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Short communication

Influence of Trendelenburg position and pneumoperitoneum treatment on gastroesophageal reflux in dogs

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Abstrakt

Gastroesophageal reflux is a latent factor that may cause esophagitis, esophageal stenosis, and aspiration pneumonia through the regurgitation of the gastric fluid contents. For laparoscopic surgery, posture-changing and pneumoperitoneum operations are conducted to develop the visual field.

However, few studies have examined the influence of these operations on gastroesophageal reflux. In this experiment using 10 Beagles, 10 mL of contrast medium was administered into the stomach, and the dogs were placed in the Trendelenburg position with 10-degree tilting.

Pneumoperitoneum treatment with carbon dioxide was performed, with an intraperitoneal pressure of 10 mmHg. The presence or absence of gastroesophageal reflux was evaluated using computed tomography (CT).

In horizontal and Trendelenburg positions, there was no reflux of Contrast medium. However, reflux was observed in the Trendelenburg position under pneumoperitoneum ($p<0.05$). These results suggest that the risk of gastroesophageal reflux increases during laparoscopic surgery in the Trendelenburg position with 10-degree tilting under an intraperitoneal pressure of 10 mmHg.

Introduction

Gastroesophageal reflux is considered to be a latent factor that may cause esophagitis, esophageal stenosis and aspiration pneumonia. It induces serious symptoms in some cases. Therefore, in the esophagus, regurgitation of the gastric fluid contents is prevented by pressure in the lower esophageal sphincter (Mittal and Balaban 1997, Paterson 2001). However, if the preventive mechanism is affected, reflux may occur. There are several mechanisms involved in reflux: 1) gastric wall-extending stimuli or anesthetics temporarily relax the lower esophageal sphincter, leading to reflux; 2) esophageal hiatus hernia reduces the pressure in the lower esophageal sphincter or leads to complete relaxation, inducing reflux; and 3) an increase in the abdominal pressure causes reflux. Of these, the onset of gastroesophageal reflux related to temporary relaxation of the lower esophageal sphincter is considered the major mechanism (Lehmann et al. 2002). For laparoscopic surgery, positional changes and pneumoperitoneum treatment with carbon dioxide are used to develop the visual field of the target organ. In the Trendelenburg position with 10-degree

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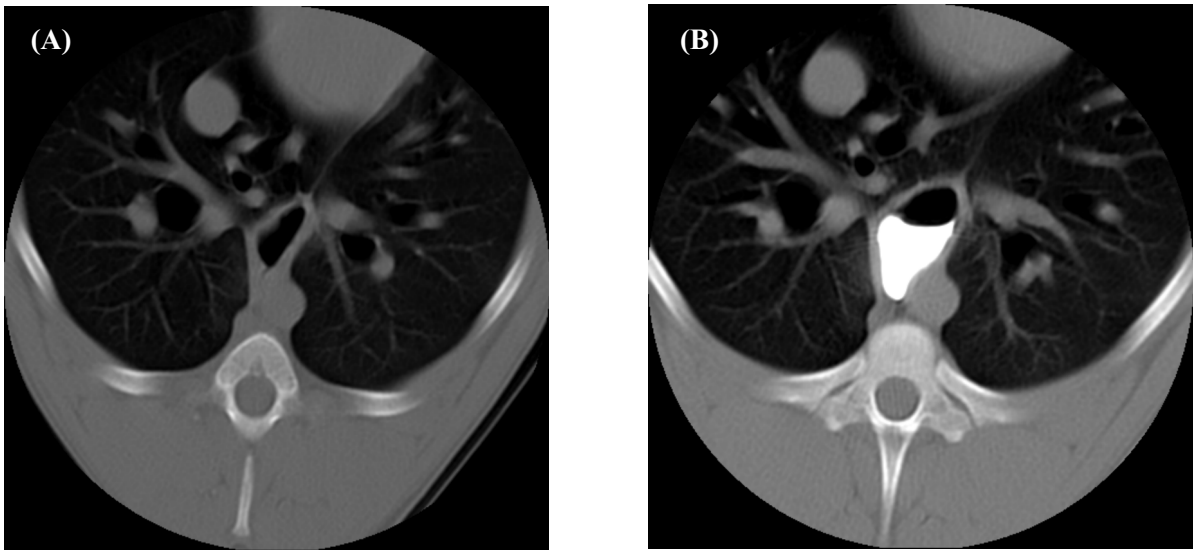

Fig. 1. Contrast study of the lower esophagus with CT imaging. (A) Gastro esophageal reflux is not detected. (B) Gastro esophageal reflux is confirmed by the contrast agent in the lower esphagus.

Table 1. The number of positive of gastro esophageal reflux (n=10).

	HP	TP	TP + PP
Positive/n	0/10	0/10	3/10*

HP: Horizontal psition, TP: Trendelenburg position, TP + PP: Trendelenburg position + pneumoperitoneum
* $p<0.05$

tilting, the visual field of the lower abdomen is maintained by shifting organs to the cranial end for procedures such as examination of colon and prostate. Under pneumoperitoneum condition, the intraperitoneal visual field is maintained by increasing the abdominal pressure with carbon dioxide. Few studies have examined the influence of these treatments on gastroesophageal reflux in anesthetized dogs (Waterman et al. 1995). In this experiment, we investigated the influence of the Trendelenburg position with 10-degree tilting and carbon dioxide pneumoperitoneum treatment with an intraperitoneal pressure of 10 mmHg on gastroesophageal reflux in dogs, assuming laparoscopic surgery in clinical practice.

