ORIGINAL ARTICLE

# Evaluation of gastroesophageal reflux in pediatric laparoscopic appendectomy procedures

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## ABSTRACT

**BACKGROUND:** The increased intra-abdominal pressure during laparoscopic surgical procedures was reported to be a factor in the development of gastroesophageal reflux. This study evaluated the presence of gastroesophageal reflux and associated factors using 24-h pH monitoring in children undergoing laparoscopic appendectomy.

**METHODS:** Children who underwent laparoscopic surgery for presumed acute appendicitis between June 2017 and June 2018 were included in the study. After pre-operative endotracheal intubation, pH catheters were placed for 24-h esophageal pH monitoring. Relationships between gastroesophageal reflux and procedure time, pre-operative fasting time, age, weight, and body mass index (BMI) were evaluated.

**RESULTS:** A total of 60 pediatric patients were included in the study. Their mean (SD) age was 11.82 (3.71) years (range, 4–17 years). The mean (SD) body weight was 41.27 (16.72) kg (range, 15–90 kg) and the mean (SD) BMI were 17.96 (4.37). The mean pre-operative fasting time was 15.52 (12.1) h, while the mean operative time was 38.42 (17.96) min. Lower age and weight were significantly associated with the presence of post-operative gastroesophageal reflux ($p<0.05$). Mean procedure time, mean pre-operative fasting time, and BMI were not significantly associated with intra- or post-operative gastroesophageal reflux ($p>0.05$).

**CONCLUSION:** The lack of a significant relationship between mean procedure time and gastroesophageal reflux suggests that the mean duration of the laparoscopic procedures performed in this study is safe in terms of gastroesophageal reflux. The results also indicate that young age and low weight should be considered risk factors for gastroesophageal reflux in pediatric patients undergoing laparoscopic appendectomy.

**Keywords:** Gastroesophageal reflux; laparoscopy; pH monitoring.

## INTRODUCTION

Gastroesophageal reflux (GER) is the retrograde flow of gastric content into the esophagus due to dysfunction of the lower esophageal sphincter and is the most common gastroenterological disorder in childhood.[1] Risk factors for GER include medicines, neurodevelopmental disorders, motility disorders, obesity, abnormal angle of His, and conditions that cause increased intra-abdominal pressure.[1–3]

Laparoscopy is widely used in many intra-abdominal surgical procedures in children. In laparoscopy, increased intra-abdominal pressure caused by carbon dioxide ($CO_2$) insufflation, as well as factors such as patient position, nasogastric catheterization, and fasting time have been reported to affect the development of intraoperative GER.[4–6] Studies of adult patient groups have shown that GER can occur in 2–20% of laparoscopic surgeries.[7]

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In GER, the acidic stomach contents may cause irritation of the airways. In patients under general anesthesia, this effect can lead to life-threatening conditions such as laryngospasm and bronchospasm that result in hypoventilation and hypoxia and require emergency airway intervention.[8–10] In addition, children are more prone to hypoxia for reasons such as their narrow airways, low functional residual capacity, and high oxygen consumption.[9] Therefore, GER is thought to pose a serious risk in children receiving general anesthesia.

Detecting the presence of acid in the esophagus at a pathological level and duration with 24-h pH monitoring is still widely used for the diagnosis of GER.[11] However, there has not been enough research on GER during laparoscopic surgery in children, and there is a dearth of information regarding the outcomes of intraoperative GER.[12–14] Therefore, the aim of this study was to utilize 24-h intraesophageal pH monitoring to evaluate the presence of intraoperative and post-operative GER and associated factors in children undergoing laparoscopic appendectomy.

## MATERIALS AND METHODS

The study included children who underwent laparoscopic surgery for presumed acute appendicitis between June 2017 and June 2018. The study was conducted in accordance with the Declaration of Helsinki and approval was obtained from the Local Ethics Committee of the university, where the study was conducted (no: 2017/72). The children's legal guardians were informed in detail, and patients whose guardians voluntarily signed consent forms were included in the study. Patients without written informed consent forms and those previously treated for gastroesophageal reflux disease (GERD) were not included in the study. The strengthening the reporting of observational studies in epidemiology (STROBE) checklist for cross-sectional studies was implemented in the drafting of this article.

