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Case Control Study

Anesthetic management and associated complications of peroral endoscopic myotomy: A case series

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Abstract**AIM**

To investigate the anesthetic management of peroral endoscopic myotomy (POEM) and its associated complications.

METHODS

This study was a single-center, retrospective, observational study comprising a case series of all patients who underwent POEM in our hospital from April 2015 to November 2016. We collected data regarding patient characteristics, anesthetic methods, surgical factors, and complications using an electronic chart.

RESULTS

There were 86 patients who underwent POEM in our hospital during the study period. Preoperatively, patients were maintained on a low residue diet for 48 h prior to the procedure. They were fasted of solids for 24 h before surgery. There was one case of aspiration (1.2%). During POEM, patients were positioned supine with the upper abdomen covered by a clear drape so

that pneumoperitoneum could be timeously identified. In three cases, the peak airway pressure exceeded 35 cmH₂O during volume controlled ventilation with tidal volumes of 6-8 mL/kg and subsequent impairment of ventilation. These cases had been diagnosed with spastic esophageal disorders (SEDs) and the length of the muscular incision on the esophageal side was longer than normal.

CONCLUSION

In the anesthetic management of POEM, it is important to prevent aspiration during induction of anesthesia and to identify and treat complications associated with CO₂ insufflation.

Key words: Peroral endoscopic myotomy; Anesthetic management; Ventilatory impairment

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Core tip: In the anesthetic management of peroral endoscopic myotomy (POEM), it is important to identify and treat complications associated with CO₂ insufflation. In this retrospective case series, we experienced three cases of ventilatory complications caused by CO₂ insufflation. These cases had been diagnosed with spastic esophageal disorders and the length of the muscular incision on the esophageal side was longer than usual. In particular, pneumoperitoneum needs to be carefully assessed for during the procedure, especially when a longer muscular incision is necessary. Significantly, this is the first case series report of ventilatory impairment occurring as an anesthetic complication of POEM using CO₂ insufflation.

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INTRODUCTION

Until recently, treatment options for esophageal achalasia have comprised pharmacological therapy, endoscopic pneumatic balloon dilation and surgical intervention such as Heller's myotomy^[1,2]. Peroral endoscopic myotomy (POEM) is a novel procedure that has become established as the best treatment option for esophageal achalasia, as POEM is safer and less invasive than other surgery, and is expected to offer long-lasting symptom control^[3-6]. While POEM is performed under general anesthesia, few reports exist about its anesthetic management, particularly regarding anesthetic complications. We describe here the anesthetic management and associated complications

in 86 patients who underwent POEM for esophageal achalasia at our institution.

MATERIALS AND METHODS

This study was a single-center, retrospective, observational study comprising a case series of all patients who underwent POEM in our hospital from April 2015 to November 2016. Kobe University Hospital institutional Review Board approved this observational study. The institutional Review Board of Kobe University Hospital Number of assessment report: 1587. Written informed consent has been obtained from the patients.

Statistical analysis

We collected data regarding patient characteristics, anesthetic methods, surgical factors, and complications using an electronic chart. The patient characteristics include age, sex, body mass index, preoperative symptoms, previous intervention, diagnosis and preoperative Eckardt score. The anesthetic methods include type and dose of anesthetic agents during anesthesia. The surgical factors include duration of anesthesia, duration of surgery, length of muscular incision, perioperative adverse events, hospital stay and Eckardt score 2 mo later. The results are shown as the median (25%-75%, interquartile range) and number (%). Differences in the Eckardt score before and after POEM were compared with the Mann-Whitney *U* test. We used SPSS 20.0 software to perform statistical analysis. A *P* value < 0.05 was defined as being statistically significant.

RESULTS

Patient characteristics

There were 86 patients who underwent POEM in our hospital during the period April 2015 to November 2016. Table 1 summarizes the patient characteristics. The median age was 51 years, and 35 of the patients were male (41%). The median BMI was 20.6 kg/cm². Regarding pathology, esophageal achalasia was the cause in 80 cases (93.0%), jackhammer esophagus in five (5.8%) and diffuse esophageal spasm in one (1.2%).

