Medium-term efficacy of laparoscopic Dor fundoplication combined with the reconstruction of angle of His in the treatment of gastroesophageal reflux disease

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Abstract

Background Gastroesophageal reflux disease (GERD)is currently one of the most common digestive tract diseases. There is no report on laparoscopic fundoplication combined with reconstruction of angle of His (RAH) in the treatment of GERD. Thus, this study aimed to investigate the medium-term efficacy of laparoscopic Dor fundoplication combined with RAH for GERD patients.
Methods Clinical data of GERD patients who underwent Dor fundoplication combined with RAH (Dor+RAH group, 116 cases) or Dor fundoplication (Dor group, 107 cases) in Department of General Surgery, Xuanwu Hospital, Capital Medical University from January 2019 to June 2022 were retrospectively analyzed. Esophageal and extraesophageal symptom scores, functional complications, and patient satisfaction were compared between the two groups after two years postoperatively.
Results There was no significant difference in esophageal and extraesophageal symptom scores between the two groups before surgery (all $P>0.05$). At 2 years postoperatively, esophageal and extraesophageal symptom scores of both two groups decreased significantly compared with those preoperatively (all $P<0.01$). In the 2-year postoperative symptom scores, the scores for regurgitation and heartburn in the Dor+RAH group were lower than those in the Dor group, with statistically significant differences ($P<0.01$, $P=0.006$), while there were no significant differences in other symptom scores between the two groups (all $P>0.05$). The incidences of postoperative functional complications (including dysphagia, abdominal distension, difficulty to belch, increased flatus, and chronic abdominal pain) were similar in both groups, and all were significantly relieved by conservative treatment. The patient satisfaction rate with surgical treatment was 92.2% (107/116) in the Dor+RAH group, showing no significant difference from 90.7% (97/107) in the Dor group ($P=0.671$).
Conclusions: Both Dor fundoplication combined with RAH and pure Dor fundoplication demonstrate good anti-reflux effects in treating GERD, with few surgical complications and high patient satisfaction. Compared with Dor fundoplication, Dor fundoplication with RAH has a better effect in controlling regurgitation and heartburn symptoms, indicating it may have a better therapeutic effect for GERD patients.

Background

Gastro-esophageal reflux disease (GERD) refers to the reflux of gastric and duodenal contents into the esophagus, throat, mouth, respiratory tract and other sites, causing a series of uncomfortable symptoms, signs and complications[1–5]. It is currently one of the most common digestive tract diseases[6, 7]. As a global disease, GERD is characterized by high incidence rate and high misdiagnosis and mistreatment rate. The course of the disease can last for months to decades, seriously affecting patients' life and work, and has become a major public health problem [[8–10]].

In recent decades, laparoscopic antireflux surgery has received increasing attentions. The first laparoscopic Nissen fundoplication was performed and reported by GEAGEa in 1991[11]. Since then, this surgical procedure has gradually become popular in European and American countries and has become the "gold standard" for the treatment of GERD[12, 13]. When the surgical indications are strictly

controlled and appropriate cases are selected, laparoscopic Nissen fundoplication can achieve definite and good antireflux effects. However, the surgery itself may cause some complications related to digestive tract functions, such as dysphagia, abdominal distension, difficulty to belch, etc. On the premise of not reducing the surgical efficacy, in order to reduce the occurrence of postoperative complications, domestic and foreign scholars have continuously tried new antireflux surgical procedures[14]: (1) modifying the Nissen procedures, such as the Nissen-Rossetti procedure that preserves the short gastric vessels; (2) reducing the circumferential wrapping of the esophagus, that is, partial fundoplication[15, 16], such as the posterior Toupet (270°), the anterior Dor (180°) and 90° fundoplication. Studies have shown that compared with the Nissen procedure, laparoscopic Dor fundoplication can achieve similar antireflux effects, while reducing postoperative complications such as dysphagia and abdominal distension[17, 18].

