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MULTIMEDIA ARTICLE

A Protective Technique for Retraction of the Liver During Laparoscopic Gastrectomy for Gastric Adenocarcinoma: Using a Penrose Drain

Toshihiko Shinohara · Seiichiro Kanaya · Fumihiro Yoshimura · Yoshihiro Hiramatsu · Shusuke Haruta · Yuichiro Kawamura · Simone Giacopuzzi · Tetsuji Fujita · Ichiro Uyama

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Abstract

Background Retraction of the liver is necessary to ensure an adequate working space in laparoscopic surgery, but the retraction force applied may cause transient liver dysfunction. We have introduced the technique using a Penrose drain to suspend the liver with the performance of laparoscopic gastrectomy for gastric adenocarcinoma.

Methods 111 patients with gastric adenocarcinoma underwent laparoscopic gastrectomy using either a Penrose drain (n=47) or a Nathanson's retractor (n=64) for displacement of the liver. Serum levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, alkaline phoshatase (ALP) and albumin were compared among the groups at baseline, immediately after operation, and on postoperative days (POD) 1, 2, 3, 5, and 7.

Results The levels of ALT on POD 2, 3, and 5 were significant higher in the Nathanson's retractor group than in the Penrose drain group. Levels of AST on POD 2 and 3 were also higher in the Nathanson's retractor group than in the Penrose drain group. There was no significant difference in total bilirubin, ALP, and serum albumin levels between groups.

Conclusions The use of the Penrose drain for retraction of the liver appears to attenuate postoperative liver dysfunction during laparoscopic gastrectomy for gastric adenocarcinoma.

Keywords Laparoscopic gastrectomy · Stomach neoplasm · Liver dysfunction · Liver retraction · Penrose drain

Introduction

Postoperative liver dysfunction is frequently encountered after laparoscopic surgery. In 1994, Halevy et al.[1] first pointed out transient derangement of liver function following laparoscopic cholecystectomy in the absence of bile duct injury. They showed the possibility that increased intra-abdominal pressure under the CO2 pneumoperitoneum could decrease hepatic perfusion and cause transient liver dysfunction. As to the hemodynamic state of the liver, the effect of the CO2 pneumoperitoneum on hepatic perfusion during laparoscopic surgery remains controversial.[2–7] Several authors have investigated other possible risk factors for liver dysfunction associated with laparoscopic surgery, such as inadequate patients position, specific type of procedure, adverse effects of anesthetic agents, division of the aberrant hepatic artery, inadvertent thermal injury during surgery, and liver contusion from a surgical liver retractor.[1,3,8–11]

The lateral segment of the liver often interferes with the extension of surgical field during surgery for patients with diseases of the upper abdomen. For displacement of the liver, various surgical liver retractors have been usually applied.[10–13] However, such mechanical retractors can cause focal hepatic injury that may result in hepatocellular damage, consequent postoperative transient rise in amino-

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T. Shinohara (✉) · S. Kanaya · F. Yoshimura · Y. Hiramatsu · S. Haruta · Y. Kawamura · S. Giacopuzzi · I. Uyama
Department of Surgery,
Fujita Health University School of Medicine,
1-98 Dengakugakubo, Kutsukakecho, Toyoake,
470-1192 Aichi, Japan
e-mail: shinohara@jikei.ac.jp

T. Shinohara · T. Fujita
Department of Surgery, The Jikei University School of Medicine,
Tokyo, Japan

transferases.[9,11] Therefore, to reduce postoperative liver dysfunction, a protective technique for retraction to enable visualization of the operative field is desirable. For this purpose, we have introduced a simple technique using a Penrose drain to suspend the liver with the successful performance of 42 laparoscopic gastrectomies for gastric adenocarcinoma.[13] To assess whether the liver dysfunction can be reduced by this technique, we performed a prospective nonrandomized observational study.

Methods

This study was conducted after Institutional Review Board approval of from Fujita Health University School of Medicine. Between October 2007 and March 2009, 111 patients who underwent laparoscopic gastrectomy with curative intent were included in the present study. Patients with chronic liver damage and a history of alcohol abuse or liver disease such as hepatitis B virus, hepatitis C virus, and acute viral hepatitis were excluded from the study. Patients who underwent palliative resection and in whom sacrifice of an aberrant left hepatic artery during the operation and patients who underwent concomitant cholecystectomy were excluded from the study.

