Surg Endosc (2017) 31:237–244
DOI 10.1007/s00464-016-4962-2

Crus incision without repair is a risk factor for esophageal hiatal hernia after laparoscopic total gastrectomy: a retrospective cohort study

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Received: 10 February 2016 / Accepted: 28 April 2016 / Published online: 13 May 2016

Abstract
Background Although postoperative esophageal hiatal hernia (EHH) is primarily considered a post-operative complication of esophagectomy, it is also a rare post-operative complication of laparoscopic total gastrectomy (LTG), with a reported incidence rate of 0.5 %. The purpose of this study is to analyze the incidence, clinical features, and prevention of EHH following LTG for gastric cancer.
Methods Between October 2008 and July 2014, 78 patients who underwent LTG for gastric cancer in our hospital were analyzed. We compared the crus incision group (in which the left crus of the diaphragm was incised without suture repair) with the crus conserving or repair group (in which the crus was preserved or the crus was incised and underwent suture repair). The primary endpoint was incidence of postoperative EHH.
Results Of the 78 patients, 7 (9.0 %) developed postoperative EHH. Three of seven patients (42.9 %) were symptomatic and required an emergency operation for intestinal obstruction. Four of seven patients (57.1 %) were asymptomatic and did not require an operation. Incising the left crus of the diaphragm without suture repair during LTG was considered the only risk factor for postoperative EHH (0 of 29 for preserving the crus or incising and performing suture repair of the crus vs. 7 of 49 in crus incision without suture repair; $p = 0.033$).
Conclusions The present data suggest that incision of the crus without suture repair is associated with EHH after LTG. If crus incision is required, crus repair may be effective for the prevention of postoperative EHH.

Keywords Crus repair · Esophageal hiatal hernia · Laparoscopic total gastrectomy

The number of laparoscopic total gastrectomies (LTGs) for gastric cancer has recently been increasing in Japan [1–4]. It has been suggested that the reduction in adhesions after laparoscopic surgery could increase the risk of internal hernia [5, 6]. Jejunojejunostomy mesenteric defect, Petersen's space, and mesenterium of the transverse colon are known internal hernia orifices after gastrectomy with Roux-en-Y reconstruction [1, 2, 7–9]. In the case of total gastrectomy, postoperative esophageal hiatal hernia (EHH) is an important complication [1, 3, 4]. The purpose of this non-randomized, retrospective cohort study was to analyze the incidence, clinical features, and prevention of EHH after LTG for gastric cancer.

Patients and methods

Patients

Between October 2008 and July 2014, 78 patients underwent LTG for gastric cancer that was diagnosed by endoscopy and biopsy in our hospital. All operations were performed by an experienced surgeon who was also a licensed attending doctor for laparoscopic surgery. All patients in this study underwent the following standard operations: (1) LTG, which was indicated because of the

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location and macroscopic appearance of the primary tumor, and (2) D0, D1, D1+, or D2 lymphadenectomy as per the guideline of the Japanese Gastric Cancer Association [10].

Definition of EHH

Preoperative EHH was defined as dilation of cardia, which was diagnosed on the basis of endoscopic observation. Postoperative EHH was divided into two types: (1) the conventional type involving herniated contents other than a jejunum limb (Fig. 1) and (2) the migration type involving migration of the anastomotic staple from the esophageal hiatus (≧3 cm) (Fig. 2) [11–20]. Both diagnoses were based on computed tomography (CT) scan findings. A CT scan was performed every 6 months after surgery at minimum.

Surgical technique for esophagojejunostomy

Functional end-to-end anastomosis [21]

The jejunal limb and the esophagus were excised sufficiently to allow passage of the jaws of the endoscopic linear stapler (ETS45, Ethicon Endo Surgery, blue cartridge) or (Endo-GIA 45, Covidien, purple cartridge) (Fig. 3). The stapler device was closed and fired, creating an anastomosis. These firing procedures converted the two holes into one common hole, which was then closed with one or two linear staplers (Fig. 4). Functional end-to-end anastomosis was completely established (Fig. 5).