Materials and Methods

As test animals, we used 10 clinically healthy adult Beagles weighing 8.5 to 17.0 kg and ages 2 to 3 years. Prior to this experiment, all animals were fasted for 12 hr. As preanesthetics, atropine sulfate at 0.025 mg/kg and butorphanol tartrate at 0.1 mg/kg were intravenously administered. Subsequently, anesthesia was induced by intravenously administering propofol at 6 mg/kg, and endotracheal intubation was performed. Subsequently, anesthesia was maintained by inhalation anesthesia with mixed gas consisting of oxygen and isoflurane (end tidal isoflurane concentration 2%, 1.5 minimum alveolar concentration). Respiratory control was performed using a ventilator so that the end-tidal carbon dioxide pressure was 40 to 45 mmHg. The regurgitation of the gastric contents was evaluated using CT based on the presence or absence of contrast medium infused into the stomach. Animal experimentation protocol was approved by President of Kitasato University based on the judgment by Institutional Animal Care and Use Committee of Kitasato University (Approval no. 09-018). Initially, the anesthetized dogs were placed in a left side position and a gastrointestinal endoscope was orally inserted into the stomach. An indwelling needle was percutaneously inserted into the intragastric space under direct vision. After suctioning air from the stomach as much as possible, the endoscope was removed and 10 mL of iodine contrast medium (300mg/ml) diluted two fold with physiological saline was administered into the stomach through the indwelling needle. Helical CT was performed under the following conditions: X-ray tube current, 150 mA; X-ray tube voltage, 120 kV; beam thickness, 3.0 mm; bed moving speed,

5.0 cm/second, and rearrangement index, 5.0. Imaging was conducted involving the 3rd intercostal space to cardia. When changing the position, the operating table was tilted, and each dog was placed in the Trendelenburg position, with a tilting angle of 10 degrees. For pneumoperitoneum induction, a needle for pneumoperitoneum was inserted into the abdominal cavity through the umbilical region and carbon dioxide was supplied at a speed of 1.0 L/min using a pneumoperitoneum device. The intraperitoneal pressure was set as 10 mmHg. For imaging, the dogs were horizontally placed in a supine position on a bed. Imaging was conducted at the following 3 time points: after the administration of contrast medium (horizontal position), 3 min after changing the position to the Trendelenburg position with 10-degree tilting (Trendelenburg position) and 3 min after the intraperitoneal pressure had reached 10 mmHg in pneumoperitoneum with carbon dioxide in the Trendelenburg position with 10-degree tilting (Trendelenburg position + pneumoperitoneum). Based on CT images under the respective conditions, dogs with the regurgitation of contrast medium in the lower esophagus were regarded as showing positive findings, and those without it as showing negative findings. (Fig. 1) For statistical analysis, the number of regurgitation episodes per session was compared using Cochran's Q test with respect to the posture and pneumoperitoneum operations. A p-value of 0.05 was regarded as significant.

Results and Discussion

In the horizontal position after the intragastric administration of contrast medium, there was no gastroesophageal reflux. When changing the position to the Trendelenburg position, there was no regurgitation to the lower esophagus. After induction of pneumoperitoneum in the Trendelenburg position, the significant regurgitation of contrast medium to the lower esophagus was confirmed in 3 of the 10 dogs ($p<0.05$), (Table 1).

Various factors may be involved in the development of gastroesophageal reflux. In particular, changing the posture is an etiological factor for gastroesophageal reflux in dogs. Pratschke et al. (2001) reported that the pressure difference between the stomach and esophagus in anesthetized Greyhounds in a prone position was less marked than in other positions, increasing the risk of gastroesophageal reflux and that gastric fixation increased the pressure difference. Anagnostou et al. (2017) indicated that the frequency of gastroesophageal reflux in a prone position in large dogs with a deep chest was higher than in small dogs under anesthesia. Little et al. (1989) reported that the incidences of lower esophageal sphincter relaxation in dogs in side and supine positions were lower than in standing position. This experiment was conducted in a supine position. Even when changing the posture to the Trendelenburg position with 10-degree tilting, there was no esophageal reflux of intragastric contrast medium. Neither the anesthetics used in this experiment nor a switch to the Trendelenburg position may induce gastroesophageal reflux. Our results support previous studies. An increase in the intragastric pressure is considered to be an etiological factor of gastroesophageal reflux (Cox et al. 1988). In this experiment, 10 mL of contrast medium was administered to each Beagle. At this dose, the intragastric pressure may not have been excessively increased based on the finding that the maximum volume of the dog stomach was approximately 90 mL/kg (Mathews 2007). On the other hand, pneumoperitoneum induction with carbon dioxide, in which the intraperitoneal pressure was established as 10 mmHg, induced esophageal reflux of contrast medium in 3 of the 10 dogs. An increase in the intraperitoneal pressure is considered to be an etiological factor for gastroesophageal reflux and it was reported that intraperitoneal surgery more frequently caused gastroesophageal reflux compared with extraperitoneal surgery (Galatos and Raptopoulos 1995, Vakil et al. 2006). In this experiment, neither the lower esophageal sphincter nor intragastric pressures were measured. However, a pneumoperitoneum-related increase in the abdominal pressure may have changed the pressure difference between the stomach and esophagus, contributing to reflux. A study involving humans reported that the Trendelenburg position with a tilting angle of 15 degrees did not influence the intragastric pressure (Heijke et al. 1991). A pneumoperitoneum-related increase in the intraperitoneal pressure may more markedly influence the pressure difference between the stomach and esophagus compared with postural tilting. The conditions of this experiment were selected, considering laparoscopic surgery for the lower abdomen in clinical practice. The results suggest that the Trendelenburg position with 10-degrere tilting and pneumoperitoneum induction with an intraperitoneal pressure of 10 mmHg induce gastroesophageal reflux; strategies to prevent and manage perioperative complications may be necessary.

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