Patients undergoing surgery for presumed acute appendicitis were placed in the supine position. Anesthesia was induced with sodium thiopental (5 mg/kg) and rocuronium (0.6 g/kg). After confirming adequate anesthesia, the anesthesiologist performed intubation by direct laryngoscopy. A nasogastric catheter was placed for gastric decompression and a 24-h pH catheter was placed and fixed to the nasogastric catheter under laryngoscopic guidance. To standardize the placement of the pH catheter in all patients and eliminate the need to confirm the position radiologically, the upper pH sensor was positioned at the esophageal inlet. The other pH sensor was located 5 cm lower on the pH catheter. As a result, measurements were obtained from the upper half of the esophagus. Using this system, the presence of GER was evaluated in the intraoperative and post-operative period of the laparoscopic appendectomy procedures.

Esophageal pH was measured using a pH recorder (Orion II, MMS, Netherlands) and pH catheter (VersaFlex Z, Alpine Biomed, Fountain Valley, CA, USA) with two single-use probes spaced 5 cm apart was used to measure. Before each measurement, the pH meter device was calibrated by computer using standard calibration solutions (pH Buffer Solution, pH 7.01±0.05/pH 4.00±0.05, Reagecon, Ireland). Recording was initiated after intubation and placement of the pH catheter. As standard procedure, all patients were positioned for surgery in 10-degree Trendelenburg position, with the angle confirmed electronically using the protractor (Angle Measurement) application (Seong Eon Kim, EONSOFT). During laparoscopy, $CO_2$ gas was insufflated intraperitoneally at a flow rate of 3–5 L/min and pressure of 8–10 mmHg. The procedure was completed laparoscopically in all of the children.

Procedure time was defined as the time from initiating the recording to completing the surgery, removing the intra-abdominal $CO_2$, and reverting Trendelenburg position. Intraoperative measurements were recorded during this interval. For the first 24 h postoperatively, all patients in the study were monitored with a nasogastric catheter, free drainage, and fasting. At post-operative 24 h, the recording was terminated and the pH catheter was removed together with the nasogastric catheter. Post-operative measurements were recorded from the end of surgery until nasogastric catheter extraction at post-operative 24 h.

Readings from the pH meter probes placed at the esophageal inlet and 5 cm distal (in the mid-esophagus) were recorded as pH1A and pH2A in the intraoperative period and pH1B and pH2B in the postoperative period, respectively. The patients' pH meter records were analyzed and DeMeester scores (DMS) were determined for the intra- and post-operative period using the relevant pH measurements. DMS values above 14.78 were classified as GER and those below 14.78 as non-GER.[15]

The children's age, sex, height, weight, body mass index (BMI), fasting time, procedure time, and surgical findings were recorded. The patients were divided into four groups according to BMI value: Underweight (BMI < 18.5), normal (18.5 < BMI < 24.9), overweight (25 < BMI < 29.9), and obese (30 < BMI).[16] In addition, early and late clinical findings that may be associated with reflux such as bronchospasm and vomiting were recorded during the 24-h post-operative follow-up period.

Relationships between the presence of GER based on the patients' DMS values and their age, fasting time, procedure time, weight, BMI, and post-operative findings were evaluated using Chi-square, analysis of variance, and Tukey tests.

## RESULTS

The study included 60 children who underwent laparoscopic surgery for presumed acute appendicitis between June