The premedication and anesthesic techniques for laparoscopic gastric surgery were standardized during the study period. Briefly following, general anesthesia was assisted with an epidural block, CO2 pneumoperitoneum was maintained at 10 mmHg and each patient was placed in reverse Trendelenburg position with the legs held apart. After completion of the CO2 pneumoperitoneum, a Penrose drain was used in 47 patients, and a Nathanson's liver retractor was used in the remaining 64 patients to displace the lateral segment of the liver and provide a wide view of the operative field. The Penrose drain measuring 6 mm in width was threaded with three pieces of 2-0 nylon thread 5 cm apart (Fig. 1a). First, the end of the nylon thread at the center was placed in the space between the diaphragm and the liver below the small hole that has been prepared in the left triangular ligament of the liver, and then pulled out to the ventral side of the liver through the small hole. Next, the nylon thread is pulled out through the abdominal wall using an End Close™ (Covidien, Mansfield, MA, USA; Fig. 1b). The End Close™ was introduced from the position slightly caudal to the right costal arch into the peritoneal cavity so that it emerged through the abdominal wall at the right side of the falciform ligament of the liver. The nylon thread on the right side of the Penrose drain was grasped and directed outside the abdomen. Finally, the End Close™ was inserted into the peritoneal cavity from the area around the left costal arch: the nylon thread at the left was led out of the body (ESM 1). The lateral segment of the liver was suspended while being held at three points (Fig. 2). The Nathanson's liver retractor was introduced close to the xiphoid process and then placed on the lateral segment of the liver. Surgery was performed by the same surgical team with a standardized laparoscopic technique. All patients were selected for the Penrose drain or Nathanson's liver retractor at the discretion of the surgeon's preference, but different surgeons utilized one technique over another. Furthermore, there was not an inherent selection bias by the surgeons who used both techniques. Laparoscopic gastrectomy was completed using the methods originated by us as described previously.[12–14]

All relevant clinical data were prospectively collected and recorded including patient demographics, types of gastrectomy, operation time, estimated blood loss, incidence of concomitant splenectomy, extent of lymph node dissection, presence or absence of postoperative complications, length of postoperative hospital stay, depth of tumor invasion, patho-

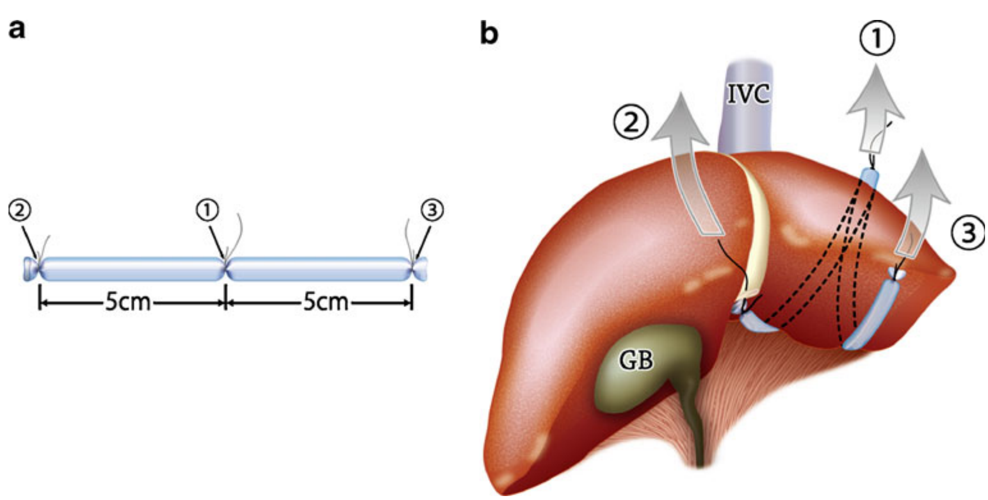

Fig. 1 Schematic illustration of suspension the lateral segment of the liver using a Penrose drain. **a** Formation of the Penrose drain, **b** the nylon thread at the right side of the Penrose drain (*2*) penetrated through the inferior margin of the round ligament of the liver

