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A novel liver retraction method in laparoscopic gastrectomy for gastric cancer

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Abstract

Background Retracting the lateral liver segment during laparoscopic distal gastrectomy is important for achieving an optimal surgical field. However, excessive force may injure the liver, causing temporary abnormalities of liver function tests after laparoscopic surgery. We developed a new liver retraction method and assessed its safety and utility.

Patients and methods We retrospectively analyzed records in our surgical database of consecutive surgical patients who underwent laparoscopic distal gastrectomy for early gastric cancer. We divided the 229 patients into two groups based on the liver retraction method used, either flexible liver retraction with clipping and suturing (FLICS) or the Nathanson retractor (NR). One-to-one propensity score matching was performed to match patients, resulting in the records of 53 pairs of cases extracted from the database. Operative and postoperative outcomes were assessed, including following the values of serum liver enzymes, total bilirubin, and C-reactive protein until postoperative day 30.

Results There were no significant differences in patient characteristics or preoperative data in the two groups. The retraction method was not changed intraoperatively for any patients. The operative time was significantly shorter in the FLICS group, but the amount of bleeding did not differ. Liver injury was not observed as a result of liver retraction during surgery. In both groups, serum liver enzymes temporarily increased after surgery but improved rapidly thereafter. The postoperative increases in aspartate transaminase, alanine transaminase, and C-reactive protein levels were significantly lower in the FLICS than in the NR group. No serious complications associated with liver retraction were observed in either group.

Conclusions Our new liver retraction technique provided an optimal surgical field without inducing liver dysfunction. It is a simple, safe, and effective liver retraction technique.

Keywords Laparoscopic gastrectomy · Gastric cancer · Liver retraction · Internal organ retractor · Nathanson's retractor · Propensity score-matched analysis

Laparoscopic gastrectomy has been widely used in Japan since 1991 to treat gastric cancer [1]. Comparative studies of laparoscopic and conventional open surgery have confirmed the safety and effectiveness of laparoscopic gastrectomy [2–6], even in some cases of advanced gastric cancer [7, 8]. Laparoscopic surgery in the treatment of gastric cancer has developed to the extent that it can be regarded as the standard procedure.

It is essential during laparoscopic surgery to ensure sufficient exposure for the surgeon to visualize the surgical field and its surrounding structures so as to perform the procedure safely and effectively [9]. Upward retraction of the lateral segment of the liver is required for surgical access to the upper abdominal organs during laparoscopic surgery. This is most commonly achieved by inserting an external laparoscopic grasper or retractor through a port or incision. Various liver retraction methods for this purpose have been devised [10–15], including some that do not require an additional skin incision. Regardless, many intraabdominal procedures remain technically difficult or cumbersome. A limited field of view may also prevent adequate lymph node dissection.

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For several decades, the Nathanson retractor (NR) has been widely used because of its ease of deployment during laparoscopy. However, the pressure it exerts on the liver causes hepatic congestion because of vascular compression. In our own experience and that of others [12, 16, 17], using the NR has resulted in increased postoperative serum liver enzyme in many cases. To avoid this problem, we devised a liver retraction method combining use of an internal retractor with sutures to help lift the organ, which we designated flexible liver retraction with clipping and suturing (FLICS). The purpose of this study was to assess the usefulness of our new retraction technique.

Materials and methods

Patients and characteristics

We retrospectively analyzed patient records compiled in our institution's surgical database. Records of consecutive surgical patients who underwent laparoscopic distal gastrectomy (LDG) for gastric cancer were extracted from the database. The following data were collected: patient characteristics [age, sex, performance status, American Society of Anesthesiologists Physical Status Classification (ASA-PS), height, weight, body mass index (BMI, kg/m^2), tumor size, and histology]; preoperative tumor data (clinical T status, clinical N status, clinical stage, Lauren classification, and preoperative treatment with endoscopic submucosal dissection); preoperative laboratory values [serum albumin, prothrombin time, C-reactive protein (CRP), gamma-glutamyl transpeptidase, total bilirubin, alkaline phosphatase (ALP), aspartate transaminase (AST), and alanine transaminase (ALT)]; the volume of the lateral segment of the liver with computed tomography volumetry (CTV); surgical outcome including intraoperative events (surgical approach, operative time, estimated blood loss, procedures performed, and immediate intraoperative complications); postoperative course and laboratory tests of liver function; and mid-term and long-term outcomes. The TNM classification of malignant tumors (TNM) was based on the Japanese classification of gastric carcinoma, 3rd English Edition [18].