Angle of His is the angle between the lower esophagus and the gastric fundus, which is involved in the formation of the gastroesophageal valve and is one of the important antireflux structures. When hiatal hernia (HH) occurs, the structure the angle of His will be damaged, leading to the reduction or disappearance of its antireflux function. Therefore, theoretically, reconstructing the angle of His, meaning restoring the function of the gastroesophageal valve, can play a role in anti-reflux and improving the symptoms and complications of GERD. At present, there is no report on laparoscopic Dor fundoplication combined with reconstruction of angle of His (RAH) in the treatment of GERD in the international literatures. Since January 2019, Department of General Surgery, Xuanwu Hospital, Capital Medical University has explored this surgical procedure, followed up the patients, analyzed the data, and now reports the medium-term follow-up results as follows.

Methods

Subjects

A retrospective analysis was performed on GERD patients who were hospitalized in the General Surgery Department of Xuanwu Hospital of Capital Medical University from January 2019 to June 2022 and received laparoscopic anterior Dor fundoplication combined with RAH (Dor + RAH group, 116 cases) or pure Dor fundoplication (Dor group, 107 cases). All patients underwent pre-operative examinations, such as symptom scoring, upper gastrointestinal endoscopy, high-resolution esophageal manometry (HRM), 24-hour multichannel intraluminal impedance pH (24-h MII-pH) monitoring, and upper gastrointestinal barium meal radiography. This study was approved by the hospital ethics committee, and all patients were informed and signed informed consent forms.

Inclusion criteria: □ Age ≥ 18 years; □ GERD-related symptoms for ≥ 6 months, such as regurgitation, heartburn (burning sensation behind the sternum), non-cardiac chest pain, subxiphoid distension and fullness, cough, wheezing, and pharyngeal foreign body sensation, etc.; □ GERD was diagnosed by preoperative objective examinations; □ Achalasia and nutcracker syndrome were excluded by HRM; □ The informed consent form was provided by all patients. Exclusion criteria: □ History of surgery in the

esophagus, stomach and other parts; □ patients with esophageal and gastrointestinal malignant tumors; □ those complicated with severe central nervous system diseases, fibromyalgia, severe coagulation disorders and other diseases; □ those who could not tolerate surgery due to severe cardiovascular and cerebrovascular diseases, etc.; □ those who refused to participate in the study.

Preoperative Examinations

Positive diagnostic criteria for esophageal 24-h MII-pH monitoring (Sandhill Scientific, Highlands Ranch, CO, USA) [19]: DeMeester scores ≥ 14.72, or acid exposure time (AET) ≥ 4.2%, or percent bolus exposure time (BET) ≥ 1.4%, or total number of reflux episodes ≥ 73.

HRM examination: The resting pressure of the lower esophageal sphincter (LES) < 13 mmHg was defined as reduced LES pressure (normal reference value: 13–43 mmHg). HH was diagnosed when the LES pressure zone was separated from the diaphragmatic pressure zone.

Upper gastrointestinal endoscopy: Reflux esophagitis was classified into LA-A□LA-B□LA-C and LA-D according to the Los Angeles (LA) classification criteria. Endoscopic diagnostic criteria for HH: With the patient in the left lateral decubitus position during quiet breathing (avoiding nausea or vomiting), the gastroesophageal junction (Z-line or dentate line) was clearly observed. The distance from the Z-line to the incisors and the distance from the diaphragmatic indentation to the incisors were measured, and the difference between the two distances was calculated. A distance difference ≥ 2.0 cm was defined as HH.

The diagnostic criteria for GERD: Positive diagnosis was made with 24-h MII-pH monitoring indicated GERD, or reflux esophagitis was found with gastroscopy.

The diagnostic criteria for HH: The diagnosis of HH could be made if HH was found in either HRM or gastroscopy.