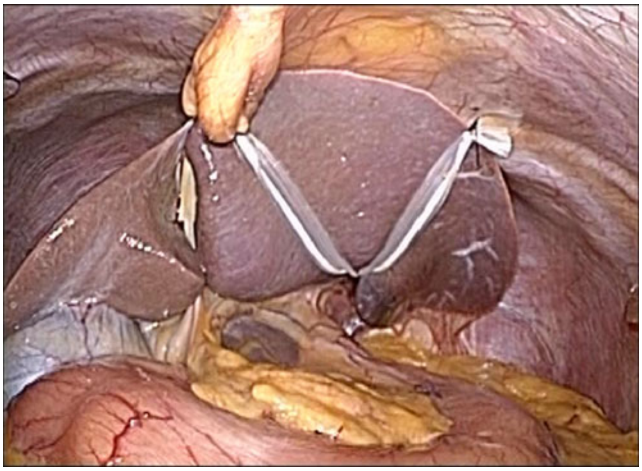

Fig. 2 Appearance of completed, suspending the liver by the Penrose drain. This technique provided satisfying view of the working fields during laparoscopic gastrectomy

logical type. All patients had routine hematological surveys of liver function assessed by alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, alkaline phoshatase (ALP), and albumin prior to and immediately after operation and on postoperative days (POD) 1, 2, 3, 5, and 7. The normal ranges for these parameters are 6–30 IU/L for ALT, 13–33 IU/L for AST, 0.3–1.2 mg/dl for total bilirubin, 115–359 IU/L for ALP, and 4.0–5.0 for albumin.

Results

As previously mentioned, 47 patients (42.3%) had laparoscopic gastrectomy using the Penrose drain for liver retraction that took less than 10 min in all cases, whereas the Nathanson's liver retractor was used in a group of 64 patients (57.7%). Both techniques provided a satisfactory view of the working fields during laparoscopic gastrectomy and we encountered no complications requiring any treatments during retraction of the liver. There was no significant difference between groups in age, sex ratio, preoperative body mass index, the depth of tumor invasion, and histological type (Table 1).

The operative outcomes are summarized in Table 2. All operations were accomplished using an entirely laparoscopic approach. The two groups were similar in types of gastrectomy, operation time, estimated blood loss, incidence of concomitant splenectomy, extent of lymph node dissection, presence or absence of postoperative complications, and length of postoperative hospital stay. No patients in either group received a blood transfusion during or after the operation.

There was no significant difference between groups in the patient's baseline levels of each liver function tests. Circulating ALT and AST levels increased significantly from baseline within 24 h following operations in each group. The levels of serum ALT on POD 2, 3, and 5 were statistically significant higher in the Nathanson's liver retractor group (mean ± SD, 213.8±30.9 IU, 146.6±20.6 IU, and 98.0±13.4 IU) than in the Penrose drain group (124.0±11.5 IU, 90.2±7.8 IU, and 60.9±4.1 IU; P=0.008, P=0.012, and P=0.010, respectively; Fig. 3a). Furthermore, levels of serum AST on POD 2 and 3 were significant higher in the Nathanson's liver retractor group (mean ± SD, 173.0±23.4 IU and 72.0±8.1 IU) than in the Penrose drain group (94.3±8.5 IU and 50.9±4.1 IU; P=0.002 and P=0.022, respectively; Fig. 3b). Peak AST occurred on POD 1 and gradually returned to preoperative values after 7 days in each group. The ALT also peaked at 24–48 h following operation and gradual decreased but did not return to the normal range within 7 days in each group.