Preoperative management and induction of anesthesia

Table 2 summarizes key anesthetic and surgical factors. In the first two cases, esophagoscopy was performed under sedation before induction of anesthesia to ensure complete evacuation of esophageal contents. However, because Friedrich *et al*^[7] reported that esophagoscopy under sedation elevated the risk of aspiration, we did not evacuate esophageal contents *via* esophagoscopy before induction in any of the following cases. Instead, a low residue diet was maintained for 48 h prior to the procedure. Patients were fasted of solids for 24 h and then of clear liquids for 2 h before the procedure. Patients were placed in the semi-Fowler's position prior

Table 1 Patient characteristics

Characteristics	Values
Age median (range); yr	51 (42-66)
Sex male (%)	35 (41)
BMI median (range); kg/cm ²	20.6 (18.6-22.8)
Preoperative symptoms; n (%)	
Weight loss	44 (51)
Chest pain	51 (59)
Dysphagia	84 (98)
Regurgitation	78 (91)
Previous interventions; n (%) (overlapping)	
None	44 (51)
Pharmacological therapy	21 (24)
Endoscopic pneumatic balloon dilation	20 (23)
Surgical myotomy	4 (5)
Diagnosis; n (%)	
Esophageal achalasia	80 (93)
Jackhammer esophagus	5 (6)
Diffuse esophageal spasm	1 (1)
Preoperative Eckardt score median (range); point	6 (4-7)

Table 2 Anesthetic and surgical factors

Parameters	Values
Cricoid pressure; n (%)	26 (46)
Maintenance with inhalational agents; n (%)	78 (91)
Duration of anesthesia mean \pm SD; min	117 \pm 31
Duration of surgery mean \pm SD; min	83 \pm 31
Length of muscular incision	
Esophageal side average \pm SD; cm	10.4 \pm 3.9
Gastric side average \pm SD; cm	2.7 \pm 0.7
Total average \pm SD; cm	13.1 \pm 3.9
Perioperative adverse events; n (%)	
Aspiration	1 (1)
Subcutaneous emphysema	21 (24)
EtCO ₂ > 50 mmHg during procedure	34 (40)
Upper abdominal needle decompression required	12 (14)
Airway pressure > 35 cmH ₂ O during operation	3 (3)
Mucosal injury not requiring invasive treatment	9 (10)
Mediastinitis with antibiotic therapy	1 (1)
Hospital stay mean \pm SD; d	5.45 \pm 2.18
Eckhart score 2 mo later; median (range); point	0 (0-1)

to induction of anesthesia and rapid sequence induction (RSI) was performed in all cases. We left the decision to use cricoid pressure up to the attending anesthesiologist; this was performed in 36 cases (42%). Anesthesia was induced with propofol (1.0-3.0 mg/kg), rocuronium (0.6-1.2 mg/kg), and either continuous intravenous infusion of remifentanyl at 0.2-0.4 μ g/kg/min or intravenous administration of remifentanyl 50-100 μ g.

There was one case of aspiration (1.16%) during induction of anesthesia, a female patient in her twenties. Because preoperative esophagoscopy revealed a moderate amount of residue in the esophagus, we had evacuated the esophageal contents with esophagoscopy two days before the procedure and maintained the patient on a low residue diet for 48 h prior to POEM, fasted of solids and liquids as previously described. Esophageal manometry revealed elevation of both integrated relaxation pressure (57 mmHg; normal <

15 mmHg) and lower esophageal sphincter pressure during expiration (52 mmHg; normal 10-35 mmHg). After administration of remifentanyl 100 μ g, propofol 3.0 mg/kg, and rocuronium 1.2 mg/kg, we recognized reflux of liquid contents before laryngoscopy. This was immediately suctioned, followed by intubation. We then suctioned aspirated vomitus through the endotracheal tube as soon as possible *via* bronchoscopy. Aspirated contents were found to be liquid, without solid particles. As the patient's respiratory status did not worsen, surgery went ahead as scheduled, and POEM performed in its entirety. After surgery, the patient was extubated in the operating room after full emergence from anesthesia and was returned to the ward after recovery. The postoperative course was uneventful and there were no respiratory complications such as pneumonia.

