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Original Research Article

Airway Complications during Laparoscopic Surgery Under General Anesthesia Using Endotracheal Tube Versus Supraglottic Airway Device: A Prospective Comparative Study

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Abstract

Background: Pneumoperitoneum during laparoscopic surgery under general anesthesia is known to cause a decrease in pulmonary compliance and increase in airway pressures. Traditionally, endotracheal tubes (ETTs) have been used because they create a definitive airway, while second generation supraglottic airway devices (SGAs) have been shown to seal the airway better and to drain the stomach with less stimulation of the airway. The aim of the present study was to compare the incidence of airway complications in ETT and SGA in elective laparoscopy.

Methods: This was a prospective comparative study of 120 adult ASA physical status I-II patients undergoing elective laparoscopic surgery. Patients were randomized to either ETT (n=60) or SGA (n=60; second generation device with gastric drainage channel). The following were used: standardized induction, neuromuscular blockade, controlled ventilation, pneumoperitoneum pressure, and postoperative assessment. The main outcome was the composite of airway complications within 24 hours. Secondary outcomes were device insertion characteristics, ventilatory variables, hemodynamic responses, postoperative sore throat, cough, and hoarseness, nausea-vomiting, and PACU discharge time.

Results: There were no differences in baseline characteristics between groups. The mean insertion time was significantly less for SGA than ETT (15.2±3.8 vs. 22.8±5.4 seconds; $p<0.001$). Peak airway pressure following pneumoperitoneum was similar (23.4±3.8 vs. 24.1±4.2 cmH2O; $p=0.34$), and the increase in mean arterial pressure during insertion was less with SGA (8.6±5.7 vs. 15.8±7.1 mmHg; $p<0.001$). The composite airway complication rate was significantly greater in the ETT group (43.3%) compared to the SGA group (20.0%) ($p=0.006$). Sore throat (31.7% vs. 11.7%; $p=0.008$), emergence cough (26.7% vs. 8.3%; $p=0.009$), and hoarseness (18.3% vs. 5.0%; $p=0.024$) were more frequent after ETT. None of the patients had aspiration, regurgitation or clinically significant bronchospasm.

Conclusions: In the right adult patient undergoing elective laparoscopic surgery, second-generation SGA was effective for ventilation and was found to be associated with fewer postoperative airway complications and a more stable hemodynamic response than ETT.

Keywords: airway complications; endotracheal tube; general anesthesia; laparoscopic surgery; supraglottic airway device; sore throat.

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Introduction

Airway management during laparoscopic surgery is still a crucial part of anesthetic safety as the combination of CO2 pneumoperitoneum, surgical positioning and controlled ventilation all affect respiratory mechanics and the risk of leak, gastric insufflation, hypoventilation, and postoperative morbidity of the throat. One of the most common airway complaints following general anesthesia is sore throat, and the risk is affected by the type of airway instrumentation, cuff pressure, mucosal trauma, patient factors, and the length of surgery [1]. The endotracheal tube has traditionally been considered the standard airway for laparoscopic surgery, as it holds the trachea and allows for

positive pressure ventilation. Laryngoscopy and tracheal intubation, however, stimulate sympathetic responses, can provoke cough during emergence and can cause mucosal irritation, hoarseness, dysphagia and sore throat. Supraglottic airway devices were developed to offer a less invasive airway, which does not pass through the vocal cords, and second generation devices have incorporated increased seal pressures and gastric drainage channels to minimize leakage and gastric insufflation [2].

Laparoscopic procedures pose certain anesthetic concerns due to the pneumoperitoneum, which decreases diaphragmatic excursion, functional residual capacity and increases peak airway pressure. Therefore, careful ventilation, adequate muscle relaxation, limitation of intra-abdominal pressure and monitoring of end-tidal carbon dioxide are essential [3]. Previous comparative trials have shown that certain laryngeal mask devices can maintain ventilation during laparoscopy during cholecystectomy and gynecological laparoscopy, especially in the fasted patient, in the absence of gastroesophageal reflux and anticipated difficult airway [4,5].

The results of subsequent randomized studies and meta-analyses indicated that SGAs could provide a reduction in airway morbidity and hemodynamic response compared with ETT, and could deliver similar oxygenation and ventilation in well-selected laparoscopic patients [6-10].