Surgical procedure

All surgeries were performed by the same surgical team. The patient was placed in a supine position with a head-high and foot-low (Split-leg) position at an angle of 30° to 45°. The chief surgeon stood between the patient's legs, the first assistant was on the patient's left side, and the endoscope holder was on the patient's right side. After successful tracheal intubation anesthesia, a conventional five-port method was used to establish observation and operation ports. Once the light source entered the abdominal cavity, the size and type of HH could be roughly observed. The hepatogastric ligament and lesser omentum were transected with a ultrasonic scalpel, the hernia sac was dissected, the esophageal was fully mobilized, the hernia contents were reduced, and the length of the abdominal segment of the esophagus was ensured to be ≥3 cm without tension. Care was taken to protect the anterior and posterior branches of the vagus nerve. The right and left of diaphragmatic crura were sutured together with 2 − 0 non-absorbable sutures to narrow the hiatus to an appropriate degree without compressing

the esophagus. If the anteroposterior diameter of the hiatus was ≥ 5 cm or the diaphragmatic cruras were obviously weak, a patch (Covidien, 8 cm×8 cm) was placed at the diaphragmatic crura and fixed with an absorbable stapler.

Anterior Dor Fundoplication with the reconstruction of angle of His: Gastric fundus was mobilized fully and the short gastric vessels could be transected if necessary. The fundus was pulled from the anterior side of the esophagus to the right side of the esophagus, and abdominal segment of the esophagus was wrapped with the fundus with the degree of 180–200. The folded fundus was sutured and fixed to the esophagus and diaphragm with 3 − 0 non-absorbable sutures for 3–4 stitches, and the Dor fundoplication was created. On the left side of the esophagus, the folded fundus was sutured and fixed to the diaphragm with 3 − 0 non-absorbable sutures, avoiding the inferior phrenic vessels, to complete the reconstruction of angle of His, as shown in Fig. 1.

Observation indicators

Symptom scoring: Patients were surveyed using a self-developed questionnaire-based grading symptom scoring system before surgery and 2 years after surgery. Attack frequency score (0–5 points): 0 points: asymptomatic; 1 point : attack frequency < 1 day/week; 2 points : attacks 1–2 days/week; 3 points : 3–4 days/week; 4 points: 5–6 days/week; 5 points: ≥6 days/week. Symptom severity score (0–5 points): 0 points: asymptomatic; 1 point: mild symptoms; 2 points: mild discomfort, not affecting daily life or work; 3 points: moderate, affecting daily life and work; 4 points: severe discomfort, causing partial inability to care for oneself; 5 points: extremely severe, life-threatening, causing loss of self-care ability, with a history of one or more rescues. The score of each symptom was the sum of the symptom severity score and the frequency score. Esophageal symptoms included regurgitation, heartburn, non-cardiac chest pain, and a feeling of subxiphoid distension and fullness. Extraesophageal symptoms included cough, wheezing, and pharyngeal foreign body sensation. Postoperative functional complications: dysphagia, abdominal distension, difficulty to belch, increased flatus, chronic abdominal pain, as well as postoperative recurrence and reoperation. The severity of postoperative dysphagia was classified into none, mild, moderate and severe. None dysphagia: no choking sensation when eating solid foods, no need for water; mild dysphagia: obvious choking sensation when eating solid foods, requiring water to relieve symptoms; moderate dysphagia: only able to eat liquid or soft foods, unable to eat solid foods; severe dysphagia: unable to drink water and other liquid food. Satisfaction survey: At 2 years postoperatively, outpatient or telephone follow-up was conducted to assess patients' overall satisfaction with surgical efficacy, classified as satisfied, neutral, or dissatisfied.

Statistical analysis

The SPSS 26.0 statistical software package (IBM, Armonk, NY) was used for data processing. Continuous data were summarized as Mean ± SD if normally distributed and as median (interquartile rang, IQR) otherwise, and categorical variables were summarized as counts and frequencies. For measurement data that follow a normal distribution, an independent two-sample t-test was used for

comparisons between groups. For paired non-normally distributed measurement data, the Wilcoxon signed-rank test was used for comparisons. For two independent samples of non-normally distributed measurement data, the Mann-Whitney U test was used for comparisons. Chi-squared test was used for categorical parameter. All tests of significance were 2-sides, with $P < 0.05$ considered statistically significant.

Results

Patient characteristic

A total of 223 patients were included in the analysis, among whom 116 were in the Dor + RAH group (52 male and 64 female; mean age, 53.98±11.68 years) and 107 were in the Dor group (46 male and 61 female; mean age, 54.87±11.98 years). There were not significant differences in the ages, body mass index, sex distribution of subjects, distribution of reflux esophagitis, parameters of 24-h MII-pH monitoring and HRM, and implantation rate of patches among two groups ($P >0.05$ for all) (Table 1).