The lead surgeon in each case was one of three who were certified by the skill-qualification system of the Japanese Society of Endoscopic Surgery and who had adequate experience performing LDG. The patients whose records were reviewed for the study included only those undergoing LDG with liver retraction by one of two techniques, either the FLICS procedure with a surgical retraction clip (Internal Organ Retractor; B. Braun, AG, Melsungen, Germany) or the Nathonson laparoscopic liver retractor (Nathanson Liver Retractor; Cook Medical, IN, USA). Records considered for inclusion in the study were of patients who had early gastric cancer (i.e., clinical stage I); no previous organ resection; no previous surgery requiring liver retraction; and no history of chronic liver damage, alcohol abuse, viral hepatitis (A, B, or C), cirrhosis, or hepatomegaly.

Surgical approach

Our surgical procedure for LDG has been previously reported [19]. Briefly, the initial port was placed via a 2.5 cm infra-umbilical incision made with the open method using a commercially available access port (EZ Access; Hakko, Nagano, Japan). During the procedure, pneumoperitoneum was established with carbon dioxide insufflation at a pressure of approximately 10–12 mmHg according to the body type. A 10 mm flexible high-definition scope (Endoeye flexible HD camera system; Olympus Medical Systems Corporation, Tokyo, Japan) was used to visualize the surgical field. LDG required five ports (one 12 mm port in the umbilicus, 5 and 12 mm ports in the right and left lateral abdomen, respectively, and one puncture with forceps in the upper midline of the abdomen to retract the liver). We mainly used a conventional straight grasper and ultrasonic coagulation cutting device (Harmonic Scalpel; Ethicon Endo-Surgery, Cincinnati, OH, USA) to perform gastric mobilization and lymph node dissection. The reconstruction procedure was performed using the intracorporeal anastomotic technique [20, 21].

Liver retraction methods

Nathanson retractor

The NR was inserted close to the xiphoid process and then placed near the hepatic hilum under the lateral segment of the liver. The retractor was fixed during surgery or repositioned as necessary to provide an adequate surgical field. If the pressure applied was strong enough to cause congestion or signs of ischemia, the pressure on the liver was weakened.

Flexible liver retraction with clipping and suturing technique

Details of the FLICS procedure are shown in Figs. 1 and 2. Along with the Internal Organ Retractor, 48 mm straight needle 2-0 prolene sutures (Ethicon Endo-Surgery, Cincinnati, OH, USA) were used for traction. During pneumoperitoneum, the right hypochondrium was punctured and the hepatic crown lifted to the right temporal side with the suture. After dissection of the lesser omentum, the retractor was inserted into one of the 12 mm trocars and clipped to the cut edge of the lesser omentum. After puncturing at the right edge of xiphoid, a suture was threaded through the loop of the retractor and then guided out of the abdominal cavity

