J Gastrointest Surg (2008) 12:1115–1120
DOI 10.1007/s11605-008-0469-z

Outcome of and Risk Factors for Incisional Hernia After Partial Hepatectomy

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Received: 20 September 2007 / Accepted: 7 January 2008 / Published online: 23 January 2008
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Abstract
Introduction This study was conducted to analyze differences among abdominal incisions, and risk factors for incisional hernia after partial hepatectomy.
Materials and Methods In 626 posthepatectomy cases, we analyzed retrospectively the distribution regarding the type of incision and assessed risk factors for incisional hernia.
Results Of the patients, 95 (15.2%) had median incisions, 233 (37.2%) had J-shaped incisions, 206 (32.9%) had right transverse incisions with vertical extensions in the midline from the subumbilical region to the xiphoid process (RTVE), and 92 (14.7%) had bilateral transverse incision with a vertical extension to the xiphoid process (a reversed T incision). The respective frequencies of incisional hernia after median, J-shaped, RTVE, and reversed T incisions were 6.3, 4.7, 5.4, and 21.7%, so that the difference between reversed T and other incisions was significant. A diagnosis of "no hernia" required a minimum follow-up of 12 months. The risk factors for incisional hernia were incision type, postoperative ascites, body mass index, repeat hepatectomy, and steroid use in multivariate analysis.
Conclusion The incidence of incisional hernia after reversed T incision was significantly higher than after other incisions. If incision extension is necessary, the midline incision should be extended from the subumbilical region.

Keywords Hepatectomy · Incisional hernia · Risk factor

Introduction

Incisional complications include not only incisional hernia but also wound dehiscence and wound infection. However, incisional hernia can occur long after surgery.

The risk factors for incisional hernia are age,[1] smoking,[2] nutritional status,[3] diagnoses of cancer, diabetes[4] or obesity,[5] and the nature of the surgical procedure (palliative or radical). With respect to abdominal procedures, several studies have also shown that type of incision plays a role. For example, compared to vertical abdominal incisions, transverse incisions are associated with a lower incidence of dehiscence, hernia, and overall wound complications.[6] However, only one report has been found about patients undergoing hepatic resection.[7]

The aim of this study was to analyze the differences among abdominal incisions and the risk factors for incisional hernia after hepatectomy.

Materials and Methods

Between January 1991 and June 2006, 684 consecutive patients who underwent elective liver resection at Yokohama City University Hospital were enrolled in this study. Patients who were concomitantly treated with the resection of other organs, resection and anastomosis of the bile duct, drainage, and resection and anastomosis of the digestive tract were excluded. Perioperatively, 5 patients died, and 53

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died of cancer recurrence within 1 year after surgery. These 58 patients were excluded from this study.

Type of Incision

A J-shaped incision was defined as a right transverse incision with a vertical extension at the midline to the xiphoid process. An RTVE incision was defined as a right transverse incision with a vertical extension at the midline from the subumbilical region to the xiphoid process. A reversed T incision was defined as a bilateral transverse incision with a vertical extension to the xiphoid process (Fig. 1).

Concerning the selection of the incision type for hepatectomy, a median or reversed T incision was performed for tumors located in the left lobe, a J-shaped incision for tumors located in the right lobe, and a reversed T or RTVE incision for large tumors (Table 1).

Intraoperative Procedure

The liver resections performed were defined according to the Couinaud classification.[8, 9] Liver resections combined with other major nongastrointestinal procedures (vascular resection, diaphragmatic resection, lung resection, adrenectomy, and lymphadenectomy) or associated with additional hepatic procedures (contralateral resection or ablation, or