Table 1
Comparison of baseline data between two groups of patients

Clinical Variables	Dor + RAH group (*N* = 116)	Dor group (*N* = 107)	Z/χ^2	*P*
Gender, (M/F), n (%)	52/64	46/61	0.216	0.782
Age (yr), mean±SD	53.98±11.68	54.87±11.98	0.431	0.811
BMI (kg/m^2), mean±SD	24.4±3.6	26.1±4.2	0.521	0.53
Reflux esophagitis, n(%)	83(71.5)	76(71.0)	0.158	0.782
24-h MII-pH monitoring				
Demeester score, median (IQR)	25.4 (14.6, 43.1)	23.4 (14.6, 41.1)	2.332	0.153
AET (%), median (IQR)	9.3 (4.2, 12.6)	8.1 (4.1, 11.1)	2.098	0.423
BET (%), median (IQR)	2.3 (0.8, 41.8)	2.2 (0.6, 3.3)	-2.413	0.156
Number of all reflux episodes, median (IQR)	70 (52, 79)	76 (56, 86)	-3.180	0.207
HRM				
Resting LES pressure (mmHg), median (IQR)	8.1 (3.6, 13.2)	8.8 (4.1, 12.2)	-4.045	0.185
Resting UES pressure (mmHg), median (IQR)	56.1 (32.1, 83.2)	58.8 (39.8, 80.3)	-2.371	0.595
Application of Mesh (%)	81(69.8)	72(67.3)	0.166	0.683

Abbreviations: M/F male/female, *BMI* body mass index, *SD* standard deviation, *24-h MII-pH* 24-hour multichannel intraluminal impedance pH, *IQR* interquartile rang, *AET* acid exposure time, *BET* bolus exposure time, *HRM* high resolution manometry, *LES* lower esophageal sphincter, *UES* upper esophageal sphincter, *Dor + RAH* Dor fundoplication combined with reconstruction of angle of His.

Comparison of reflux symptom scores

There was no significant difference in the preoperative esophageal symptoms (regurgitation, heartburn, chest pain, and subxiphoid distension and fullness) and extraesophageal symptoms (cough, wheezing, and pharyngeal foreign body sensation) between the two groups (all $P > 0.05$), as shown in Table 2. At 2 years postoperatively, the scores of esophageal symptoms and extraesophageal symptoms in both groups were significantly lower than those before surgery (all $P < 0.05$), as shown in Table 3. The scores of postoperative regurgitation and heartburn symptoms in the Dor + RAH group were lower than those in the Dor group, with significant differences (Z=-3.735, $P < 0.001$; Z=-2.736, $P = 0.006$). However, there was no significant difference in the scores of other symptoms (chest pain, subxiphoid distension and

fullness, cough, wheezing, and pharyngeal foreign body sensation) between the two groups (all $P > 0.05$), as shown in Table 4.

Table 2
Comparison of preoperative GERD symptom scores between two groups

Symptom scores, median (IQR)	**Dor + RAH (*N* = 116)**	**Dor group (*N* = 107)**	***Z*** ***Z***	***P*** ***P***
Esophageal symptoms				
Regurgitation	7(6, 8)	7(6, 7)	-1.255	0.209
Heart burn	7(6, 8)	7(6, 8)	-1.753	0.08
Chest pain	4(0, 6)	3(0, 5)	-0.567	0.571
Subxiphoid distension and fullness	3.5(0, 6)	2(0, 5)	-0.256	0.798
Extraesophageal symptoms				
Cough	2(0, 5)	0(0, 5)	-0.997	0.319
Wheezing	4(0, 5)	0(0, 5)	-1.776	0.076
Pharyngeal foreign body sensation	4(0, 5)	3(0, 5)	-1.124	0.261

Abbreviations: GERD gastro-esophageal reflux disease, *IQR* interquartile rang, *Dor + RAH* Dor fundoplication combined with reconstruction of angle of His.