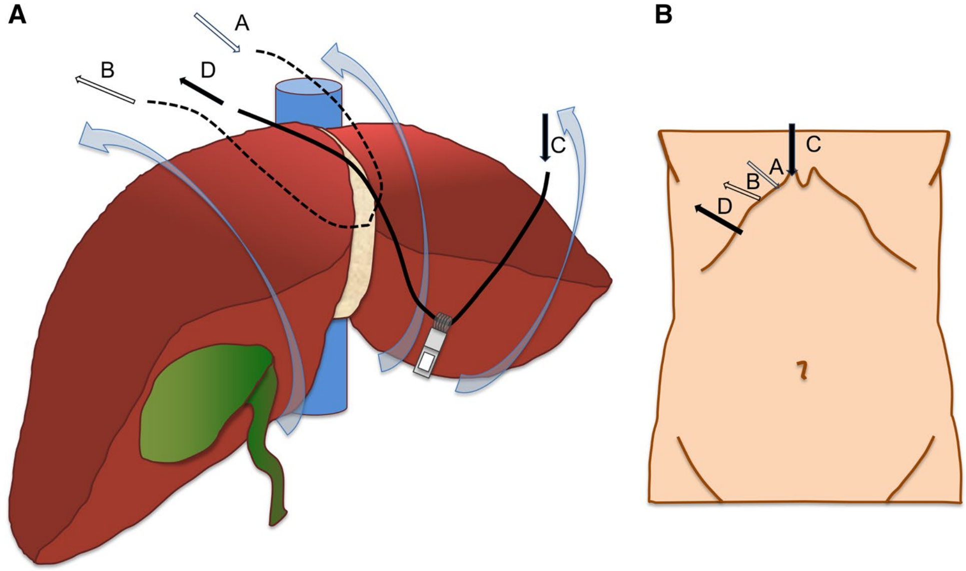

Fig. 1 Schematic of the flexible liver retraction with clipping and suturing method. **A** Traction is placed extracorporeally on sutures A–D to retract the liver. **B** Within the abdominal cavity, the internal organ retractor is clipped to the lesser omentum, and tension on sutures A–D allows retraction of the liver to the upper right of the cavity