The total bilirubin levels peaked at POD 1 both in the Nathanson's liver retractor and the Penrose drain group. The levels did not differ between groups (mean ± SD, 1.26±0.43 and 1.78±1.26 mg/dl; P=0.302). The ALP levels decreased

Table 1 Comparison of patient characteristics

	Penrose drain (n=47)	Nathanson's retractor (n=64)	P value
Age, year	64.8±10.6	62.8±10.0	0.310
Sex, n (%)			0.683
Female	13 (27.7)	20 (31.2)	
Male	34 (72.3)	44 (68.8)	
Body mass index, kg/m^2	21.8±3.9	21.4±2.6	0.519
Depth of tumor invasion[a]; n (%)			0.740
Early (cT1)	22 (46.8)	32 (50.0)	
Advanced (cT2, T3, T4)	25 (53.2)	32 (50.0)	
Pathological type[a], n (%)			0.680
Intestinal	29 (61.7)	37 (57.8)	
Diffuse	18 (38.3)	27 (42.2)	

An unpaired t test was used to determine statistical significance between means

The chi-square test was used to test the equality of percentages between dichotomous groups

[a] According to the guidelines of the Japanese Research Society for Gastric Cancer[18]

Table 2 Comparison of operative outcomes

	Penrose drain (*n*=47)	Nathanson's retractor (*n*=64)	*P* value
Operation time, min	308.7±79.1	333.81±95.6	0.145
Blood loss, ml	129.9±36.4	88.3±12.2	0.283
Type of resection, *n* (%)			0.244
Distal gastrectomy	35 (74.5)	41 (64.1)	
Total gastrectomy	12 (25.5)	23 (35.9)	
Concomitant splenectomy, *n* (%)			0.463
Yes	7 (14.9)	13 (20.3)	
No	40 (85.1)	51 (79.7)	
Lymph node dissection[a], *n* (%)			0.695
D1	26 (55.3)	33 (51.6)	
D2	21 (44.7)	31 (48.4)	
Postoperative complications, *n* (%)			0.129
Yes	4 (8.5)	12 (18.7)	
No	43 (91.5)	52 (81.3)	
Postoperative hospital stay, days	17.0±2.4	21.1±2.2	0.218

An unpaired *t* test was used to determine statistical significance. The chi-square test was used to test the equality of percentages between dichotomous groups. The Fisher exact test was used when a table had a cell with an expected frequency of <5

[a] According to the guidelines of the Japanese Research Society for Gastric Cancer[18]

postoperatively and reached their lowest levels at POD 2 in the Nathanson's liver retractor group and the Penrose drain group. There was no significant difference in ALP levels between groups (mean ± SD, 172.6±50.3 and 183.8±53.8 IU/L; P=0.329). Serum albumin levels also decreased immediately and reached their lowest levels on POD 1 in the Nathanson's liver retractor and the Penrose drain group. The levels did not differ between groups (mean ± SD, 3.13±0.38 and 3.12±0.36 IU/L; P=0.917). There was no 30-day or in-hospital mortality or postoperative liver failure in either group.

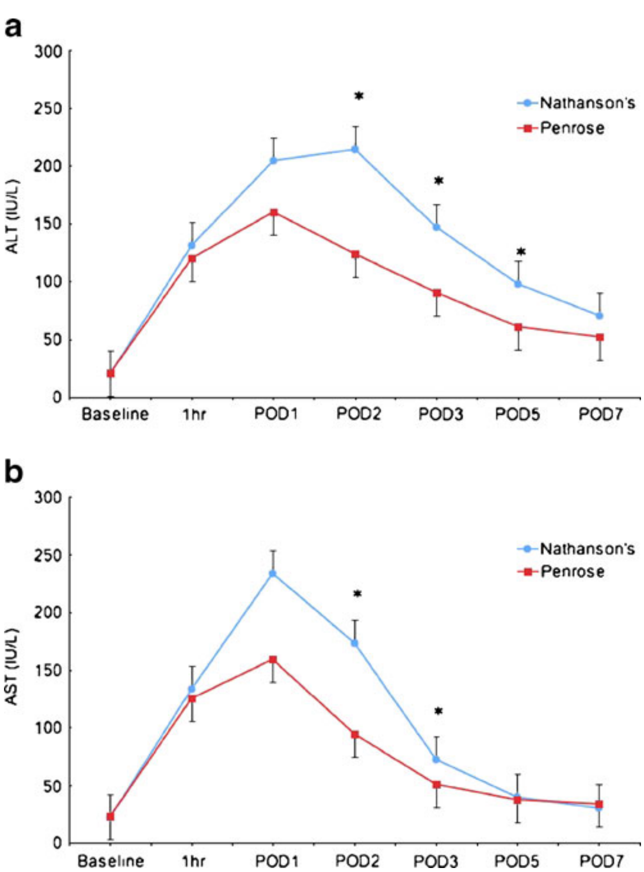

Fig. 3 Changes of ALT levels (**a**), AST levels (**b**) after laparoscopic gastrectomy. *Significant difference between groups