2017 and June 2018. Their mean (SD) age was 11.82 (3.71) years (range, 4–17 years). Thirty-six (60%) of the patients were boys and 24 (40%) were girls. The mean (SD) weight and height were 41.27 (16.72) kg (range, 15–90 kg) and 150 (21.02) cm (range, 105–185 cm). The mean (SD) BMI was 17.96 (4.37), and 55% (n=33) of the patients were classified as underweight (BMI < 18.5), 35% (n=21) as normal weight (18.5 < BMI < 24.9), 6.6% (n=4) as overweight (25 < BMI < 29.9), and 3.3% (n=2) as obese (BMI > 30). The patients' mean (SD) pre-operative fasting time was 15.52 (12.1) h (range, 5–72 h) and procedure time was 38.42 (17.96) min (range, 12–90 min). When the surgical findings of the patients in the study were evaluated, it was determined that 48 (80%) of the patients had acute appendicitis and 6 (10%) had perforated acute appendicitis. No pathological findings were found in the other 6 patients (10%). In the first 24 h postoperatively, the patients were monitored for clinical findings that may be associated with reflux. One patient (1.6%) had signs of bronchospasm during post-operative awakening, while three patients (5%) vomited during the first 24 h of post-operative follow-up.

According to intraoperative DMS values, GER was detected at the esophageal inlet (pH1A) in 14 patients (23.3%) and in the mid-esophagus (pH2A) in 16 patients (26.6%). Post-operative DMS values indicated GER at the esophageal inlet (pH1B) in eight patients (13.3%) and in the mid-esophagus (pH2B) in 14 patients (23.3%). The intra-operative and post-operative DMS values of the patients are shown in Table 1. Due to the technical recording problems of the pH metering device, six patients were excluded from the study. Four patients were excluded from the study due to a history of GER disease.

**Table 1.** The distribution of patients with and without gastroesophageal reflux based on intraoperative and postoperative DeMeester score (DMS). DMS values above 14.78 were evaluated as gastroesophageal reflux

| | n | % |
|---|---|---|
| Intraoperative esophageal inlet DMS value (pH1A) | | |
| <14.78 | 46 | 76.7 |
| >14.78 | 14 | 23.3 |
| Intraoperative mid-esophagus DMS value (pH2A) | | |
| <14.78 | 44 | 73.3 |
| >14.78 | 16 | 26.7 |
| Postoperative esophageal inlet DMS value (pH1B) | | |
| <14.78 | 52 | 86.7 |
| >14.78 | 8 | 13.3 |
| Postoperative mid-esophagus DMS value (pH2B) | | |
| <14.78 | 46 | 76.7 |
| >14.78 | 14 | 23.3 |

DMS: DeMeester Scores.

There were no significant differences in mean procedure time or pre-operative fasting time according to intraoperative (pH1A and pH2A) and post-operative (pH1B and pH2B) DMS values (p>0.05). In addition, there were no significant differences in mean age or weight according to intraoperative DMS (pH1A and pH2A) and post-operative esophageal inlet DMS (pH1B) (p>0.05). However, patients with post-operative GER in the mid-esophagus (pH2B) had a significantly lower mean age (p=0.001) and mean weight (p=0.023). The distribution of pH1A, pH2A, pH1B, and pH2B DMS values did not differ significantly among the BMI groups, and mean BMI did not differ significantly according to the presence of GER (p>0.05). Comparisons of patient age, weight, BMI, pre-operative fasting time, and procedure time between patients with and without GER according to intra- and post-operative DMS values are shown in Table 2.

The distribution of intra- and post-operative DMS values was evaluated according to the presence of signs of bronchospasm and vomiting in the first 24 h postoperatively. A significantly higher proportion of patients with post-operative findings suggestive of GER had intraoperative DMS values indicating GER (pH1A: p=0.011, pH2A: p=0.024; Table 3). Post-operative DMS values (pH1B and pH2B) showed no significant difference based on the presence of possibly GER-related findings (p>0.05). The relationship between surgical findings (acute appendicitis, perforated appendicitis, and non-pathological findings) and GER was examined. No significant correlation was found between surgical findings and GER (p>0.05).

## DISCUSSION

In this study, 24-h esophageal pH monitoring did not reveal a significant relationship between GER and laparoscopic procedure time (p>0.05). This result suggests that the duration of laparoscopic surgery in the study, which was 38.42 min (SD 17.96, range 12–90 min), was safe in terms of GER. Although there was no statistically significant association between GER and BMI, we found that patients with GER had significantly lower mean weight and age. This finding suggests that young age and low weight may be factors to consider when evaluating the risk of GER in laparoscopic surgical procedures in children.