However, regurgitation, aspiration, lack of seal during pneumoperitoneum and device displacement remain concerns, particularly in longer procedures or with patients who have a higher body mass index. Further investigations with second generation devices that have access to the stomach have also confirmed their feasibility in long-term laparoscopic hepatectomy and donor nephrectomy, but local prospective evidence from daily laparoscopic practice is still valuable as the performance of the devices is dependent on the selection of cases, the experience of the anesthetist and the institutional protocols [11-13].

The aim of the present study was to compare the airway complications in elective laparoscopic surgery under general anesthesia with endotracheal tube and second-generation supraglottic airway device. The main objective was to compare the overall incidence of airway complications within 24 hours of the operation. Secondary endpoints included insertion characteristics, intraoperative ventilation, hemodynamic response, postoperative throat symptoms, and recovery-room outcomes.

Materials and Methods

Study design and setting: This was a prospective comparative study in the Department of Anaesthesiology of a tertiary-care teaching hospital. This study involved adult patients undergoing elective laparoscopic surgery under general anesthesia for 12 months.

Sample size: A sample size of 120 patients was used, with 60 patients in each group. The calculation was performed using the assumption of a clinically significant difference in airway complications between the ETT and SGA groups (40% vs. 18%), a power of 80%, and an alpha error of 5%. The sample was rounded to 60 in each group to make up for potential dropouts or conversion to open surgery.

Inclusion criteria: ASA physical status I or II, Mallampati class I-II, body mass index 18-30 kg/m2, and elective laparoscopic procedures of less than 120 minutes duration were included.

Exclusion criteria: Patients who had a full stomach, pregnancy, gastroesophageal reflux disease, a hiatus hernia, morbid obesity, an anticipated difficult airway, a restricted mouth opening, an active respiratory tract infection, risk of aspiration, or were scheduled for open surgery were excluded.

Group allocation and airway device: Patients were randomly allocated into two groups of equal size using a computer-generated sequence with a sealed envelope concealment method and the airway device was used. After direct laryngoscopy, Group ETT was provided with cuffed endotracheal tube with the proper internal diameter. Group SGA was given a second generation supraglottic airway device with a gastric drainage channel based on manufacturer's recommended weight ranges. The correct placement was confirmed by the movement of the chest, capnography, no significant leak, and the ability to pass a gastric tube through the drainage channel.

Anesthetic protocol: Standard monitoring included electrocardiography, non-invasive blood pressure, pulse oximetry, end-tidal carbon dioxide, airway pressure, and temperature. Institutional protocol was followed for premedication. Induction of anesthesia was performed by intravenous injection of propofol 2 mg/kg, fentanyl 2 micrograms/kg and rocuronium 0.6 mg/kg. Anesthesia was maintained with oxygen-air mixture, sevoflurane, intermittent rocuronium and controlled ventilation. Tidal volume was adjusted to 6-8 mL/kg predicted body weight, respiratory rate was adjusted to keep EtCO2 35-45 mmHg and positive end-expiratory pressure of 5 cmH2O was applied. The pneumoperitoneum pressure was kept at 10-14 mmHg.

Outcome assessment: Device insertion time, device insertion attempts, ease of gastric tube insertion, peak airway pressure, end-tidal carbon

dioxide, oxygen saturation, heart rate, mean arterial pressure and requirement for airway manipulation were recorded. Airway complications were laryngospasm, bronchospasm, desaturation (SpO2 <94%), significant leak (requiring repositioning or changing of device), regurgitation, aspiration, blood staining of device, lip or dental trauma, postoperative sore throat, cough, hoarseness, dysphagia, nausea-vomiting, and delayed PACU discharge. A blinded observer evaluated postoperative throat symptoms at 1 hour and 24 hours.

Data analysis: Data were entered in MS Excel and analyzed by using the standard statistical software. Continuous variables were expressed as mean ± standard deviation and compared using independent-samples t-test. Categorical variables were presented as numbers and percentages and compared by chi-square test or Fisher exact test as appropriate. A p value of <0.05 was deemed as statistically significant.

Results

128 patients were screened, 8 were excluded due to BMI > 30 kg/m2, reflux symptoms or refusal to participate. A total of 120 patients (60 ETT and 60 SGA) were included in the final analysis. None of the patients were randomized for open surgery or exclusion.

There were no differences between the groups in terms of the demographic profile, ASA classification, Mallampati class, type of laparoscopic surgery, duration of pneumoperitoneum and total duration of anesthesia (Table 1). The mean age was 38.4±10.6 years in the ETT group and 37.2±9.8 years in the SGA group (p=0.52). Mean body mass index was also comparable (24.6±2.8 vs. 24.2±3.0 kg/m2; p=0.45).