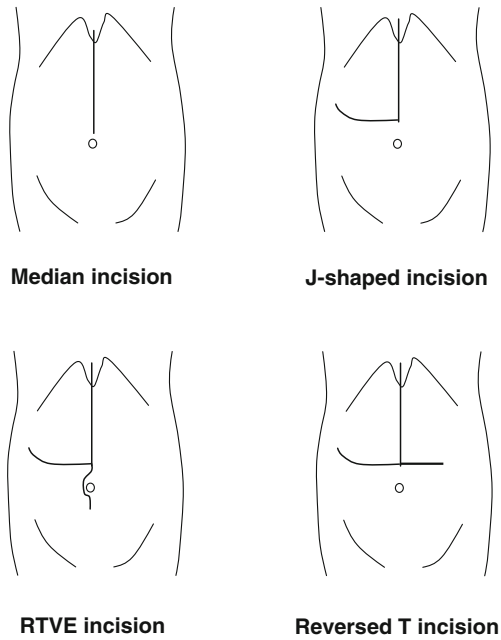

Figure 1 Types of incision. A J-shaped incision was defined as a right transverse incision with a vertical extension at the midline to the xiphoid process. An RTVM incision was defined as a right transverse incision with a vertical extension at the midline from the below the umbilicus to the xiphoid process. A reversed T incision was defined as a bilateral transverse incision with a vertical extension to the xiphoid process.

Table 1 Site of Incisional Hernia According to Abdominal Incision

Site	Median (n=95)	J-shaped (n=233)	RTVE (n=206)	Reversed T (n=92)
Right lateral abdomen	–	3	0	2
Trifurcation or bifurcation	–	3	6	11
Median area	6	5	5	5
Left lateral abdomen	–	–	–	2
Total	6	11	11	20

both) were included. Routine administration of prophylactic antibiotics was performed with the induction of anesthesia and then usually continued for 72–120 h after the completion of surgery.[10] The types of antimicrobial prophylaxis used were left to the judgment of the physician in charge.

Closure of Abdominal Wall

Closure of the abdominal wall muscle and fascia was performed using layered closure with an no. 1 interrupted silk suture or no. 1 Ethigard (Ethicon, Somerville, NJ, USA). Skin closure was done using a silk suture, nylon, or a skin stapler.

Postoperative Management

Postoperative management was similar for the entire cohort. All patients were monitored in the intensive care unit on the first postoperative night and were then transferred to a general ward. Postoperative pain control was performed by fentanyl citrate infusion via an epidural tube inserted during the operation in patients in whom the preoperative coagulation function was relatively well maintained, and the tube was, in principle, removed 3 days after the operation. For additional analgesia, Pentagin® or fentanyl was intravenously injected.

The remaining cavity was drained using large-bore silastic drains connected to a closed collecting system (suction pressure=10 cm H_2O). The drains were usually left in place until the drainage fluid was serous and the daily loss was below 100 ml. An open drainage system was sometimes selected in the early period (from January 1991 to March 1997).

Follow-up

A diagnosis of “no hernia” required a minimum follow-up of 12 months. No patients were lost to follow-up within 2 years. The duration of follow-up was 12 to 168 months, and the mean was 52.8 months. Until 2 years after operation, we performed a physical examination, including palpation every month, and took computed tomography (CT) scans every 3 months. From 2 to 5 years after operation, we performed a physical examination, including

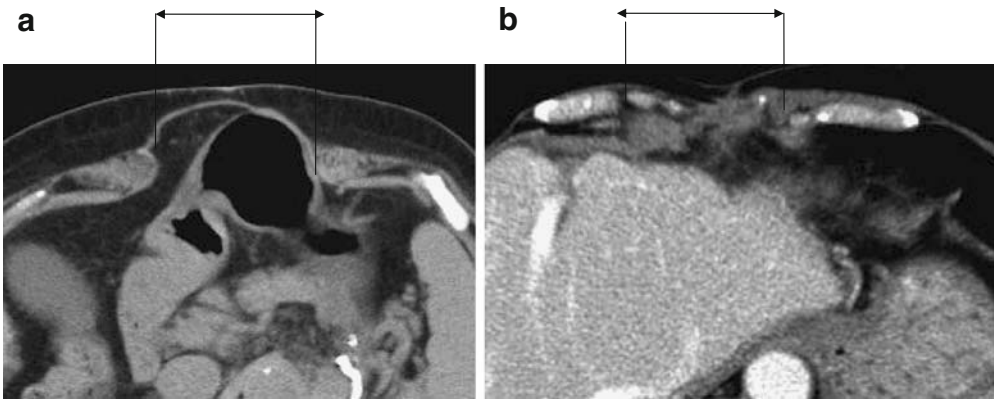

Figure 2 Computed tomograms of incisional hernias. In this study, not only incisional hernias that were covered with peritoneum and protruded from the abdominal wall (**a**) but also those in which fascial continuity of the abdominal wall was demonstrated by CT (**b**) were included in incisional hernias.