Post-operative pH meter records revealed a significant relationship between pH2B measurements and lower age and body weight. In this study, the position of the pH1 probe was standardized as the esophageal inlet. However, considering age-related differences esophageal length, the position of the pH2 probe, located 5 cm distal to the pH1 probe, was not fixed. Regarding 24-h esophageal pH meter measurements, May et al.[17] reported that the length of the esophagus was ranged from 19 to 39 cm in their study on children aged 5.7 years (range, 4–13 years). Considering the mean (SD) age of the patients in the present study was 11.82 (3.71) years

**Table 2.** Comparison of the patients' mean age, weight, body mass index (BMI), preoperative fasting time, and procedure time according to intraoperative (pH1A, pH2A) and postoperative (pH1B, pH2B) DeMeester scores (DMS). DMS values above 14.78 were evaluated as gastroesophageal reflux

| | Intraoperative esophageal inlet DMS (pH1A) | | | | p |
|---|---|---|---|---|---|
| | <14.78 (n=46) | | >14.78 (n=14) | | |
| | Mean±SD | Min–Max | Mean±SD | Min–Max | |
| Age (years) | 11.61±3.89 | 4–17 | 12.5±3.11 | 7–17 | 0.436 |
| Weight (kg) | 39.37±15.48 | 15–73 | 47.5±19.67 | 25–90 | 0.112 |
| BMI (kg/m²) | 17.44±3.97 | 10.71–27.04 | 19.66±5.31 | 12.57–31.64 | 0.098 |
| Fasting time (h) | 16.46±13.35 | 5–72 | 12.43±5.93 | 6–24 | 0.279 |
| Procedure time (min) | 61.80±17.27 | 30–95 | 58.8±25.1 | 25–120 | 0.610 |
| | Intraoperative mid–esophagus DMS value (pH2A) | | | | p |
| | <14.78 (n=44) | | >14.78 (n=16) | | |
| | Mean±SD | Min–Max | Mean±SD | Min–Max | |
| Age (years) | 11.84±3.91 | 4–17 | 11.75±3.24 | 6–17 | 0.934 |
| Weight (kg) | 40.34±15.29 | 15–73 | 43.81±20.51 | 20–90 | 0.482 |
| BMI (kg/m²) | 17.80±3.91 | 10.71–27.04 | 18.40±5.58 | 10.94–31.64 | 0.639 |
| Fasting time (h) | 16.43±13.57 | 5–72 | 13.00±6.29 | 6–30 | 0.336 |
| Procedure time (min) | 60.52±18.06 | 30–95 | 62.70±22.57 | 25–120 | 0.703 |
| | Postoperative esophageal inlet DMS value (pH1B) | | | | p |
| | <14.78 (n=52) | | >14.78 (n=8) | | |
| | Mean±SD | Min–Max | Mean±SD | Min–Max | |
| Age (years) | 11.62±3.74 | 4–17 | 13.13±3.44 | 7–17 | 0.288 |
| Weight (kg) | 40.13±17.20 | 15–90 | 48.63±11.49 | 25–60 | 0.184 |
| BMI (kg/m²) | 17.65±4.57 | 10.71–31.64 | 19.98±1.91 | 16.85–22.67 | 0.162 |
| Fasting time (h) | 14.44±10.06 | 5–72 | 22.50±20.83 | 8–72 | 0.316 |
| Procedure time (min) | 60.66±16.68 | 30–95 | 64.0±32.64 | 25–120 | 0.784 |
| | Postoperative mid–esophagus DMS value (pH2B) | | | | p |
| | <14.78 (n=46) | | >14.78 (n=14) | | |
| | Mean±SD | Min–Max | Mean±SD | Min–Max | |
| Age (years) | 12.65±3.46 | 5–17 | 9.07±3.25 | 4–15 | 0.001* |
| Weight (kg) | 44.0±16.57 | 15–90 | 32.43±14.51 | 17–60 | 0.023* |
| BMI (kg/m²) | 18.33±4.54 | 10.71–31.64 | 16.75±3.67 | 10.94–22.67 | 0.240 |
| Fasting time (h) | 15.24±10.57 | 5–72 | 16.43±16.67 | 6–72 | 0.751 |
| Procedure time (min) | 59.9±17.31 | 30–95 | 65.14±24.67 | 25–120 | 0.372 |

*Statistically significant (p<0.05). BMI: Body mass index; SD: Standard deviation.