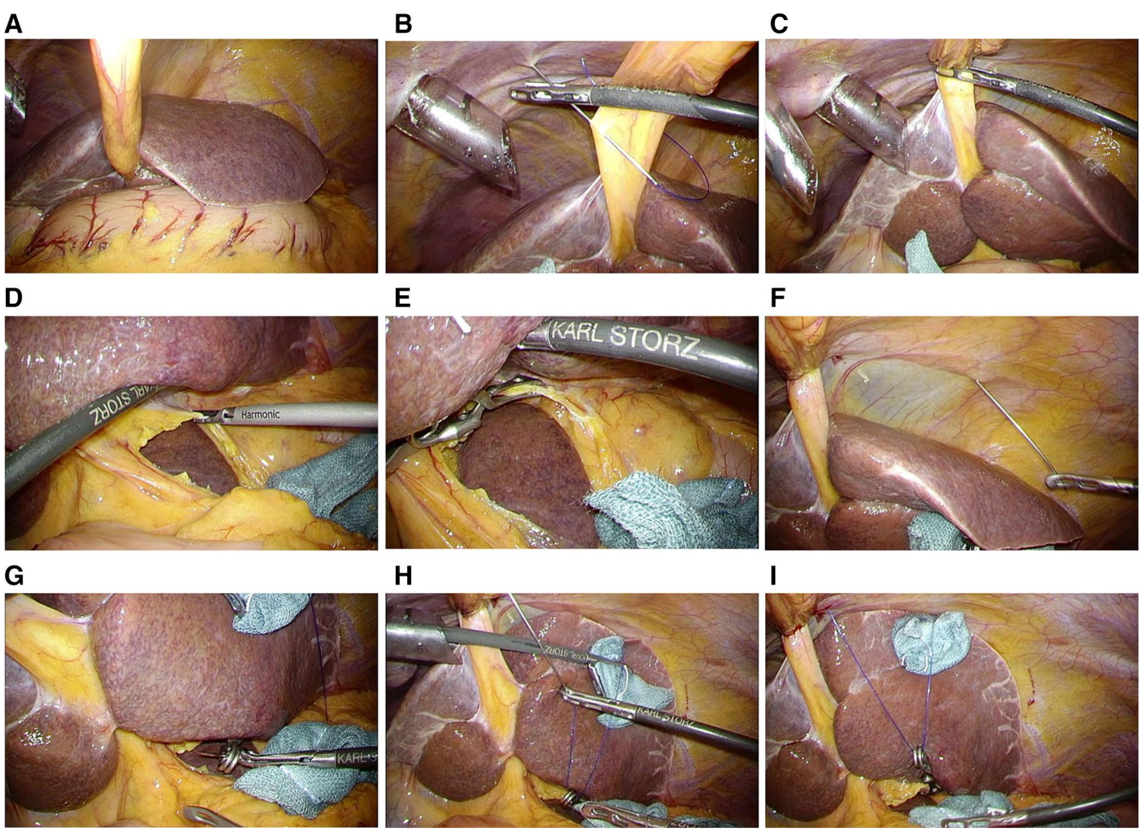

Fig. 2 Flexible liver retraction with clipping and suturing in situ during laparoscopic distal gastrectomy. **A**–**C** The right hypochondrium is punctured by the suture needle and the hepatic crown lifted to the right. **D** The lesser omentum is dissected, and **E** the internal organ retractor clipped to the cut edge. **F** After puncturing from the right of the xiphoid, **G** the suture is threaded through the clip, and **F** then guided out of the cavity

by puncturing the right hypochondrium. Liver retraction was accomplished by external traction on the sutures.

Propensity score matching

One-to-one propensity score matching (PSM) was used to reduce sampling bias and potential confounding by matching patients in the NR and FLICS groups. PSM was used to address the differing distribution of variables among individuals allocated to each group. It was performed using a logistic regression model with the following covariates: age, sex, ASA-PS, BMI, histology, preoperative laboratory data (albumin, prothrombin time, CRP, AST, ALT, bilirubin, and ALP), preoperative treatment with endoscopic submucosal dissection, Lauren classification, and preoperative clinical stage.

Study outcomes

The primary outcome of our study was early (up to 30 days) postoperative complications (0–30 days). Secondary outcomes include operative results (operative time, blood loss, and transfusion requirements) and short-term outcome (hospital stay, postoperative complications, and changes in liver function laboratory values). Elevations of serum liver enzymes were evaluated on the basis of the common terminology criteria for adverse events version [22], with an abnormal value defined as ≥ 3 times the upper limit of normal. Liver dysfunction was defined as a postoperative condition requiring treatment with a low albumin and/or a high prothrombin time.

Postoperative morbidity was defined as an event occurring during the first 60 postoperative days and was graded with the Clavien–Dindo classification [23]. Postoperative mortality was defined as death within 30 days after LDG.

Statistical analysis

All statistical calculations were performed with JMP PRO software (JMP version 13.1.0, SAS Institute, Cary, NC, USA). The demographic and clinicopathologic characteristics were summarized using descriptive analysis, and all data are presented as means ± standard deviations unless otherwise specified. We used a caliper width of 0.2 of the pooled standard deviation of the logit of the propensity score for PSM. The *t* test or Mann–Whitney *U* test, Pearson's χ^2 test, repeated measures analysis, and logistic analysis were used to compare continuous and categorical variables as appropriate. All values were two tailed, and *P* values < 0.05 were considered significant.

Results

Patient characteristics

Figure 3 depicts the study flow chart. Between January 2012 and December 2016, a total of 1432 patients with gastric cancer were admitted to our institution, of them, 434 underwent LDG for clinical early-stage gastric cancer (cT1N0M0, clinical stage I). According to the exclusion criteria, 205 patients were excluded and remaining 229 patients with LDG were included in this study. After PSM, the records of 106 patients who had undergone LDG for early gastric cancer were included in the study, 53 in the FLICS group and 53 in the NR group. There were no significant differences between the two groups in terms of baseline characteristics (Table 1).