palpation every 2 or 3 months, and carried out a CT scan every 6 months. After 5 years, we performed physical examination, including palpation every 3 months, and did a CT scan every 6–12 months.

Diagnosis of Incisional Hernia

Incisional hernia was diagnosed based on a review of medical records and findings on CT. In general, a hernia is defined as a protrusion that is covered with the peritoneum and protrudes from the abdominal wall (Fig. 2a). In this study, when the fascial discontinuity of the abdominal wall was demonstrated by objective findings including palpation findings and CT-scans (Fig. 2b), even in the absence of a protrusion from the abdominal wall, the case was included in incisional hernias.

The definition of surgical site infection (SSI) followed that in the guidelines[11] for the prevention of surgical site infection issued by Centers for Disease Control and Prevention. Organ/space SSI occurred within 30 days after the operation; infection appeared to be related to the operation and involved any part of the anatomy (e.g., organ or spaces) other than the incision, which was opened or manipulated during the operation, and at least one of the following: (1) purulent drainage from a drain that was placed through a stab wound into the organ/space, (2) organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space, and (3) an abscess or other evidence of infection involving the organ/space found on direct examination during reoperation or by histopathologic or radiologic examination. Generally, wound infection was defined as incisional erythema requiring antibiotics or an incision opened for grossly infected or culture-positive fluid.[12]

Postoperative Ascites

Ascites was considered intractable when definitely observed by diagnostic imaging techniques such as CT and ultrasonography more than 1 month after the operation, despite diuretic administration (furosemide, 60 mg/day; Soldactone®, 75 mg/day or more), after removal of the drain.

Patient demographics, disease-related variables, operative variables, and the outcome were analyzed and compared among the incision types. The risk factors for incisional hernia after hepatectomy were estimated.

Statistics

Results are expressed as the mean+SD. Continuous variables were evaluated using the unpaired Student's *t* test and the Mann–Whitney test. Categorical data were compared using the χ^2 test and Fisher's exact test, where appropriate. Multivariate analysis was performed with logistic regression analysis, which had been programmed in STAT-view version 5.0 software (SAS Institute Inc., USA). A level of $P<0.05$ was considered significant.

Results

From January 1991 to June 2006, hepatic resection was performed in 684 patients, 626 (91.5%) of whom met the inclusion criteria of this study. Among them, 95 (15.2%)

- Rate of incidence: 7.7%(48/626)
- Time before occurrence: 2-23 months, 9.5±5.2 months

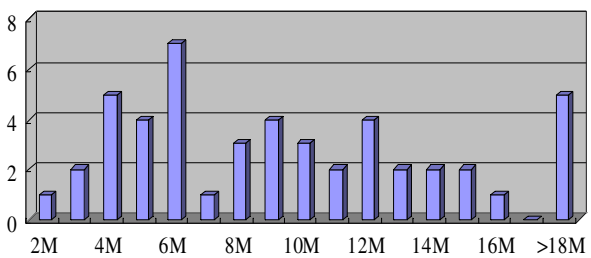

Figure 3 Incidence of incisional hernias. Of all patients, 48 (7.7%) had an incisional hernia. Incisional hernias developed 2–23 months (mean, 9.5 months) after hepatectomy.