All patients successfully had the airways inserted. The success rate was 93.3% in the ETT group and 96.7% in the SGA group (p=0.40) for the first attempt. The time for the device to be inserted was significantly shorter in the SGA group (15.2±3.8 seconds) than in the ETT group (22.8±5.4 seconds; p<0.001). Peak airway pressure and end-tidal carbon dioxide levels were within acceptable limits in both groups (Table 2). ETT caused a significantly greater rise in mean arterial pressure at insertion than SGA (15.8±7.1 mmHg vs. 8.6±5.7 mmHg, respectively; p<0.001).

The airway complication rate was significantly higher in the ETT group than the SGA group (43.3% vs. 20.0%, p=0.006). Sore throat, emergence cough and hoarseness were significantly more common after ETT. In both groups, there were no episodes of aspiration, regurgitation, clinically significant bronchospasm or failed ventilation. PACU stay was shorter in the SGA group (38.6±9.4 minutes) than in the ETT group (45.2±11.8 minutes; p=0.001), as shown in Table 3.

Table 1: Baseline demographic and operative characteristics

Variable	ETT group (n=60)	SGA group (n=60)	p value
Age (years), mean ± SD	38.4 ± 10.6	37.2 ± 9.8	0.52
Female sex, n (%)	38 (63.3)	40 (66.7)	0.70
BMI (kg/m2), mean ± SD	24.6 ± 2.8	24.2 ± 3.0	0.45
ASA I/II, n	34/26	36/24	0.71
Mallampati I/II, n	42/18	44/16	0.68
Laparoscopic cholecystectomy, n (%)	28 (46.7)	30 (50.0)	0.71
Gynecological laparoscopy, n (%)	20 (33.3)	19 (31.7)	0.84
Other laparoscopic procedures, n (%)	12 (20.0)	11 (18.3)	0.81
Pneumoperitoneum duration (min)	54.8 ± 16.2	52.9 ± 15.4	0.51
Anesthesia duration (min)	82.5 ± 20.6	79.4 ± 19.8	0.40

Table 2: Airway insertion, ventilation, and hemodynamic variables

Variable	ETT group (n=60)	SGA group (n=60)	p value
First-attempt success, n (%)	56 (93.3)	58 (96.7)	0.40
Insertion time (seconds)	22.8 ± 5.4	15.2 ± 3.8	<0.001
Gastric tube insertion success, n (%)	60 (100.0)	58 (96.7)	0.15
Peak airway pressure after induction (cmH2O)	17.8 ± 3.1	17.2 ± 2.9	0.28
Peak airway pressure after pneumoperitoneum (cmH2O)	24.1 ± 4.2	23.4 ± 3.8	0.34
EtCO2 during pneumoperitoneum (mmHg)	38.8 ± 3.6	39.1 ± 3.8	0.66
Lowest SpO2 intraoperatively (%)	98.2 ± 1.4	98.5 ± 1.2	0.21
MAP rise after insertion (mmHg)	15.8 ± 7.1	8.6 ± 5.7	<0.001
Heart rate rise after insertion (beats/min)	16.4 ± 8.5	8.9 ± 6.8	<0.001

Table 3: Perioperative airway complications and recovery outcomes

Complication/outcome	ETT group (n=60)	SGA group (n=60)	p value
Composite airway complication, n (%)	26 (43.3)	12 (20.0)	0.006
Postoperative sore throat, n (%)	19 (31.7)	7 (11.7)	0.008
Emergence cough, n (%)	16 (26.7)	5 (8.3)	0.009
Hoarseness, n (%)	11 (18.3)	3 (5.0)	0.024
Dysphagia, n (%)	7 (11.7)	2 (3.3)	0.083
Blood staining of device, n (%)	8 (13.3)	3 (5.0)	0.12
Desaturation <94%, n (%)	2 (3.3)	1 (1.7)	0.56
Laryngospasm, n (%)	1 (1.7)	0 (0.0)	0.31
Regurgitation/aspiration, n (%)	0 (0.0)	0 (0.0)	-
PONV, n (%)	9 (15.0)	7 (11.7)	0.59
PACU stay (min)	45.2 ± 11.8	38.6 ± 9.4	0.001

Discussion

The present prospective comparative study showed that the incidence of airway complications was significantly lower in selected adult patients undergoing elective laparoscopic surgery with SGA compared to ETT. This decrease was primarily due to decreased postoperative sore throat, emergence cough and hoarseness. Concurrently, intra-operative oxygenation, end-tidal carbon dioxide and peak airway pressure were similar, indicating that SGA ensured adequate ventilation under the study conditions.