Intraoperative events

Intraoperative monitoring included routine use of noninvasive blood pressure, electrocardiography, pulse oximetry, capnography (End tidal CO₂: EtCO₂), urinary catheterization and eardrum temperature monitoring. Anesthesia was maintained with sevoflurane (1.0%-1.5%), desflurane (3.0%-5.0%), or propofol (target controlled infusion of 2.5-3.5 μ g/mL) with a mixture of 40% oxygen in air. Inhalational maintenance (sevoflurane or desflurane) was chosen in 78 cases (91%).

We left decisions regarding ventilation up to the attending anesthesiologist. During POEM, patients were positioned supine with the upper abdomen covered by a clear drape so that pneumoperitoneum could be identified immediately. In 21 cases (24.4%) subcutaneous emphysema was noted. In 34 cases (39.5%) EtCO₂ exceeded 50 mmHg. Among these, needle decompression of the upper abdomen was necessary in twelve cases (14.0%). In three cases, the peak airway pressure exceeded 35 cmH₂O under 6-8 mL/kg volume controlled ventilation. Of these three cases, two were diagnoses of jackhammer esophagus and the other a case of diffuse esophageal spasm.

Table 3 shows the characteristic of these three cases. In all three cases, the EtCO₂ had increased to more than 60 mmHg, peak airway pressure exceeded 35 cmH₂O, and SpO₂ decreased between 60 to 90 min after surgery commenced. Following needle decompression of the upper abdomen, the EtCO₂ and the peak airway pressure decreased immediately and ventilatory parameters improved in two cases. In the other case, the EtCO₂ remained abnormally high (177 mmHg) and it was necessary to stop surgery for about over 1 h because needle decompression did not result in immediate improvement. The EtCO₂ and peak airway pressure decreased gradually after interruption of CO₂ insufflation. Then, ventilatory parameters improved, surgery restarted and POEM proceeded uneventfully. After full emergence from anesthesia, the patient was extubated in the operating room and transferred to

Table 3 Characteristics of three cases

Characteristics	Case 1	Case 2	Case 3
Age; yr	74	61	73
Sex	Female	Male	Female
BMI; kg/cm ²	25.9	23.4	21.5
Preoperative symptoms			
Weight loss	Yes	None	None
Chest pain	Yes	None	Yes
Dysphagia	Yes	Yes	Yes
Regurgitation	Yes	Yes	Yes
Previous intervention	Pharmacological therapy	None	None
Lower esophageal sphincter pressure; mmHg	31	64	51
Diagnosis	Diffuse esophageal spasm	Jackhammer esophagus	Jackhammer esophagus
Duration of anesthesia; minutes	163	141	229
Maintenance of anesthesia	inhalation	inhalation	inhalation
Length of muscular incision			
Esophageal side; cm	18	15	19
Gastric side; cm	3	3	4
Maximum EtCO ₂ ; mmHg	67	63	177
Maximum peak airway pressure under 6-8 mL/kg volume controlled ventilation; mmHg	37	40	46

BMI: Body mass index.

Table 4 Review of anesthetic management of peroral endoscopic myotomy in the existing literature

Author	n	Preparation for POEM	Aspiration at induction	CO ₂ -related complications
Löser <i>et al</i> ^[9]	173	Liquid diet 2 to 5 d prior to POEM Nil per os overnight (for at least eight hours) Esophagoscopy was performed one day before POEM	None	Subcutaneous emphysema in 49 cases Pneumothorax in 1 case
Jayan <i>et al</i> ^[10]	21	Low residue diet 48 h before POEM Fasted from 20:00 on day before POEM	None	Subcutaneous emphysema in 5 cases
Goudra <i>et al</i> ^[11]	24	Fasting times for both solids and liquids were variable	1	No comment
Yang <i>et al</i> ^[12]	52	Clear liquid diet for 48 h before POEM Nil per os after midnight on day of POEM	None	Peak airway pressure > 35 cmH ₂ O in 5 cases
Tanaka ^[13]	28	Nil per os for 24 h before POEM Esophagoscopy was performed before induction of anesthesia	None	Subcutaneous emphysema in 1 case

POEM: Peroral endoscopic myotomy.

the intensive care unit. The patient was discharged on postoperative day 9. Okada *et al*^[8] described this case previously in detail.