Table 2 Patient Profiles

	Median	J-shaped	RTVE	Reversed T	*P* value
Number	95	233	206	92	
Age	63.3±10.1	61.9±11.6	61.5±11.0	61.6±9.7	0.6034
Sex (M/F)	54:41	155:78	143:63	69:23	0.0532
HCC/LM/Other	$36/50/9_{a}$	$108/99/26_{a}$	$82/119/5_{b}$	$37/47/8_{a}$	0.0050
Underlying disease (NL/CH/LC)	65/11/19	127/51/55	129/44/33	52/22/18	0.1091
DM (+/+/−)	73/8/14	166/34/33	127/41/38	58/17/17	0.0988
Smoking (+/+/−)	$27/13/55_{b}$	$107/50/76_{a}$	$98/34/74_{a}$	$40/13/39_{ab}$	0.0015
BMI	22.3±2.9	22.4±3.0	22.3±3.1	22.8±3.3	0.5648
Steroids (Y/N)	0/95	3/230	1/205	0/92	0.4198
Pulmonary dis. (Y/N)	4/91	8/225	11/195	6/86	0.6208
Alb	$4.05±0.46_{ab}$	$4.04±0.45_{a}$	$3.98±0.41_{b}$	$3.96±0.47_{b}$	0.0022
T-bil	0.77±0.36	0.77±0.39	0.77±0.35	0.76±0.36	0.9927
ICG15R	13.6±10.7	13.5±9.8	12.3±7.9	13.3±6.9	0.1365

HCC Hepatocellular carcinoma, *LM* liver metastasis, *NL* normal liver, *CH* chronic hepatitis, *LC* liver cirrhosis, *DM* diabetes mellitus, *BMI* body mass index, *Alb* albumin, *T-bil*, total bilirubin, *ICG15R* indocyanine green retention test

had a median incision, 233 (37.2%) had a J-shaped incision, 206 (32.9%) had an RTVE incision, and 92 (14.7%) had a reversed T incision. Perioperative mortality was identical in the four groups.

Of the total, 48 patients (7.7%) developed incisional hernia. Incisional hernias developed 2–23 months (mean, 9.5 months) after hepatectomy (Fig. 3). The site of hernias was frequently the trifurcation and median areas and infrequently the lateral abdominal area (Table 2).

Table 3 summarizes the association of demographics and preoperative variables with the incision type. Among the four incision types, there were no significant differences in terms of gender, primary disease, underlying disease, diabetes mellitus, body mass index (BMI), use of steroids, presence of lung disease, serum albumin, total bilirubin, and ICG 15. On the other hand, Table 4 summarizes the association of demographics and intraoperative and postoperative variables with incision types. The blood loss and transfusion volume were definitely smaller for the median and J-shaped incisions than for the reversed T and RTVE incisions. The resected proportion was significantly smaller for the median incision than for the other three types of incision. Although there may be period-associated differences, the use of silk and SSI were frequently observed for the RTVE and reversed T incisions. The incidence of postoperative ascites did not differ among the types of incision.

The respective frequencies of incisional hernia after median, J-shaped, RTVE, and reversed T incisions were 6.3, 4.7, 5.4, and 21.7%. The difference between reversed T and other incisions was significant (Table 5).

Risk Factors for Incisional Hernia After Partial Hepatectomy

Of the 626, 48 developed incisional hernia. A total of 21 independent clinical variables, including 11 preoperative

Table 3 Patient Profiles

	Median	J-shaped	RTVE	Reversed T	*P* value
Number	95	233	206	92	
Repeated Hx (Y/N)	8/87	20/213	20/186	15/73	0.1339
Op. length (min)	$317±149_{c}$	$360±120_{b}$	$480±143_{a}$	$445±139_{a}$	<0.0001
Blood loss (ml)	$700±708_{c}$	$1098±907_{b}$	$2175±2707_{a}$	$1926±3356_{a}$	<0.0001
Transfusion (ml)	$267±362_{a}$	$202±362_{a}$	$822±1261_{b}$	$622±1331_{b}$	<0.0001
Tumor diameter (mm)	$33.6±22.6_{c}$	$43.4±33.0_{b}$	$51.2±47.0_{ab}$	$58.9±57.8_{a}$	0.0009
Proportion resected	$17.3±10.2_{b}$	$32.1±19.1_{a}$	$32.4±20.8_{a}$	$28.7±24.3_{a}$	<0.0001
Suture (Silk/AS)	$44/51_{b}$	$37/196_{ab}$	$148/58_{a}$	$55/37_{b}$	<0.0001
SSI (Y/N)	$9/86_{c}$	$9/222_{a}$	$43/163_{ab}$	$12/80_{bc}$	<0.0001
Wound infection (Y/N)	4/91	5/228	9/197	4/88	0.5611
Ascites (Y/N)	2/93	14/219	13/193	7/85	0.3820