Fig. 1 Postoperative esophageal hiatal hernia (conventional type: herniated contents other than the jejunum limb)

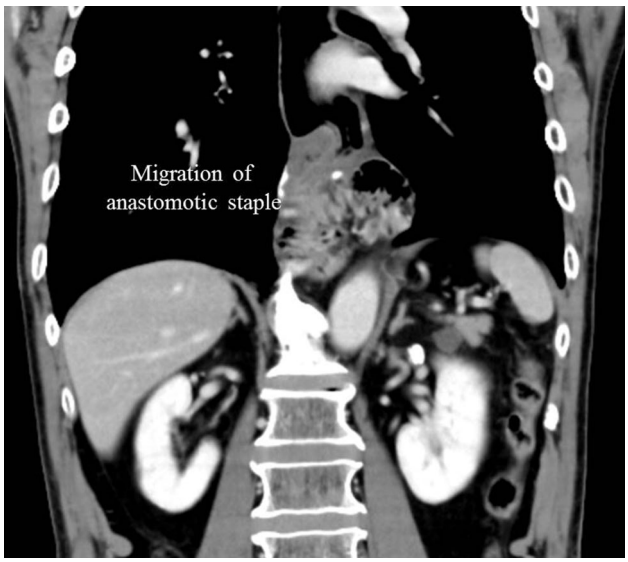

Fig. 2 Postoperative esophageal hiatal hernia [migration type: migration of anastomotic staple from the esophageal hiatus (≥3 cm)]

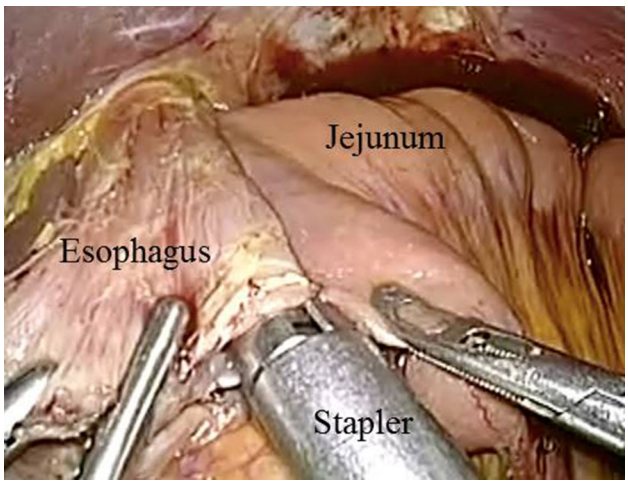

Fig. 3 The jejunal limb and the esophagus were excised sufficiently to allow passage of the jaws of the endoscopic linear stapler

Overlap method anastomosis [22]

An enterotomy was made 5 cm distal to the stapler line on the antimesenteric side of the jejunum. Another enterotomy was made on the left edge of the esophageal stump. After each fork was completely inserted into each lumen, the firing of the linear stapler converted the two openings into an entry hole to create an end-to-side anastomosis (Fig. 6). An AV-shaped anastomotic staple line between the esophagus and the jejunum was created, and intraluminal hemostasis was confirmed. The entry hole of the stapler

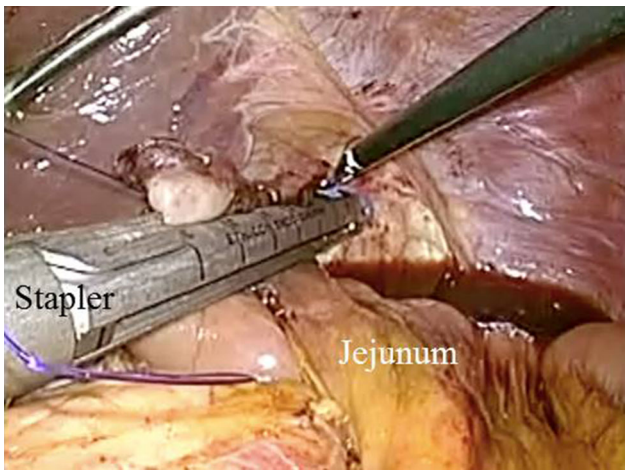

Fig. 4 These firing procedures converted the two holes into one common hole, which was then closed with one or two linear staplers