These findings are clinically plausible since laryngoscopy and insertion of a cuffed tube into the glottis results in increased mucosal contact and stimulation of the trachea during ETT placement. SGA, on the other hand, is placed above the laryngeal inlet and does not directly irritate the trachea. The lower sore throat and cough in the SGA group is consistent with the airway morbidity profile reported in systematic reviews of postoperative sore throat [1] and randomized laparoscopic studies that reported that LMA-based airway management resulted in less early postoperative discomfort [8].

The ETT group had a significantly larger hemodynamic response after airway instrumentation. This is consistent with previous findings that tracheal intubation elicits a greater sympathetic response than ProSeal LMA during laparoscopy, such as bariatric laparoscopy [6]. This transient response may not be clinically significant in most ASA I-II patients, but in patients with ischemic heart disease, hypertension, or intracranial disease, attenuation of airway stimulation may be desirable. This study, however, did not include such higher-risk patients and extrapolation should be done with caution.

A major issue with the use of SGA during laparoscopy is ventilatory adequacy. Pneumoperitoneum causes an increase in airway pressure and may lead to gastric insufflation if the seal is not perfect. In the current study, peak airway pressure following pneumoperitoneum was similar in both groups and none of the patients in the SGA group required conversion to ETT. This is consistent with previous studies showing successful ventilation using ProSeal or newer second generation SGAs during laparoscopy for gynecologic surgery and laparoscopy for cholecystectomy [4,5,7]. The results are also similar to the meta-analytical results showing that SGAs can be used for adequate ventilation in the appropriate selected laparoscopic patient [9,10].

There were no cases of regurgitation or aspiration in either group. This is not a negative finding of the absence of aspiration risk, rather it is a reflection of patient selection, fasting status, exclusion of reflux and obesity, use of a second generation device and controlled pneumoperitoneum pressure. Recent studies have assessed intragastric pressure and second-generation SGAs in longer laparoscopic hepatobiliary procedures, and this reassures that gastric drainage-channel devices may be safe if used with careful attention to the criteria [11,12]. A retrospective donor nephrectomy study by Lee et al. also found no desaturation, hypercapnia or aspiration pneumonitis and noted good respiratory mechanics with second generation SGA [13].

The shorter insertion time of SGA in the present study is in line with clinical experience and could be beneficial in routine elective anesthesia. However, the ETT is still essential for patients at risk of aspiration, emergency surgery, severe obesity, uncontrolled reflux, anticipated difficult ventilation, high airway pressures, and procedures requiring steep Trendelenburg for extended periods of time. Thus, the current results indicate that SGAs can be used as an alternative and not as a blanket solution to ETT.

There are some limitations to this study. The results are not applicable to all laparoscopic patients, as it was performed in selected ASA I-II patients with BMI less than 30 kg/m2 and expected normal airway. The study was not sufficiently powered to detect very rare events like aspiration.

Not all patients were graded using the SGA position with fiberoptic or had continuous cuff-pressure monitoring. Due to the nature of the intervention, blinding of the anesthetist was not possible. Lastly, various laparoscopic procedures were included, but there were no significant differences in the distribution or duration of procedures between the groups.

In conclusion, the results indicate that second-generation SGA can be safely employed in carefully selected elective laparoscopic procedures and can minimize postoperative airway morbidity. More extensive, multicenter studies of the second-generation devices, continuous leak-pressure monitoring, cuff-pressure control, and longer follow-up are required to establish device-specific safety in broader surgical and patient-risk groups.

Conclusion

A second generation supraglottic airway device was found to be an effective ventilatory device that was comparable to endotracheal intubation in selected adult ASA I-II patients undergoing elective laparoscopic surgery under general anesthesia.

It was linked to a significantly reduced incidence of airway complications such as postoperative sore throat, cough, and hoarseness, and reduced hemodynamic response to airway insertion.

For patients who are at risk for aspiration, have a difficult airway, are severely obese, or undergoing procedures that are likely to cause high airway pressures, endotracheal intubation is still the gold standard, but second-generation supraglottic airway devices are a valuable and less stimulating option for carefully selected laparoscopic procedures.

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