Table 3
Symptom scores of patients in both groups before and after antireflux surgery

Symptom scores, median (IQR)	Before surgery	After surgery	*Z*	*P*
Dor + RAH group				
Esophageal symptoms				
Regurgitation	7(6, 8)	0.5(0, 1)	-13.298	<0.001
Heart burn	7(6, 8)	1(0, 2)	-13.029	<0.001
Chest pain	4(0, 6)	0(0, 2)	-5.276	<0.001
Subxiphoid distension and fullness	3.5(0, 6)	0(0, 1)	-5.851	<0.001
Extraesophageal symptoms				
Cough	2(0, 5)	0(0, 1.75)	-4.814	<0.001
Wheezing	4(0, 5)	0(0, 2)	-4.820	<0.001
Pharyngeal foreign body sensation	4(0, 5)	0(0, 2)	-5.970	<0.001
Dor group				
Esophageal symptoms				
Regurgitation	7(6, 8)	2(0, 2)	-11.794	<0.001
Heart burn	7(6, 8)	1(0, 2)	-5.811	<0.001
Chest pain	3(0, 5)	0(0, 2)	-4.734	<0.001
Subxiphoid distension and fullness	2(0, 5)	0(0, 2)	-4.104	<0.001
Extraesophageal symptoms				
Cough	0(0, 5)	0(0, 1)	-3.604	<0.001
Wheezing	0(0, 5)	0(0, 1)	-3.974	<0.001
Pharyngeal foreign body sensation	3(0, 5)	0(0, 2)	-3.298	<0.001

Abbreviations:IQR interquartile rang, *Dor + RAH* Dor fundoplication combined with reconstruction of angle of His.

Table 4
Comparison of postoperative GERD symptom scores between two groups

Symptom scores, median (IQR)	Dor + RAH group (*N* = 116)	Dor group (*N* = 107)	*Z*	*P*
Esophageal symptoms				
Regurgitation	0.5(0, 1)	1(0, 2)	-3.735	<0.001
Heart burn	1(0, 2)	2(0, 2)	-2.736	0.006
Chest pain	0(0, 2)	0(0, 2)	-0.88	0.379
Subxiphoid distension and fullness	0(0, 1)	0(0, 2)	-0.592	0.554
Extraesophageal symptoms				
Cough	0(0, 1.75)	0(0, 1)	-0.927	0.354
Wheezing	0(0, 2)	0(0, 1)	-1.77	0.077
Pharyngeal foreign body sensation	0(0, 2)	0(0, 2)	-0.02	0.984

Abbreviations: GERD gastro-esophageal reflux disease, *IQR* interquartile rang, *Dor + RAH* Dor fundoplication combined with reconstruction of angle of His.

Comparison of the occurrence of functional complications

Within 2 weeks after surgery, 93.3% of patients experienced dysphagia. The incidence was 92.2% (107/116) in the Dor + RAH group and 94.3% (101/107) in the Dor group, with no significant difference between the two groups (χ^2=0.411, *P* = 0.522). With dietary guidance, all patients showed significant improvement in dysphagia symptoms, and all patients were able to transition to a semi-liquid diet at 2 months postoperatively. At 2 years postoperatively, no moderate dysphagia was observed in either group, and all patients could eat soft food smoothly. None of the patients required endoscopic esophageal dilation or secondary surgery.

At 1 month postoperatively, the incidence rates of abdominal distension, difficulty to belch, increased flatus, and chronic abdominal pain were 11.2%, 10.2%, 6.2%, and 2.1%, respectively. With dietary guidance, lifestyle modifications, and medication, all of the above symptoms were significantly alleviated in patients at 2 years postoperatively.

Comparison of of satisfaction

At 2 years postoperatively, 106 patients in the Dor + RAH group were satisfied with the overall surgical efficacy, 7 had neutral opinions, and 3 were dissatisfied. In the Dor group, 96 patients were satisfied, 7 had neutral opinions, and 4 were dissatisfied. The satisfaction rate with surgical treatment was 91.4%

(106/116) in the Dor + RAH group and 89.7% (96/107) in the Dor group, with no significant difference between the two groups (χ^2 =0.18, *P* = 0.672).