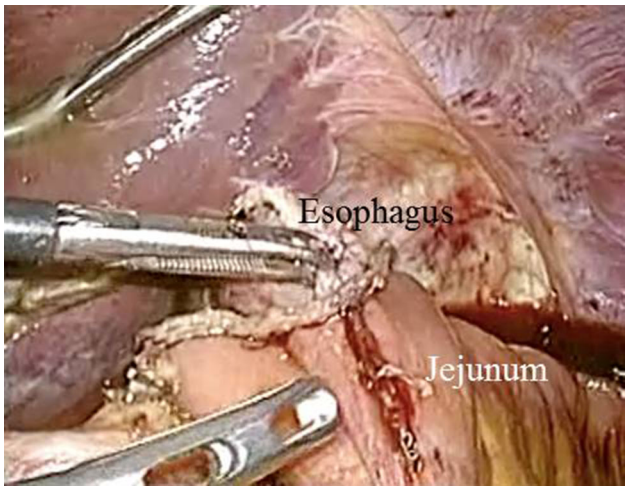

Fig. 5 Functional end-to-end anastomosis was completely established

was closed by an intracorporeal interrupted hand-sewn technique with 3-0 monofilament absorbed fiber (Fig. 7). Overlap method anastomosis was completely established (Fig. 8).

Crus incision and repair

We divided the patients who received LTG into three groups: (1) crus preserving, (2) crus incision and repair, and (3) crus incision without repair. During LTG, the left crus of the diaphragm was widely incised for overlap anastomosis or intrathoracic functional end-to-end anastomosis (Fig. 9). For crus repair, we sutured the hiatus and anchored the jejunal limb to the hiatus using 3-0 non-absorbable monofilament fiber (Fig. 10).

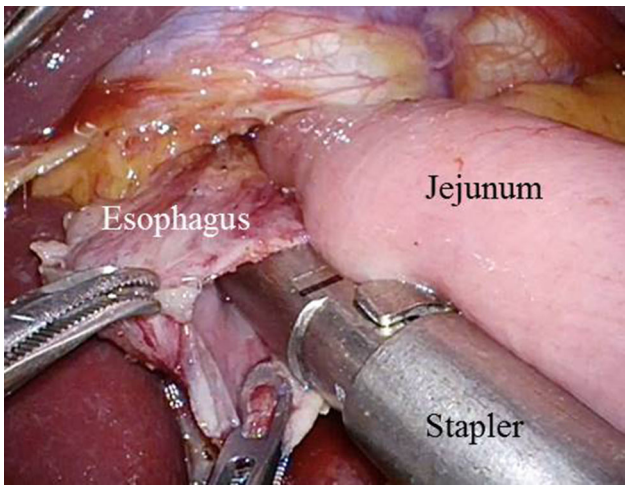

Fig. 6 After each fork was completely inserted into each lumen, the firing of the linear stapler converted the two openings into an entry hole to create an end-to-side anastomosis

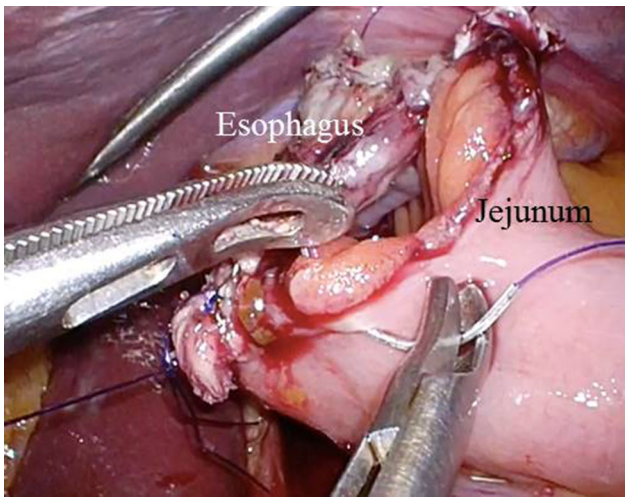

Fig. 7 The entry hole of the stapler was closed by an intracorporeal interrupted hand-sewn technique with 3-0 monofilament absorbed fiber

Statistical analysis

Patient characteristics and operative details were analyzed using the Chi-square test, the unpaired *t* test, and the Mann–Whitney test. The association between the intervention of the crus of the diaphragm, and the EHH was analyzed using the Chi-square test. All statistical analyses were performed using the Stata/IC (STATA Statistical Software, version 14.0; Stata Corp., College Station, TX, USA). Two-sided probability (*p*) values of <0.05 were considered significant.