Other complications and postoperative course

Other complications included esophageal mucosal injury in nine cases (10.5%), all of which were treated by endoscopic clipping of the mucosa. There was one case of postoperative mediastinitis that required six weeks of antibiotic therapy. There were no cases of postoperative pneumonia. The number of days from surgery to discharge was an average of 5.45 ± 2.18 in-hospital days. The median preoperative and two-month postoperative Eckardt scores were 6 (4-7) and 0 (0-1), respectively. The median Eckardt score was accepted as indicating significant improvement of symptoms ($P < 0.001$).

DISCUSSION

In this retrospective case series, we experienced

one case of aspiration which occurred at induction of anesthesia, and three cases of ventilatory complications caused by CO₂ insufflation. Significantly, this is the first case series report of ventilatory impairment occurring as an anesthetic complication of POEM using CO₂ insufflation.

Until now, there have been five reports of the anesthetic management of POEM^[9-13]. These are summarized in Table 4. All reports concluded that prevention of aspiration during induction of anesthesia and awareness of CO₂-related complications, such as mediastinal emphysema, were very important factors to consider. One case of aspiration (0.3%) occurred during induction of anesthesia in the 298 patients described in the five reports. In that particular case, rapid induction was chosen as the induction method and the authors concluded that rapid sequence induction was safer for patients with esophageal achalasia^[11]. Tanaka *et al*^[13] used esophagoscopy to evacuate esophageal contents prior to induction of anesthesia in all cases. On the other hand, Yang *et al*^[12] suggested that it was possible

to perform induction safely by maintaining patients on a clear liquid diet for 48 h prior to the procedure, instead of endoscopic evacuation of esophageal contents immediately before the procedure.

In the first two cases of our series, we evacuated esophageal contents *via* esophagoscopy under sedation prior to the procedure, according to the recommendation of Tanaka *et al.*^[13]. However, Friedrich *et al.*^[7] examined 15690 endoscopies under sedation and revealed a 0.1% incidence of respiratory infection following endoscopy. We felt the risk of esophagoscopy under sedation outweighed the benefits in patients who already had a high risk of aspiration, such as those with esophageal achalasia. As such, from the third case onwards we did not perform esophagoscopy before the procedure, and instead maintained patients on a low residue diet for 48 h preoperatively, fasting them of solids and liquids as previously described. RSI was chosen in all cases for induction of anesthesia. Despite these measures, we experienced one instance of aspiration during induction. In this case, preoperative esophagoscopy showed a moderate amount of residue in the esophagus, while esophageal manometry revealed elevated lower esophageal sphincter pressure during expiration (52 mmHg). It is generally known that anesthetic agents decrease lower esophageal sphincter pressure^[14,15]. Upper esophageal sphincter pressure is similarly decreased by these agents^[14,15]. However, these reports relate to a case without esophageal pathology, and the effects of anesthetic agents on esophageal sphincter pressure in achalasia patients are not yet known.

Given that esophageal achalasia is characterized by incomplete relaxation of the lower esophageal sphincter, we speculated that the aspiration occurred because only the upper esophageal sphincter pressure decreased upon administration of anesthetic agent, there was a moderate amount of esophageal content, and the lower esophageal sphincter pressure was high. Following this case, we decided to insert a gastric tube awake in all cases thought to be at high risk of aspiration, in order to evacuate secretions and reduce esophageal pressure prior to induction of anesthesia. These included cases with obvious residue during preoperative esophagoscopy, elevated lower esophageal sphincter pressure and severe esophageal dilatation.

It is known that complications associated with CO₂ insufflation, such as subcutaneous emphysema, mediastinal emphysema and pneumoperitoneum are common during POEM, because of the need to secure an operative field^[16,17]. As such, it is important to keep the upper abdomen exposed to identify pneumoperitoneum timeously. If pneumoperitoneum occurs, it should be treated with rapid needle decompression of the upper abdomen. However, some reports have concluded that while subcutaneous emphysema, mediastinal emphysema and pneumoperitoneum were common during POEM, these did not cause serious complications and no special intervention was required^[18, 19]. In the

previous five reports^[9-13], EtCO₂ increased during POEM, but no case of ventilatory impairment occurred. Our report is the first one describing ventilatory impairment during POEM. The target diseases of the three cases concerned were jackhammer esophagus and diffuse esophageal spasm. These diseases are classified as Spastic Esophageal Disorders (SEDs). Because POEM allows for a longer length of muscular incision on the esophageal side, POEM is more useful than laparoscopic Heller operation for SEDs, and may become first-line treatment for SEDs in the future^[20]. In our 86 patients, the average length of the lateral esophageal muscle layer incision was 10.4 ± 3.9 cm. The incision length in the three cases with ventilatory impairment were 18 cm, 19 cm and 15 cm on the esophageal side, considerably longer than average. In these three cases, we thought that the longer incision length led to massive leakage of CO₂ into the mediastinum.