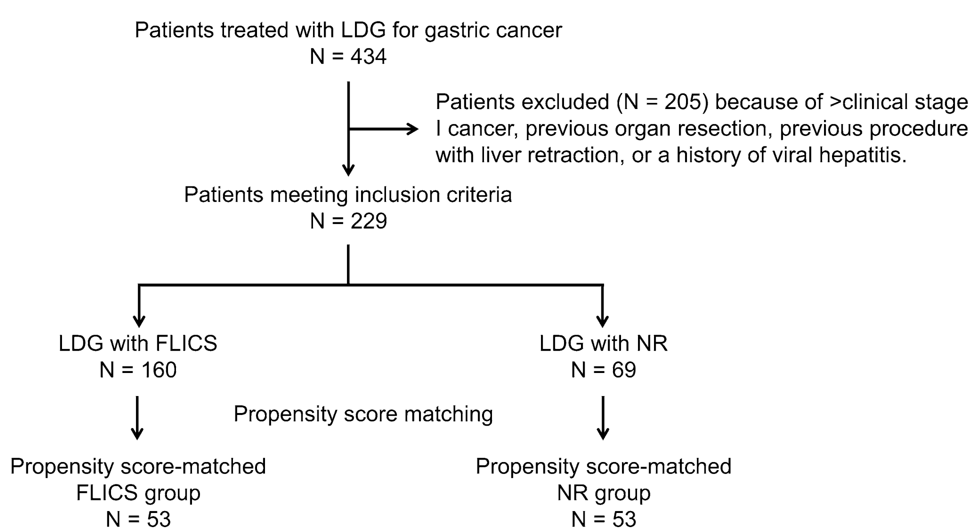

Fig. 3 Study flow chart for patients treated with laparoscopic distal gastrectomy (LDG) for gastric cancer. *FLICS* flexible liver retraction with clipping and suturing, *NR* Nathanson retractor

Table 1 Baseline characteristics of one-to-one propensity score-matched patients who underwent laparoscopic distal gastrectomy for gastric cancer

	FLICS group ($n=53$)	NR group ($n=53$)	P value
Age (years)	67 (34–79)	66 (27–91)	0.99
Sex (M:F)	40 (75.5%):13 (24.5%)	41 (77.4%):12 (22.6%)	0.82
ASA-PS (1:2:3)	11 (20.8%):42 (79.3%):0 (0%)	11 (20.8%):42 (79.3%):0 (0%)	1.00
Height (cm)	167 (146–184)	166 (138–177)	0.80
Weight (kg)	61.4 (35.3–88.9)	60.0 (48.0–80.5)	0.68
BMI (kg/m^2)	22.6 (15.7–29.5)	22.1 (17.7–29.5)	0.92
cT (cT1:cT2)	50 (94.3%):3 (5.7%)	51 (96.2%):2 (3.8%)	0.65
cN (cN0:cN+)	53 (100%):0 (0%)	53 (100%):0 (0%)	1.00
Clinical stage (IA:IB)	51 (96.2%):2 (3.8%)	51 (96.2%):2 (3.8%)	1.00
Lauren classification (diffuse/intestinal)	19 (35.9%):34 (64.1%)	21 (39.6%):32 (60.4%)	0.69
Preoperative ESD (yes:no)	14 (26.4%):39(73.6%)	13 (24.5%):40 (75.5%)	0.82
ALB (g/dl)	4.2 (3.4–4.9)	4.2 (3.5–5)	0.70
PT (%)	98 (67–141)	98 (41–142)	0.38
CRP (mg/dl)	0.05 (0.01–1.09)	0.05 (0.01–2.00)	0.87
γGTP (U/l)	24 (9–217)	26 (6–198)	0.88
T-Bil (mg/dl)	0.7 (0.2–4.6)	0.8 (0.5–2.1)	0.75
ALP (U/l)	186 (87–540)	193 (94–290)	0.49
AST (U/l)	21 (7–51)	20 (13–40)	0.94
ALT (U/l)	16 (8–49)	17 (8–64)	0.85
Volume of the left lateral segment of the liver (cm^3)	193.3 (94.0–446.6)	186.0 (98.5–441.9)	0.87