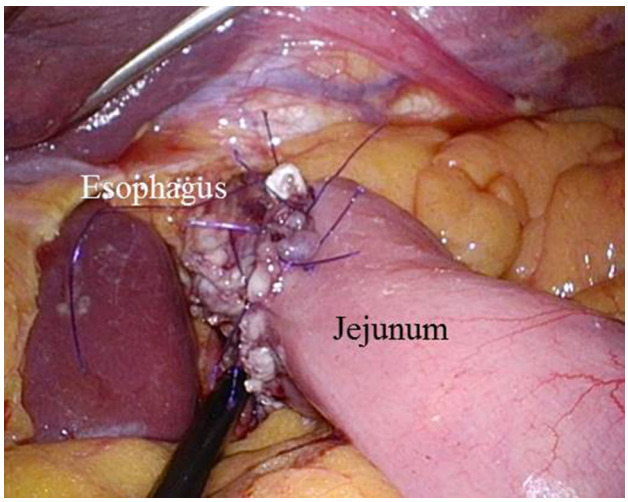

Fig. 8 Overlap method anastomosis was completely established

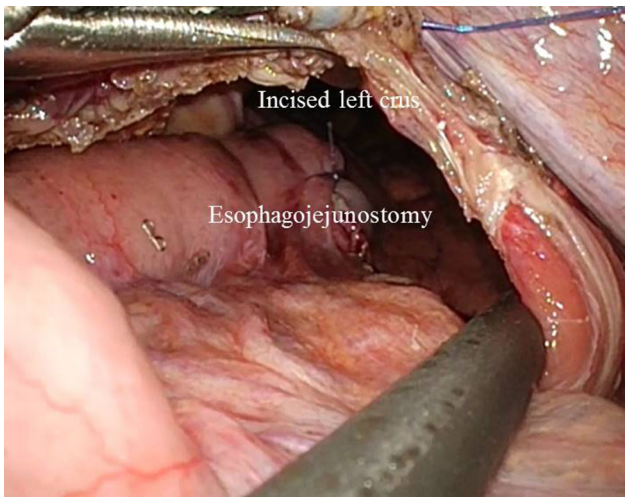

Fig. 9 During laparoscopic total gastrectomy, the crus was widely incised for overlap anastomosis

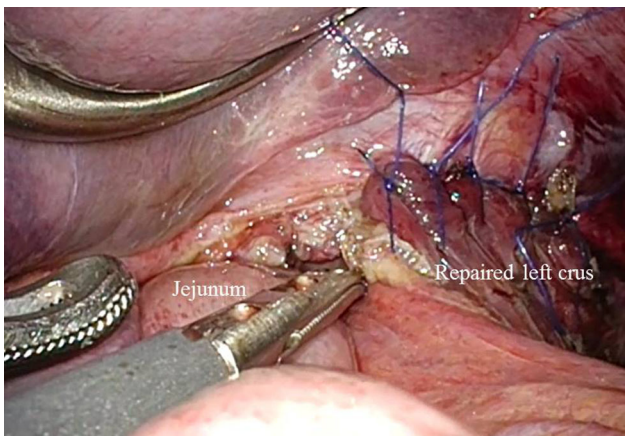

Fig. 10 We sutured the hiatus and anchored the jejunal limb to the hiatus using 3-0 absorbable monofilament fiber

Results

Baseline characteristics (Table 1)

Of the 78 identified patients who underwent LTG for gastric cancer, there were 51 males (65.4 %) and 27 females (34.6 %), aged 34–93 years (median: 66 years). The follow-up period after surgery was 1–73 months (median: 25 months). There was no significance in the baseline characteristics of patients who underwent LTG with respect to preoperative factors, intraoperative factors, or postoperative factors. There were 15 cases of preserving the crus, 14 cases of the incision and repair of the crus, and 49 cases of crus incision.

Patients with EHH after LTG (Table 2)

Of the 78 patients, seven (9.0 %) were diagnosed with postoperative EHH. All patients were diagnosed by CT. The mean interval between LTG and diagnosis of EHH was 17.6 months (1–36 months). Of the seven patients with postoperative EHH, three (42.9 %) were symptomatic and required an emergency operation for intestinal obstruction. There were no complications in the three patients who required an operation. Four patients (57.1 %) were asymptomatic and did not require an operation. In the symptomatic patients, two were of the conventional type and one had comorbid hernias (migration type and Petersen's hernia) and underwent crus repair and jejunum fixation to crura. The patient with comorbid hernias also underwent closure of the Petersen's hernia orifice.

EHH risk factors (Chi-square test) (Table 3)

Table 3 shows the relationship between the intervention of the crus of the diaphragm and EHH. Only crus incision without repair during LTG was associated with an increased risk in the development of postoperative EHH (0 of 29 for preserving the crus or the incision and repair of the crus vs. 7 of 49 for crus incision without repair; $p = 0.033$).