(range, 4–17 years), it is clear that although the pH2 probe did not have a fixed position, measurements were obtained from the upper half of the esophagus in all patients. This issue must be borne in mind when evaluating the results of the study.

Miyazawa et al.[18] reported that GER is a normal phenomenon during daily activity and is more common at younger ages, especially in infants. Although GER has been associated with increased weight and especially obesity in adults, there have been few pH monitoring studies evaluating the relation-

**Table 3.** The distribution of patients according to presence of findings that may be associated with postoperative GER (bronchospasm, vomiting) and intraoperative pH1A and pH2A DMS values

| pH1A | | Finding that may be associated with postoperative reflux | | p |
|---|---|---|---|---|
| | | No | Yes | |
| <14.78 | n (%) | 45 (80.4) | 1 (25) | 0.011 |
| >14.78* | n (%) | 11 (19.6) | 3 (75) | |
| **pH2A** | | **Finding that may be associated with postoperative reflux** | | **p** |
| | | **No** | **Yes** | |
| <14.78 | n (%) | 43 (76.8) | 1 (25) | 0.024 |
| >14.78* | n (%) | 13 (23.2) | 3 (75) | |

*Statistically significant (p<0.05).

ship between obesity and GER in children.[1,19] In our study evaluating GER in the upper half of the esophagus, no statistically significant association was found between the BMI and the presence of GER. Malaty et al.[20] reported that obesity is a risk factor in GERD, which is caused by GER at pathological level and duration. However, Rosen et al.[19] emphasized that the association between GER and low body weight was due to functional immaturity of the gastroesophageal junction, especially during infancy. Taken together, these results suggest that in addition to obesity, young age and low weight are other issues that should be considered in terms of GER during laparoscopic surgery.

Considering the risk of GER and subsequent aspiration in pediatric patients under general anesthesia, pre-operative fasting periods for solid food ranging from 5 to 6 h to 15 h have been reported.[21,22] In the present study, there was no significant relationship between pre-operative fasting time and detection of GER in intraoperative and post-operative pH monitoring. This seems to contradict the view that a longer fasting period before the procedure will reduce GER and potential associated emergency airway complications.

Before a surgical procedure, factors influencing anesthesiologists' preference of laryngeal mask or endotracheal intubation for emergency airway management include obesity, history of GER, whether the surgery is to treat GER, and whether the estimated procedure time is more than 30 min.[6] Bahadır et al.[23] reported laparoscopic procedure duration as a contributing factor to GER in their animal study. However, we observed no significant relationship between procedure time and GER in the present study. In the light of these findings, our laparoscopic procedure time of 38.42 (SD 17.96) min seems to be within safe limits in terms of the risk of GER.

Doyle et al.[7] reported that 40–53% of patients had GER during laparoscopic surgery. In the present study, this rate was determined to be 26.6% (16 patients) based on intraoperative pH monitoring. Doyle et al.[7] also reported the incidence of aspiration rate during laparoscopic surgery as 0.16–0.64%. In the case series presented here, one patient (0.6%) exhibited bronchospasm that may have been associated with GER within the first 24 h postoperatively. When the distribution of symptoms of vomiting and bronchospasm was examined according to DMS values determined by pH monitoring, significant overlap between these symptoms and GER was observed in the intraoperative but not the post-operative period. This finding suggests that patients should be monitored for GER that may be triggered during laparoscopic surgical procedures and possible post-operative GER-related clinical findings, especially considering risk factors such as age, weight, and procedure time.