Comparison of perioperative mortality, severe complications, and reoperation rates

All patients had no conversion to laparotomy, and no severe complications such as massive hemorrhage, gastrointestinal perforation, hepatic or splenic rupture, or death occurred. All patients successfully weaned from the ventilator, had their tracheal intubation removed, and were safely transferred back to the general ward after surgery. At 2 years postoperatively, all patients had no symptomatic or anatomical recurrence, and no reoperation was performed.

Discussion

Since the clinical application of laparoscopic fundoplication in 1991, numerous studies have confirmed its effectiveness, safety, and long-term efficacy in treating GERD[20, 21]. The ultimate goal of modifying and evolving anti-reflux surgical procedures is to reduce the occurrence of postoperative complications such as dysphagia while ensuring surgical efficacy. BROEDERS *et al.* [22]reported that laparoscopic anterior Dor fundoplication achieved similar 5-year anti-reflux effects compared to the Nissen procedure, while reducing the incidence of postoperative complications. The results of our study showed that anti-reflux surgery could significantly improve both esophageal and extra-esophageal symptoms in GERD patients, significantly improve quality of life, and achieve an overall satisfaction rate of approximately 90% with surgical efficacy, consistent with other research findings[23–24]. It is important to note that this study adopted subxiphoid distension and fullness as an symptom parameter. This symptom is often a clinical manifestation of HH, caused by the compression of the gastric fundus or body by the bilateral diaphragmatic crura during HH formation. It has a high incidence in HH patients and causes significant distress, but has not been mentioned in previous studies.In this study, the incidence of dysphagia during the perioperative period (within 2 weeks postoperatively) was 93.3% (208/223), with similar rates in both groups (92.2% vs. 94.3%, *P* = 0.522). All patients showed significant improvement in dysphagia symptoms through dietary guidance. At 2 months postoperatively, all patients could transition to a semi-liquid diet, and at 2 years postoperatively, there was no moderate dysphagia, with all patients able to eat soft food smoothly. During the follow-up period, none of the patients underwent endoscopic esophageal dilation or reoperation due to dysphagia. Postoperative dysphagia is one of the most common postoperative complications. In addition to considering different surgical procedures (Nissen, Toupet, Dor), selection of width of fundoplication flap (short-loose or wide-loose fundoplication)[25], and application of other auxiliary techniques (such as intraoperative bougie dilation of the esophagogastric junction)[26, 27], the authors believe that thorough preoperative explanation and communication, as well as reasonable postoperative dietary guidance, also help alleviate patients' fear of dysphagia. On one hand, surgeons should strive to avoid severe postoperative dysphagia, and on the other hand, patients should understand the surgical process, the principles of anti-reflux surgery, and the physiological evolution of the surgical site (fundoplication area) postoperatively. This helps patients to understand the

causes of dysphagia and accept mild dysphagia more easily, further improving their compliance and satisfaction with surgical treatment. Additionally, there are significant differences in the selection of surgical indications for GERD, surgical techniques, choice of surgical approaches, and overall patient management across different treatment centers, leading to large variations in treatment efficiency, recurrence rates, and patient satisfaction[24]. Therefore, comprehensive preoperative evaluation (including HRM, 24-h MII-pH monitoring, and other specific diagnostic tools), standardized diagnosis and treatment processes, and GERD centers with certain treatment experience are crucial for improving the level of individualized treatment for GERD patients[15, 28–30].

The His angle, also known as cardiac incisure, or esophagogastric angle, is the angle between the lower esophagus and the gastric fundus. The left wall of the abdominal esophagus connects to the gastric fundus, forming the angle of His at this junction, which is one of the important anti-reflux structures and participates in the formation of the gastroesophageal valve flap. In patients with HH, the angle of His significantly increases or even disappears, causing the gastroesophageal valve flap to shrink or disappear, weakening or losing its anti-reflux function[31, 32]. In view of this, this study reconstructed the angle of His during routine fundoplication to explore its anti-reflux effect. The results showed that the Dor fundoplication combined with RAH could further improved regurgitation and heartburn symptoms compared to pure fundoplication, which indicated fundoplication with RAH had better anti-reflux efficacy, while not increasing the incidence of surgical complications. Based on our surgical operational experience and insights, the reasons why the reconstruction of angle of His synergistically enhances anti-reflux effects, we analyze the possible reasons as follows: (1) After angle of His is reconstructed, the gastroesophageal valve flap structure is restored, strengthening its anti-reflux function. (2) During the process of the reconstruction of angle of His, the fundus used for plication is sutured and fixed to the diaphragm (as shown in the Fig. 1), which reduces tension on the fundoplication flap and fixes the flap, thus stabilizing the flap's shape and reducing the recurrence of HH.