Discussion

Laparoscopic surgery reduces adhesions, and patients undergoing LTG are thus at risk of developing internal hernias such as EHH [5, 6] Internal hernias after laparoscopic gastrectomy, such as jejunojejunostomy mesenteric defect, Petersen's space, and mesenterium of the transverse colon, are common and major post-operative complications of Roux-en-Y reconstruction [1, 2]. Although reports of

Table 1 Patient characteristics and operative details

Variables	Total	Crus pres./rep. *n* (%) or median (range)	Crus inc.	*p* value
Preoperative factors				
Age	66 (34–93)	65 (43–85)	66 (34–93)	0.893*
Sex				0.985†
Male	51 (65.4 %)	19 (65.5 %)	32 (65.3 %)	
Female	27 (34.6 %)	10 (34.5 %)	17 (34.7 %)	
BMI	23 (17–31)	23 (17–30)	24 (17–31)	0.864*
Serum albumin (mg/dl)	4.1 (1.4–5.2)	4.1 (3.0–5.2)	4.1 (1.4–4.6)	0.144**
Esophageal hiatal hernia	23 (29.5 %)	9 (31.0 %)	14 (28.6 %)	0.831†
Tumor size (mm)	35 (4–280)	35 (9–280)	37.5 (4–280)	0.973**
Neoadjuvant chemotherapy	3 (3.8 %)	0 (0 %)	3 (6.1 %)	0.174†
Diagnosis				0.062†
Gastric cancer (adenocarcinoma)	76 (97.4 %)	27 (93.1 %)	49 (100 %)	
GIST	2 (2.6 %)	2 (6.9 %)	0 (0 %)	
Pathological stage				0.437†
I	39 (50.0 %)	11 (37.9 %)	28 (57.1 %)	
II	16 (20.5 %)	7 (24.1 %)	9 (18.4 %)	
III	20 (25.6 %)	9 (31.0 %)	11 (22.4 %)	
IV	1 (1.3 %)	0 (0 %)	1 (2.0 %)	
Intraoperative factors				
Type of anastomosis (esophagojejunostomy)				0.001†
Functional end-to-end anastomosis	9 (11.5 %)	8 (27.6 %)	1 (2.0 %)	
Overlap method	69 (88.5 %)	21 (72.4 %)	48 (98.0 %)	
Intrathoracic anastomosis	1 (1.3 %)	0 (0 %)	1 (2.0 %)	0.439†
Type of reconstruction (Roux-en Y)				0.001†
Antecolic, isoperistaltic	51 (65.4 %)	16 (55.2 %)	35 (71.4 %)	0.246†
Antecolic, antiperistaltic	9 (11.5 %)	9 (31.0 %)	0 (0 %)	0.000†
Retrocolic, isoperistaltic	17 (21.8 %)	4 (13.8 %)	13 (26.5 %)	0.188†
Retrocolic, antiperistaltic	1 (1.3 %)	0 (0 %)	1 (2.0 %)	0.439†
Resected organ				0.184†
Gallbladder	5 (6.4 %)	4 (13.8 %)	1 (2.0 %)	
Spleen	16 (20.5 %)	5 (17.2 %)	11 (22.4 %)	
Pancreas and spleen	2 (2.6 %)	2 (6.9 %)	0 (0 %)	
Jejunostomy	19 (24.4 %)	8 (27.6 %)	11 (22.4 %)	0.609†
Extent of lymph node dissection				0.249†
D1	4 (5.1 %)	0 (0 %)	4 (8.2 %)	
D1+	56 (71.8 %)	22 (75.9 %)	34 (69.4 %)	
D2	18 (23.1 %)	7 (24.1 %)	11 (22.4 %)	
Intervention of crus diaphragmatis				
Preserving crus	15 (19.2 %)	15 (51.7 %)	0 (0 %)	–
Crus incision	49 (62.8 %)	0 (0 %)	49 (100 %)	–
Incision and repair of crus	14 (17.9 %)	14 (48.3 %)	0 (0 %)	–
Open convert	2 (2.6 %)	2 (6.9 %)	0 (0 %)	0.063†
Surgical duration (min)	380 (261–632)	382 (312–629)	370 (261–632)	0.146**
Estimated blood loss (ml)	150 (20–1650)	165 (10–1550)	105 (10–1650)	0.511**
Postoperative factors				
Complication				0.745†
Pancreatic fistula	5 (6.4 %)	2 (6.9 %)	3 (6.1 %)	
Aspiration pneumonia	1 (1.3 %)	1 (3.4 %)	0 (0 %)	