Values are presented as median (range) or number (%). $P<0.05$ was considered statistically significant

BMI body mass index, *cT* clinical T stage, *cN* clinical N stage, *ESD* endoscopic submucosal dissection, *ALB* albumin, *PT* prothrombin time, *CRP* C-reactive protein, *γGTP* γ-glutamyltransferase, *T-Bil* total bilirubin, *ALP* alkaline phosphatase, *AST* aspartate transaminase, *ALT* alanine transaminase, *ASA-PS* American Society of Anesthesiologists Physical Status Classification, *FLICS* flexible liver retraction with clipping and suturing, *NR* Nathanson liver retractor

Operative and early postoperative outcomes

Comparison of surgical characteristics in the two groups (Table 2) demonstrated a significantly shorter median operative time in the FLICS than in the NR group ($P<0.01$). There was no significant difference in the amount of blood loss ($P=0.13$). Both techniques provided a satisfactory view of the surgical field during LDG. There were no intraoperative complications relating to retraction of the liver. Curative resection (R0) was achieved in all patients. The number of lymph nodes retrieved did not differ significantly between the two groups ($P=0.19$).

More cases of overall surgical complications were observed in the NR than in the FLICS group (20 cases, 37.7% vs. 3 cases, 5.7%) ($P<0.01$) (Table 2). One patient in the NR group (1.9%) had a Clavien–Dindo class III complication (anastomotic leakage requiring reoperation) compared with none in the FLICS group. No liver dysfunction was found in either group. No drugs, including hepatic metabolic drugs, were administered in the postoperative routine; therefore, no medications had to be stopped due to the occurrence of postoperative complications. Although the FLICS group showed a shorter mean hospital stay, changes in hospital policy during the study period may have influenced this result. There was no in-hospital or 30 day mortality or postoperative liver failure in either group.

Liver damage or inflammation

There were no significant differences in results of liver function tests at baseline between the two groups. ALT and AST levels increased significantly from baseline within 24 h following surgery in both groups. On postoperative days 3, 5, and 7, both serum ALT (Fig. 4A) and AST (Fig. 4B) levels were significantly higher in the NR than in the FLICS group. The peak AST and ALT values occurred on day 1 and gradually returned to preoperative values after 7 days in each group. Total bilirubin levels were also elevated in the first few days, but the levels did not differ significantly between groups (Fig. 4C). The CRP has a trajectory similar to that of the AST and ALT values, with the elevation in the FLICS group remaining significantly lower than that in the NR group ($P<0.01$) (Fig. 4D). Although logistic analysis was performed on cases showing elevated postoperative

Table 2 Operative and postoperative outcomes in patients who underwent laparoscopic distal gastrectomy for gastric cancer

	FLICS group (n=53)	NR group (n=53)	P value
Operative time (min)	224 (140–300)	262 (191–336)	<0.01
Operative blood loss (ml)	10 (0–310)	23 (0–2140)	0.13
Type of reconstruction (BI:RY)	45 (84.9%):8 (15.1%)	45 (84.9%):8 (15.1%)	1.00
Reoperation	0	1 (1.9%)	0.24
Postoperative hospital stay (days)	8 (7–16)	13 (7–55)	<0.01
Overall surgical complications	3 (5.7%)	20 (37.7%)	<0.01
Liver dysfunction[a]	0	0	1.00
Liver enzyme elevation[b]	0	16 (30.2%)	<0.01
Pneumonia	0	1 (1.9%)	0.24
Chyloperitoneum	1 (1.9%)	1 (1.9%)	1.00
Surgical site infection	1 (1.9%)	1 (1.9%)	1.00
Organ damage (including gross liver injury)	0	0	1.00
Ileus	0	1 (1.9%)	0.24
Anastomotic leakage	0	1 (1.9%)	0.24
Anastomotic ulcer	0	1 (1.9%)	0.24
Intra-abdominal abscess	0	0	1.00
Subcutaneous hematoma	1 (1.9%)	0	0.24
Postoperative mortality	0	0	1.00
Lymph nodes retrieved	41 (4–92)	36 (9–77)	0.20