There are very few research reports on the application of RAH for the treatment of GERD. Previous reports have mentioned the use of RAH in the treatment of achalasia [33], partial gastrectomy [34, 35], sleeve gastrectomy[36], etc., with results showing that RAH can alleviate or prevent the occurrence of GERD-related symptoms after surgery. In 2022, Zhang[37] reported that laparoscopic RAH had anti-reflux effects similar to fundoplication, and had advantages such as less operative time, less intraoperative blood loss, shorter postoperative hospital stay, and fewer surgical complications. It should be noted that this study evaluated pure RAH, not fundoplication with RAH. Additionally, the method of RAH in this study is to fix the gastric fundus to the left wall of the abdominal esophagus, which is different from our method (Fig. 1).

This study explored the anti-reflux effect of laparoscopic Dor fundoplication with RAH. During clinical practice, the authors summarized several key points for the operation of the procedure: (1) Non-absorbable sutures were used for suture. The needle insertion point on the gastric fundus was selected at the highest point of the folded fundus. Before inserting the needle, the fundus was everted to avoid bulky and redundant tissues from filling between the fundus and the esophagus, so as to reduce the

occurrence of postoperative discomfort symptoms such as dysphagia and abdominal distension; (2) The needle insertion point on the diaphragm was selected at the left anterior side of the esophagus, avoiding the subphrenic blood vessels, so that the reconstructed angle of His could form a smaller and deeper acute angle, making the anti-reflux effect of the gastroesophageal valve flap more obvious (Fig. 1).

There were some limitations in our study. First, In the postoperative follow-up, there were not objective data evaluations, such as gastroscopy, 24-h MII-pH monitoring, and HRM, which may cause bias in the research results. Second, this study was a retrospective, single-center, medium-term follow-up result with a limited sample size, and the research results need to be verified by prospective, multi-center, large-sample, and long-term follow-up data.

Conclusions

In conclusion, this study preliminarily found that compared with pure laparoscopic Dor fundoplication, Dor fundoplication combined with RAH has a better anti-reflux effect and does not increase the occurrence of postoperative gastrointestinal functional complications. It is worthy of further exploration and verification of its therapeutic value for GERD.

Abbreviations

GERD
Gastro-esophageal reflux disease
RAH
reconstruction of angle of His
HH
Hiatus hernia
HRM
High-resolution manometry
24-h MII-pH
24-hour multichannel intraluminal impedance pH
AET
Acid exposure time
BET
Bolus exposure time
LES
Lower esophageal sphincter
SD
standard deviation
IQR
interquartile rang.

Declarations

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Availability of data and materials

The data generated and analyzed during this study are available from the corresponding author on reasonable request.

Authors' contributions

All authors read and approved the final version of the manuscript, including the authorship. Study concept and design: XD, HYD, and DGL; acquisition of data: XD, HYD, HJD, YPR, and DGL; analysis and interpretation of data: XD, HYD, DGL; manuscript draft: XD, HYD, HJD; critical revision of the manuscript for important intellectual content: XD, HYD, DGL, and YPR.

Competing interests

All authors have declared that no competing interests exist.

Consent to publish

Not applicable.

Ethics approval and consent to participate

Approval for this study was obtained from the institutional review boards of Xuanwu Hospital, Capital Medical University (Beijing, China), and written informed consent was acquired from all participants.