Table 1 continued

Variables	Total	Crus pres./rep. *n* (%) or median (range)	Crus inc.	*p* value
Bowel obstruction	1 (1.3 %)	0 (0 %)	1 (2.0 %)	
Weight loss (kg)	12 (0–31)	6.5 (0–20)	12 (0–31)	0.937*

Crus pres./rep. crus preserving or incision and repair, *Crus inc.* crus incision without repair

† Chi-square test

* Unpaired *t* test

** Mann–Whitney test

Table 2 Patients of esophageal hiatal hernia after laparoscopic total gastrectomy

Patient	Age (years)	Histology	Esophagoenterostomy Condition of crura	Interval between LTG and EHH (m)	Surgical treatment	Hernia type (content)
1	62	Adenocarcinoma (pT1 N0 M0 R0)	Overlap Left Crus incision	3	Hiatoplasty Jejunum fixation	Conventional type (transverse colon)
2	68	Adenocarcinoma (pT3 N2 M0 R0)	Overlap Left Crus incision	18	Hiatoplasty Jejunum fixation Closure of hernia orifice	Migration type (symptomatic) Petersen's hernia (comorbid)
3	69	Adenocarcinoma (pT1 N0 M0 R0)	Overlap Left Crus incision	36	Hiatoplasty Jejunum fixation	Conventional type (jejunum)
4	62	Adenocarcinoma (pT3 N0 M0 R0)	Overlap Left Crus incision	30	No operation	Migration type (asymptomatic)
5	61	Adenocarcinoma (pT3 N0 M0 R0)	Overlap Left Crus incision	8	No operation	Migration type (asymptomatic)
6	64	Adenocarcinoma (pT4 N2 M0 R0)	Functional end to end Left Crus incision	1	No operation	Migration type (asymptomatic)
7	66	Adenocarcinoma (pT1 N0 M0 R0)	Overlap Left Crus incision	27	No operation	Migration type (asymptomatic)

LTG laparoscopic total gastrectomy, *EHH* esophageal hiatal hernia

Table 3 Analysis of risk factor for postoperative esophageal hiatal hernia

Variables	Frequency of herniation	Risk difference (95 % CI)	*p* value
Crus pres./rep.	0 (0 %)	–	–
Crus inc.	7 (14.3 %)	0.045–0.240	0.033†

Crus pres./rep. crus preserving or incision and repair, *Crus inc.* crus incision without repair

† Chi-square test

EHH after LTG are rare [3, 4], with a reported incidence rate of 0.5 % [1], there are many papers on EHH following esophagectomy [11–20]. The incidence of EHH after esophagectomy is reported to be 0.4–13 %, though this may vary if asymptomatic EHH is included [19, 20]. There is some pathogenesis involved in postoperative EHH, including the suction effect of the negative intrathoracic pressure and positive abdominal pressure, reduced adhesions after laparoscopic surgery, and enlargement of the hiatus [19, 20, 23, 24].

EHH is difficult to diagnose because many cases are asymptomatic and the symptoms have a nonspecific and broad spectrum, including chest or abdominal pain, respiratory distress, nausea, vomiting, constipation, and gastrointestinal bleeding, all of which are easily interpreted as complications of chemotherapy [11–18]. Because a delay in diagnosis and treatment can result in intestinal necrosis with the need for resection of the small intestine, mortality rates increase from 10 to 20 to 80 % depending on the length of diagnostic delay [19, 20]. Although the accuracy

has not been firmly established, CT scans are useful for evaluating hernia contents and for providing indications for operative intervention [11–20].

Some authors argue that all postoperative EHH should be repaired because of the high mortality related to delayed diagnosis and the high rate of hernia recurrence [12, 13]. In contrast, some authors hold that, in the case of small hernia, asymptomatic hernia, or a short life expectancy due to progressive cancer, a wait-and-see approach is another treatment option [15, 19, 25]. It is well accepted that patients presenting with severe complications such as obstruction or strangulation need immediate surgical repair. For surgical repair, there are several options: transabdominal or transthoracic, simple hernia closure with or without a relaxing incision in the left hemi diaphragm, mesh repair, or another repair (prolene suture web-shoelace-like pattern) [11–18, 26]. We believe that a wait-and-see approach is preferred in the case of small hernia, asymptomatic hernia, or a short life expectancy. The patient's condition determines which repair should be performed.