Data are presented as median (range) or number (%). $P > 0.05$ was considered statistically significant

FLICS flexible liver retraction with clipping and suturing, *NR* Nathanson liver retractor, *BI* Billroth I, *RY* Roux-en-Y

[a]Liver dysfunction was defined as a postoperative condition requiring treatment with a low albumin and/or a high prothrombin time

[b]Liver enzyme elevation was defined as aspartate transaminase or alanine transaminase levels ≥ 3 × the upper limit of normal

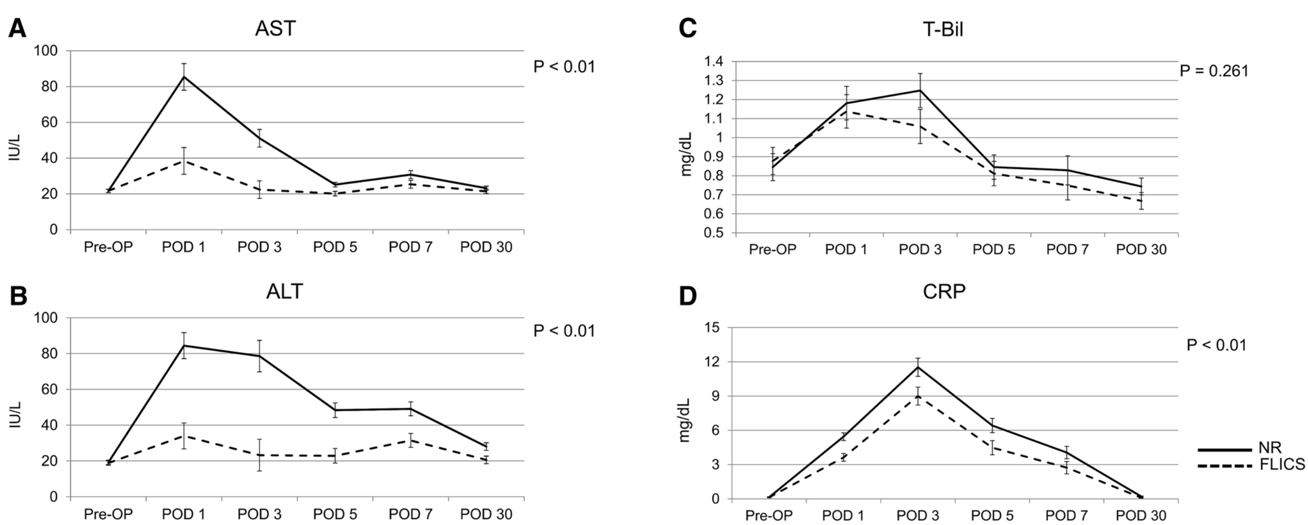

Fig. 4 Liver damage and inflammation after laparoscopic distal gastrectomy for gastric cancer, comparing liver retraction methods: flexible liver retraction with clipping and suturing (FLICS) versus Nathanson liver retractor (NR). **A** Aspartate transaminase (AST). **B** Alanine transaminase (ALT). **C** Total bilirubin (T-Bil). **D** C-reactive protein (CRP). *Pre-OP* preoperative value, *POD* postoperative day. Data are reported as means ± SD

AST/ALT and volume of the lateral segment of the liver, there was no statistical correlation ($P = 0.22$).