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Figures

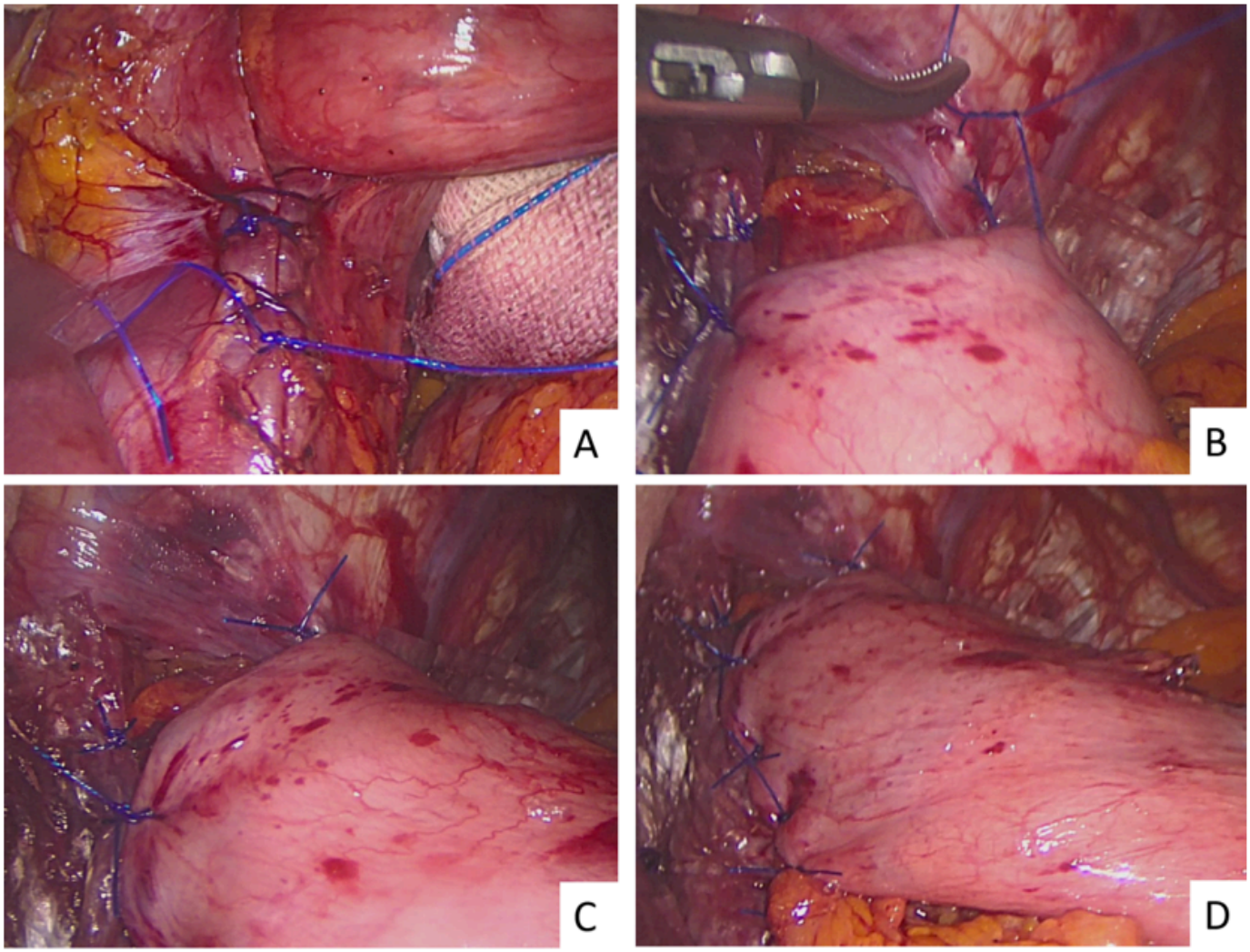

Figure 1

Key points of Dor fundoplication combined with reconstruction of angle of His procedure. **A**. Suturing two sides of the diaphragmatic crura to narrow the esophageal hiatus, **B**. Methods of reconstructon of angle of His, **C**. Effect diagram after reconstruction angle of His, **D**. Effect diagram after Dor fundoplication combined with reconstruction of angle of His procedure.