Discussion

Laparoscopic surgery has been established for the treatment of various types of diseases over the last decade. Despite its advantages over conventional open surgery in terms of less postoperative pain, shorter recovery time and improved cosmesis, a transient derangement in liver function has been recognized following various laparoscopic operations.[1,8–11,15,16] Our patients showed the evidence of a transient derangement in liver function after laparoscopic gastrectomy, as did patients with gastric adenocarcinoma in the reports by Etoh et al.[10] and Morris-Stiff et al.[11] Fortunately, serum AST and ALT levels gradually returned to the reference range in most patients with favorable clinical outcomes in all patients. However, minimizing liver dysfunction is important during the early postoperative period because the liver plays a crucial role in recovery from surgical stress and trauma. In the present study, we found that liver dysfunction could be decreased as evidenced by a reduction in serum ALT and AST levels by the use of the Penrose drain for liver retraction during laparoscopic gastric adenocarcinoma surgery.

The mechanisms of transient elevation of liver enzymes after laparoscopic resection may implicate several factors; including the presence, duration, and pressure of the CO_2

pneumoperitoneum, type of surgery, the effects of anesthetic agents, and local hepatic injury from a surgical retractor. Morino et al.[15] in a series of 52 patients who underwent laparoscopic surgery, have reported that the increase of postoperative liver enzyme was higher in the group performed at 14 mmHg of the CO2 pneumoperitoneum than those performed at 10 mmHg, and higher in the group with the CO2 pneumoperitoneum for a duration of >60 min than those of <60 min. They concluded that the elevation of liver enzymes caused by cytolysis had a significant correlation with the pressure and duration of the CO2 pneumoperitoneum during laparoscopic surgery.

Several recent researchers have evaluated the changes in liver enzymes following several types of laparoscopic surgery, and found that among the various procedures anti-reflux surgery, wherein extensive retraction is required to obtain adequate exposure of the esophagogastric junction, was significantly associated with postoperative liver dysfunction.[11,15] Practically, for patients with diseases of the cardia or upper stomach, sufficient exposure of the esophagogastric junction is vital for safe laparoscopic surgery and such extensive retraction may results in an hepatic cell damage, consequent more serious liver dysfunction after surgery.

It has been suggested that rigid retraction of the lateral segment of the liver is one of the mechanism for elevation of the aminotransferases. Yassa and Peters[17] noted visual signs of ischemia of the distal retracted liver after surgery for upper gastrointestinal malignancy. We have utilized the elastic retraction offered by the Penrose drain for over 200 cases, including patients with liver cirrhosis or those with large and friable livers and encountered no complications requiring any treatments. In our prospective cohort study, we excluded patients at high risks for postoperative liver dysfunction to compare the effect on liver function test of two liver retraction techniques. Furthermore, in our series, all the operations were carried out in the same fashion and all the patients received similar anesthetic agents. Nevertheless, ALT and AST levels were statistically significant higher in the Nathanson's liver retractor group than in the Penrose drain group, suggesting that transient liver dysfunction during laparoscopic gastrectomy was influenced by the type of liver retractor.

From a clinical standpoint, these changes were transient and thought to clinically be insignificant. In addition, the long-term oncological significance of this for patients with gastric adenocarcinoma remains unclear. However, "hepatocytes" have vital roles in the synthesis and metabolism of essential body defense proteins and carrier proteins. In the current study, transient liver rises were identified, but were evidently alleviated by using the Penrose drain technique during laparoscopic gastrectomy for gastric adenocarcinoma.

Conclusion

This technique is easy and safe to perform and thus could be performed without requiring any specific training. Retraction of the liver is necessary to ensure adequate working space in laparoscopic surgery involving the upper abdominal organs, so we believe that this technique is useful for the treatment not only of laparoscopic gastrectomy, but also of laparoscopic anti-reflux surgery, vagotomy, and obesity surgery.

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