Discussion

The present study demonstrated that FLICS, our new liver retraction method, was associated with only minimal transient elevation of liver enzymes and did not cause liver injury. FLICS avoids liver injury and adequately secures the operative field. Despite providing a good surgical field, the NR has reportedly caused a number of complications, including hepatic hematoma, liver necrosis, liver failure, atrophy, and other injuries [24–28]. In a study using computed tomography, postoperative liver abnormalities were seen after use of the NR in 14 of 52 (27%) patients who had undergone laparoscopic gastrectomy for cancer and 2 of 11 (18%) who had had laparoscopic bariatric surgery [28]. Persistent strong retraction of the liver can result in damage that goes unnoticed intraoperatively [8]. Various liver retraction methods have been reported to reduce damage to the liver [12, 17, 29, 30]. Kitajima et al. [17] suggested that liver damage could be prevented when using the NR by limiting the duration of liver retraction, periodically repositioning the retractor, or intermittently releasing it. Shinohara et al. [12] advocated the use of Penrose drains to retract the liver, which resulted in less damage to the organ than did the NR. Although they demonstrated that their technique was safe and effective, it is technically difficult to prepare. Our FLICS method can be continuously deployed to mobilize the liver to the patient's upper right side, allowing a clear surgical field. It is adaptable by changing the traction on the sutures, allowing adjustment as needed of fixation of the liver as well as normal respiratory variation.

In our study, increases in both liver enzymes and CRP values were lower in the FLICS than in the NR group. Occult liver damage indicated by transient increases in liver enzymes after laparoscopic surgery may be caused by a number of factors, including the trauma of surgery, anesthetic agents, the type of surgery, liver retraction, and induction of a pneumoperitoneum [11, 12, 31, 32]. Continuous pressure on the liver leads to local ischemia, which contributes to elevation of liver enzyme levels [17]. In addition, liver ischemia can lead to an elevated CRP [33]. The fact that increases in liver enzyme and CRP levels were less marked in the FLICS than the NR group confirms that FLICS is a safer retraction method. In the FLICS group, there was a possibility that continuous pressure on liver disappeared, and shortening of the operation time due to the standardization of the liver retraction technique could have influenced the elevation of liver enzymes and CRP. In addition, the reduction in postoperative complications may be a benefit of liver retraction, which provides a convenient and good surgical view. We believe that the overall reliability of our results is enhanced by the one-to-one matching of the study groups using PSM, which should have reduced the influence of unknown confounders.

We believe that this new liver retraction method enables various applications in upper abdominal surgery, including gastric cancer surgery as well as bariatric surgery. Even in bariatric surgery and functional disease surgery, effective liver retraction methods have been studied and requested [34]; however, iatrogenic liver damage has been a problem in conventional surgeries [35, 36]. The additional wound increases the risk of wound-related complications and scarring. In that respect, our new method, which is free of liver failure, has good surgical field deployment, and does not require additional skin incision, is very useful. In addition, our new method is considered to be applicable to surgeries other than gastric cancer surgery.

There are several limitations to this study. First, because it was based on retrospective data collected in a single institution, the number of cases was relatively small. Second, although the safety and effectiveness of the new method have been demonstrated, considerably fewer cases performed with the NR were included in the database, further reducing the number analyzed once PSM was performed. Third, over the 5-year study period, changes were made in hospital policy to reduce the length of hospitalization. Therefore, comparison of the length of stay between the two groups was not reliable, as more patients in the NR group were treated earlier in the study period and those in the FLICS group later in the study period.

Conclusion

Our new FLICS liver retraction method provides an optimal surgical field without inducing liver dysfunction. It is simple to use, and the present study has demonstrated its safety and effectiveness. We intend to continue using the FLICS technique and plan to accumulate more cases to allow ongoing review of its utility.

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Compliance with ethical standards

Disclosures Drs. Yuki Ushimaru, Takeshi Omori, Yoshiyuki Fujiwara, Yuji Shishido, Yoshitomo Yanagimoto, Keijirou Sugimura, Kazuyoshi Yamamoto, Jeong-Ho Moon, Hiroshi Miyata, Masayuki Ohue, and Masahiko Yano have no conflicts of interest or financial ties to disclose.

Ethics statement All procedures in this study were in accordance with the ethical standards of the responsible committee on institutional human experimentation and with the Helsinki Declaration of 1964 and later versions.

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