In SEDs, abnormal peristalsis of the esophageal body occurs frequently, worsening the operative field for incision on the esophageal side. Therefore, CO₂ insufflation during POEM for SEDs tends to increase for securing the operative field; as such, CO₂-related complications may occur more frequently. In our hospital, when EtCO₂ exceeds 50 mmHg, we check for the presence of subcutaneous emphysema and pneumoperitoneum by palpation and visual inspection. Should pneumoperitoneum be present, this is treated by placement of a needle to upper abdomen. Surgeons are also notified if EtCO₂ increases significantly and are asked minimize CO₂ insufflation as much as possible. Should reducing CO₂ insufflation be difficult to secure an operative field, we consider administration of scopolamine to inhibit esophageal peristalsis. However, as Tanaka *et al.*^[13] has pointed out, this carries a risk of tachycardia.

There are several limitations to this study. Firstly, this was a single-center retrospective observational study, and thus the incidence of complications associated with anesthetic management of POEM is uncertain. Secondly, this was a small, single-center study with weak generalizability. Thus, our findings should be validated in other sites. Finally, there were no specific criteria for needle placement in the upper abdomen to decrease EtCO₂. Thus, mild pneumoperitoneum might have been overlooked and would have affected the results. In this regard, a future prospective study should be conducted with an established protocol for upper abdominal needle decompression.

In conclusion, prevention of aspiration during induction and prompt recognition and treatment of CO₂-related complications are important factors in the anesthetic management of POEM. The risk of peak airway pressure elevation and ventilatory impairment caused by CO₂ insufflation is higher in cases which require a longer than normal muscular incision on the esophageal aspect. Given the risk of pneumoperitoneum, this should be checked for during

the procedure and treated by immediate needle decompression of the upper abdomen.

ARTICLE HIGHLIGHTS

Research background

Peroral endoscopic myotomy (POEM) is a novel procedure that has become established as the best treatment option for esophageal achalasia, as POEM is safer and less invasive than other surgery, and is expected to offer long-lasting symptom control. While POEM is performed under general anesthesia, few reports exist about its anesthetic management, particularly regarding anesthetic complications.

Research motivation

Fatal anesthetic complications sometimes occurred during POEM, but few reports exist about them. Hence, we describe here the anesthetic management and associated complications in 86 patients who underwent POEM for esophageal achalasia at our institution.

Research objectives

We describe here the anesthetic management and associated complications in 86 patients who underwent POEM for esophageal achalasia at our institution.

Research methods

This study was a single-center, retrospective, observational study comprising a case series of all patients who underwent POEM in our hospital from April 2015 to November 2016. We collected data regarding patient characteristics, anesthetic methods, surgical factors, and complications using an electronic chart.

Research results

There were 86 patients who underwent POEM in our hospital during the study period. There was one case of aspiration (1.2%). In three cases, the peak airway pressure exceeded 35 cmH₂O during volume controlled ventilation with tidal volumes of 6-8 mL/kg and subsequent impairment of ventilation. These cases had been diagnosed with spastic esophageal disorders (SEDs) and the length of the muscular incision on the esophageal side was longer than normal.

Research conclusions

Our report is the first one describing ventilatory impairment during POEM. In the anesthetic management of POEM, it is important to identify and treat complications associated with CO₂ insufflation. In particular, pneumoperitoneum needs to be carefully assessed for during the procedure, especially when a longer muscular incision on the esophageal side is necessary.

Research perspectives

Because POEM allows for a longer length of muscular incision on the esophageal side, POEM is more useful than laparoscopic Heller operation for SEDs, and may become first-line treatment for SEDs in the future. We speculated that the longer incision length led to massive leakage of CO₂ into the mediastinum. In this regard, a future prospective study should be conducted about complications associated with CO₂ insufflation in POEM for SEDs.

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