The results revealed that crus incision is the only risk factor for EHH after LTG. Van Sandick concluded that only iatrogenic enlargement of the hiatus during the operation was significantly associated with an increased risk of EHH after esophagectomy [19]. In this report, our data suggest that crus incision without repair is associated with EHH after LTG. For reconstruction after LTG, especially in overlap anastomosis, some surgeons believe that the wider the crus incision, the easier it is to perform esophagojejunostomic anastomosis [22]. Previously, we cut the left crus and dissected the abdominal and lower thoracic esophagus widely in order to make anastomosis easy. As of August 2014, however, if crus incision and division of the esophagus are needed, to repair the crus, we now always attempt to suture the hiatus and anchor the jejunal limb to the hiatus using 3-0 non-absorbable monofilament fiber (Fig. 2) [27–29].

This study has several limitations. According to a previous report, the frequency of EHH after LTG was 0.5 % (1 in 218 cases); this case was symptomatic and required an operation [1]. In the present series, 9.0 % (7 of 78 patients) had radiological evidence of herniated bowel into the chest and included both symptomatic and asymptomatic cases. The actual incidence of EHH could thus be even greater than reported. This may result from a technical issue (iatrogenic enlargement of the hiatus). A second limitation is that there were too few cases to conduct multivariate analysis. Moreover, in the crus preservation and repair group, because there was no EHH, we were not able to use the logistic regression model and perform the Chi-square test to analyze the risk factors for EHH.

Conclusions

EHH after LTG is an important complication that can require an emergency operation. Our data suggested that crus incision without repair is associated with EHH after LTG. Reduced division of the crus and dissection of the esophagus is preferable, but if necessary, suture repair may help avoid postoperative EHH.

Compliance with ethical standards

Disclosures Eisaku Ito, Hironori Ohdaira, Keigo Nakashima, Norihiko Suzuki, Tomonori Imakita, Nobuhiro Tsutsui, Masashi Yoshida, Masaki Kitajima and Yutaka Suzuki have no conflicts of interest or financial ties to disclose.

References

1. Miyagaki H, Takiguchi S, Kurokawa Y, Hirao M, Tamura S, Nishida T, Kimura Y, Fujiwara Y, Mori M, Doki Y (2012) Recent trend of internal hernia occurrence after gastrectomy for gastric cancer. World J Surg 36:851–857
2. Yoshikawa K, Shimada M, Kurita N, Sato H, Iwata T, Higashijima J, Chikakiyo M, Nishi M, Kashihara H, Takasu C, Matsumoto N, Eto S (2014) Characteristics of internal hernia after gastrectomy with Roux-en-Y reconstruction for gastric cancer. Surg Endosc 28:1774–1778
3. Suh Y, Lee JH, Jeon H, Kim D, Kim W (2012) Late onset iatrogenic diaphragmatic hernia after laparoscopy-assisted total gastrectomy for gastric cancer. J Gastric Cancer 12:49–52
4. Murata S, Yamazaki M, Kosugi C, Hirano A, Yoshimura Y, Shiragami R, Suzuki M, Shuto K, Koda K (2014) Hiatal hernia following total gastrectomy with Roux-en-Y reconstruction. Hernia 18:889–891
5. Schippers E, Tittel A, Ottinger A, Schumpelick V (1998) Laparoscopy versus laparotomy: comparison of adhesion-formation after bowel resection in a canine model. Dig Surg 15:145–147
6. Gamal EM, Metzger P, Mikó I, Szabó G, Bráth E, Kiss J, Furka I (1999) The judgement of adhesion formation following laparoscopic and conventional cholecystectomy in an animal model. Acta Chir Hung 38:169–172
7. Rogula T, Yenumula PR, Schauer PR (2007) A complication of Roux-en-Y gastric bypass: intestinal obstruction. Surg Endosc 21:1914–1918
8. Elms L, Moon RC, Varnadore S, Teixeira AF, Jawad MA (2014) Causes of small bowel obstruction after Roux-en-Y gastric bypass: a review of 2,395 cases at a single institution. Surg Endosc 28:1624–1628
9. Rosas U, Ahmed S, Leva N, Garg T, Rivas H, Lau J, Russo M, Morton JM (2015) Mesenteric defect closure in laparoscopic Roux-en-Y gastric bypass: a randomized controlled trial. Surg Endosc 29:2486–2490
10. Japanese Gastric Cancer Association (2011) Japanese classification of gastric carcinoma: 3rd English edition. Gastric Cancer 14:101–112
11. Choi YU, North JH Jr (2001) Diaphragmatic hernia after Ivor-Lewis esophagectomy manifested as lower gastrointestinal bleeding. Am Surg 67:30–32
12. Hamaloglu E, Topaloglu S, Törer N (2002) Diaphragmatic herniation after transhiatal esophagectomy. Dis Esophagus 15:186–188

