, standard deviations were 4.9 mmHg. For our power calculation, we assumed equal standard deviation for both groups. To sense a difference of 5.4 mmHg between the 2 groups with a two-tailed $\alpha = 0.05$ and a power of 80 %, a minimum of 13 per group were needed. A Z-test was performed to prove the lack of difference between the 2 groups. Therefore, we decided to recruit 30 patients to allow for a drop rate of 10 %.

2.1 Data analysis

SPSS13.0 statistical software was used. Quantitative data are expressed as mean ± standard deviation or median (interquartile range). Between-group comparison of general information was performed using the *t* test. Repeated measures ANOVA was performed to compare cuff pressures and airway pressures at different time points. Pearson correlation analysis was performed to determine the correlation between endotracheal tube cuff pressure and peak airway pressure. $P < 0.05$ was considered statistically significant. For data with non-normal distribution, nonparametric test was performed.

Table 2 Changes in endotracheal tube cuff pressure during surgery in patients from the two groups (mmHg, $x \pm s$, $n = 30$)

Group	Immediately after intubation	5 min after intubation	15 min after intubation	30 min after intubation	45 min after intubation	60 min after intubation
Group L	25	34.2 ± 4.8	34.7 ± 3.8	35.2 ± 3.4	35.1 ± 2.8	34.3 ± 2.5
Group O	25	27.1 ± 2.7	27.4 ± 2.6	27.3 ± 3.8	26.9 ± 2.2	26.7 ± 2.3
F value	/	34.87	57.16	72.75	110.12	111.13
P value	/	0.000	0.000	0.000	0.000	0.000

Table 3 Changes in peak airway pressure during surgery in patients from the two groups (mmHg, $x \pm s$, $n = 30$)

Group	Immediately after intubation	5 min after intubation	15 min after intubation	30 min after intubation	45 min after intubation	60 min after intubation
Group L	14.2 ± 1.4	21.3 ± 3.5	21.5 ± 3.2	22.8 ± 2.5	23.9 ± 2.4	24.3 ± 2.5
Group O	13.8 ± 1.3	13.8 ± 1.5	14.2 ± 1.8	14.3 ± 1.5	14.3 ± 1.4	14.1 ± 1.3
F value	1.32	44.26	81.47	167.35	266.58	267.96
P value	0.26	0.000	0.000	0.000	0.000	0.000

3 Results

3.1 Endotracheal tube cuff pressure and peak airway pressure

Intubation was successful after one attempt in all patients. Application of cricoid pressure to expose the glottis was not needed and bucking after intubation or during operation did not occur. Intraoperative hemodynamic parameters did not differ notably between the two groups. The differences in intraoperative opioid and postoperative analgesic requirements in the two surgical procedures (i.e., laparoscopy vs. laparotomy) were insignificant.

In both groups, the instant cuff pressure immediately after intubation was set to 25 mmHg. Accordingly peak airway pressure was 14.2 ± 1.4 mmHg in group L and 13.8 ± 1.3 mmHg in group O after ventilation. In patients from group L, cuff pressures and peak airway pressures at different time points after pneumoperitoneum was established were all significantly increased compared to the initial value, whereas in group O, cuff pressures and peak airway pressures at different time points after pneumoperitoneum was established were not significantly different from the initial value (see Tables 2, 3). In both groups, the endotracheal tube cuff pressure and peak airway pressure were significantly positively correlated (group L: $R = 0.9431$, $P < 0.01$; group O $R = 0.8468$, $P < 0.01$).

3.2 Postoperative sore throat assessment

The sore throat scores assessed 2 and 24 h after surgery in patients from the two groups are shown in Table 4. Compared to group O, the sore throat scores of patients in group L at 2 and 24 h after surgery were significantly elevated, $P < 0.05$.

Table 4 Postoperative sore throat scores in quiet and swallowing states in patients from the two groups (n = 30)

Group	2 h (x ± s)		24 h M(Q3–Q1)	
	Quiet	Swallowing	Quiet	Swallowing
Group L	2.5 ± 1.2	2.7 ± 1.3	0.3 (0.2–0.8)	0.5 (0–0.8)
Group O	0.7 ± 0.3	1.3 ± 0.3	0 (0–0.4)	0.2 (0–0.6)
P value	0.00	0.00	0.04	0.45

Q stands for quartile range, for the data are not in normal distribution. Q3–Q1 defined as the distance from the first to the third quartile

4 Discussion

Gynecological laparoscopic surgery has been widely used in clinical practice and has the advantages of being less invasive, resulting in reduced postoperative pain and quicker recovery. The results of the current study show that after pneumoperitoneum is established during laparoscopic surgery, the increase in airway pressure results in significant increase in cuff pressure. In contrast, in patients undergoing laparotomy, neither airway pressure nor cuff pressure changes significantly during operation. After pneumoperitoneum is established and Trendelenburg position is assumed, the diaphragm is elevated and lung expansion is limited, thus lung compliance is substantially reduced [4], leading to an increase in airway pressure.

Sore throat is a common complication after endotracheal intubation. In severe cases, it can affect the patient's eating behavior. Studies have shown that the incidence of sore throat after endotracheal intubation is 14–50 % [5, 6]. Postoperative sore throat is influenced by many factors, such as age and sex of the patient, diameter of the tube, number of intubation attempts, cuff pressure and bucking during operation. The increased airway pressure during mechanical ventilation after pneumoperitoneum that overinflates endotracheal tube cuff can cause excessively high pressures on the wall of the airway, block submucosal perfusion in the airway and lead to ischemic erosion and necrosis of tracheal mucosa [7]. The possible mechanism was that the increased airway pressure during laparoscopic surgery would conduct and pressed part of cuff, which resulted in the cuff pressure increasing.

In the current study, there were no significant differences in the demographics of the patients from the two groups, and bucking did not occur during the operation in either group. However, patients who underwent laparoscopic surgery suffered from sore throat more commonly than patients who underwent open surgery. This suggests that an increase in endotracheal tube cuff pressure is the main cause of postoperative sore throat among patients who receive laparoscopic surgery, which consistent with previous reports [3, 7]. Yildirim et al. report that high tracheal cuff pressure, which was related to pneumoperitoneum and head and neck position, was an important factor in the development of postoperative sore throat. In our study, all patients were kept with head of neutral position. Yildirim et al.'s study included laparoscopic cholecystectomy versus open abdominal surgery and ours selected patients undergoing gynecological laparoscopy versus gynecological laparotomy. In our study, we have not only observed the changes of cuff pressure, but also observed the changes of airway pressure during operations, which partly explained the possible mechanism of increased cuff pressure.

There are some limits in our study. One of the deficiency of this study is that proper randomization was not possible due to selection of separate surgical procedures. Secondly, we didn't measure the tube pressure before and after head-down position, so it is not clear if head-down positioning for laparoscopy may have influenced the incidence of sore throat.

The current study shows that in patients who undergo gynecological laparoscopic surgery, after pneumoperitoneum is established and Trendelenburg position assumed, airway pressure is significantly increased, resulting in significant increase in endotracheal tube cuff pressure. The incidence of postoperative sore throat in these patients is higher than in patients undergoing a laparotomy. Therefore, for patients who receive laparoscopic surgery, routine monitoring of endotracheal tube cuff pressure should be performed, and appropriate measures should be taken to reduce the incidence and severity of postoperative sore throat to improve the patient's satisfaction with hospitalization.

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