Regarding the limitations of this study, we controlled for factors that can trigger GER, such as patient position, nasogastric catheter use, and intra-abdominal pressure values and the results were obtained under these conditions. However, this design precludes analysis of the effects of modifying these factors. Due to the standardized placement of the pH catheter used in the study, measurements were obtained from the upper half of the esophagus. Therefore, the presence of GER in the distal esophagus and its clinical effects could not be evaluated. In addition, the calculated means of BMI were in normal range in the compared groups of DMS values. Furthermore, new prospective studies including large number of patients for different age groups and different levels of peritoneal inflammation are needed to understand the relationship between laparoscopy and GER.

## Conclusion

Mean procedure time of laparoscopic appendectomy in this study was not significantly associated with GER in children, indicating that this procedure is safe in terms of the risk of causing GER. However, young age and low weight should be included among the risk factors for GER in pediatric laparoscopic surgical procedures.

**Ethics Committee Approval:** This study was approved by the Mersin University Clinical Research Ethics Committee (Date: 11.02.2016, Decision No: 2016/44).

**Peer-review:** Internally peer-reviewed.

**Authorship Contributions:** Concept: G.B.B., C.İ., A.S.; Design: G.B.B., C.İ., A.S.; Supervision: H.B., A.N.; Resource: G.B.B., C.İ., A.S., H.T.; Materials: G.B.B., C.İ., A.S., H.T.; Data: G.B.B., C.İ., H.T., A.S., A.N.; Analysis: G.B.B., C.İ., H.T.; Literature search: G.B.B., C.İ.; Writing: G.B.B., C.İ., H.T., A.S.; Critical revision: H.B., A.N.

**Conflict of Interest:** None declared.

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**ORİJİNAL ÇALIŞMA - *ÖZ***

## Çocuk hastalarda laparoskopik apendektomide gastroözofageal reflünün değerlendirilmesi


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AMAÇ: Laparoskopik cerrahi işlemler sırasında artan karın içi basıncının gastroözofageal reflü gelişiminde bir faktör olduğu bildirilmiştir. Bu çalışma, laparoskopik apendektomi geçiren çocuklarda gastroözofageal reflü varlığını ve ilişkili faktörleri 24 saatlik pH monitörizasyonu kullanarak değerlendirilmesi amaçlandı.

GEREÇ VE YÖNTEM: Haziran 2017–Haziran 2018 tarihleri arasında akut apandisit düşünülerek laparoskopik cerrahi uygulanan çocuklar çalışmaya dahil edildi. Ameliyat öncesi endotrakeal entübasyondan sonra, 24 saatlik pH monitörizasyonu için kateter yerleştirildi. Gastroözofageal reflü ile işlem süresi, ameliyat öncesi açlık süresi, yaş, kilo ve vücut kitle indeksi arasındaki ilişkiler değerlendirildi.

BULGULAR: Toplam 60 çocuk hasta çalışmaya alındı. Ortalama (SD) yaşları 11.82 (3.71) yıl (4–17 yaş arası) idi. Ortalama (SD) vücut ağırlığı 41.27 (16.72) kg (aralık, 15–90 kg) ve ortalama (SD) vücut kitle indeksi 17.96 (4.37) idi. Ameliyat öncesi ortalama açlık süresi 15.52 (12.1) saat, ortalama ameliyat süresi 38.42 (17.96) dakika idi. Daha düşük yaş ve ağırlık, ameliyat sonrası gastroözofageal reflü varlığı ile anlamlı olarak ilişkiliydi ($p<0.05$). Ortalama işlem süresi, ameliyat öncesi ortalama açlık süresi ve vücut kitle indeksi, intra veya ameliyat sonrası gastroözofageal reflü ile anlamlı olarak ilişki saptanmadı ($p>0.05$).

TARTIŞMA: Ortalama işlem süresi ile gastroözofageal reflü arasında anlamlı bir ilişkinin olmaması, bu çalışmada yapılan laparoskopik işlemlerin ortalama süresinin gastroözofageal reflü açısından güvenli olduğunu düşündürmektedir. Sonuçlar ayrıca laparoskopik apendektomi yapılan çocuk hastalarda genç yaş ve düşük kilonun gastroözofageal reflü için risk faktörleri olarak düşünülmesi gerektiğini göstermektedir.



Anahtar sözcükler: Gastroözofageal reflü; laparoskopi; pH monitorizasyonu.

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