13. Aly A, Watson DI (2004) Diaphragmatic hernia after minimally invasive esophagectomy. Dis Esophagus 17:183–186
14. Fumagalli U, Rosati R, Caputo M, Bona S, Zago M, Lutmann F, Peracchia A (2006) Diaphragmatic acute massive herniation after laparoscopic gastroplasty for esophagectomy. Dis Esophagus 19:40–43
15. Vallböhmer D, Hölscher AH, Herbold T, Gutschow C, Schröder W (2007) Diaphragmatic hernia after conventional or laparoscopic-assisted transthoracic esophagectomy. Ann Thorac Surg 84:1847–1852
16. Price TN, Allen MS, Nichols FC 3rd, Cassivi SD, Wigle DA, Shen KR, Deschamps C (2011) Hiatal hernia after esophagectomy: analysis of 2,182 esophagectomies from a single institution. Ann Thorac Surg 92:2041–2045
17. Ganeshan DM, Correa AM, Bhosale P, Vaporciyan AA, Rice D, Mehran RJ, Walsh GL, Iyer R, Roth JA, Swisher SG, Hofstetter WL (2013) Diaphragmatic hernia after esophagectomy in 440 patients with long-term follow-up. Ann Thorac Surg 96:1138–1145
18. Schweigert M, Dubecz A, Ofner D, Stein HJ (2014) Gangrene of the oesophago-gastric junction caused by strangulated hiatal hernia: operative challenge or surgical dead end. Ir J Med Sci 183:323–330
19. van Sandick JW, Knegjens JL, van Lanschot JJ, Obertop H (1999) Diaphragmatic herniation following oesophagectomy. Br J Surg 86:109–112
20. Kent MS, Luketich JD, Tsai W, Churilla P, Federle M, Landreneau R, Alvelo-Rivera M, Schuchert M (2008) Revisional surgery after esophagectomy: an analysis of 43 patients. Ann Thorac Surg 86:975–983
21. Uyama I, Sugioka A, Fujita J, Komori Y, Matsui H, Hasumi A (1999) Laparoscopic total gastrectomy with distal pancreatosplenectomy and D2 lymphadenectomy for advanced gastric cancer. Gastric Cancer 2:230–234
22. Inaba K, Satoh S, Ishida Y, Taniguchi K, Isogaki J, Kanaya S, Uyama I (2010) Overlap method: novel intracorporeal esophagojejunostomy after laparoscopic total gastrectomy. J Am Coll Surg 211:e25–e29
23. Patel AD, Lin E, Lytle NW, Toro JP, Srinivasan J, Singh A, Sweeney JF, Davis SS Jr (2014) Combining laparoscopic giant paraesophageal hernia repair with sleeve gastrectomy in obese patients. Surg Endosc 29:1115–1122
24. Merchant AM, Cook MW, Srinivasan J, Davis SS, Sweeney JF, Lin E (2009) Comparison between laparoscopic paraesophageal hernia repair with sleeve gastrectomy and paraesophageal hernia repair alone in morbidly obese patients. Am Surg 75:620–625
25. Katariya K, Harvey JC, Pina E, Beattie EJ (1994) Complications of transhiatal esophagectomy. J Surg Oncol 57:157–163
26. Chabert LH, Fraind JJ, Quintero NL (2015) Prolene suture web-shoelace-like pattern: an alternative to avoid the use of mesh in the repair of a large hiatus hernia. J Laparoendosc Adv Surg Tech A 25:1019–1024
27. McNeil PM, Sugerman HJ (1986) Continuous absorbable vs interrupted nonabsorbable fascial closure. A prospective, randomized comparison. Arch Surg 121:821–823
28. Coleman MH, Awad ZT, Pomp A, Gagner M (2006) Laparoscopic closure of the Petersen mesenteric defect. Obes Surg 16:770–772
29. Sajid MS, Parampalli U, Baig MK, McFall MR (2011) A systematic review on the effectiveness of slowly-absorbable versus non-absorbable sutures for abdominal fascial closure following laparotomy. Int J Surg 9:615–625