SSI Surgical site infection

Table 4 Incidence of Incisional Hernia According to Abdominal Incision

	Median (n=95)	J-shaped (n=233)	RTVE (n=206)	Reversed T (n=92)
Incidence (%)	6 $(6.3)_a$	11$(4.7)_a$	11 $(5.4)_a$	20$(21.7)_b$

P<0.01

and 10 surgical variables, were analyzed univariately as possible risk factors for incisional hernia. Eleven of these were significant: age, underlying disease, presence of diabetes mellitus, BMI, use of steroids, pulmonary disease, incisional type, repeat hepatectomy, proportion resected, use of absorbable sutures, and ascites (Table 6).

Multivariate analysis using a logistic regression model involving the 11 significant factors determined by univariate analysis identified five significant independent variables: BMI, use of steroids, incisional type, repeat hepatectomy, and ascites (Table 7). According to logistic analysis, if the reversed T incision was performed, the risk of incisional hernia would increase by 4.775 times.

Discussion

Wound complications such as infections, dehiscence, and hernia are a common cause of extended hospitalization, outpatient care, and increased costs associated with surgery.[13] Wound complications, especially incisional hernia, may have a broader impact, such as a delayed return to work, resulting in lost wages, and a decreased quality of life or performance status while patients are recovering at home after the operation. Therefore, avoidance of the development of incisional hernias may be useful for both patient well-being and cost-effectiveness.

Incisional hernias are one of the most common complications of abdominal surgery, with an overall estimated incidence ranging from 3 to 15.7% after abdominal operations.[14, 15] Generally speaking, the incidence of incisional hernia in Western countries is higher than that in Asia. There have been only a few studies on the incidence of incisional hernias after hepatic surgery. However, living-donor liver transplantation has been increasingly performed for terminal liver failure, and the incidence of incisional hernias are now being reported for the safety and quality of life of donors. Based on these reports, the incidence of incisional hernias was 3–20%.[16, 17] Because donors undergoing surgery are generally healthy, there are only a few donors with risk factors for the development of incisional hernias. However, the incidence was high.

Table 5 Risk Factors for Incisional Hernia after Hepatectomy (Preoperative)

	Hernia Gr. (n=48)	No hernia Gr. (n=578)	P value
Age	65.2±9.3	61.7±10.9	0.0321
Sex (M/F)	29/19	392/186	0.6636
Disease (HCC/LM/OT)	26/19/3	237/296/45	0.2065
Underlying disease (NL/CH/LC)	22/10/16	351/109/118	0.0428
DM (+/+/−)	9/16/23	93/84/401	0.0015
Smoking (+/+/−)	17/8/23	199/102/277	0.9818
BMI	24.5±3.7	22.2±2.9	<0.0001
BMI (25</>25)	23/25	100/478	<0.0001
Steroids	2/46	2/576	0.0014
Pulmonary disease (+/−)	7/41	22/556	0.0006
Serum albumin	4.02±0.37	4.03±0.44	0.8938
Serum T-Bil.	0.74±0.31	0.77±0.37	0.6320
ICG-R15	14.9±8.2	12.8±8.6	0.1092

HCC Hepatocellular carcinoma, *LM* liver metastasis, *OT* other liver disease, *NL* normal liver, *CH* chronic hepatitis, *LC* liver cirrhosis, *DM* diabetes mellitus, *BMI* body mass index, *ICG15R* indocyanine green retention test

Table 6 Risk Factors for Incisional Hernia after Hepatectomy (Intraoperative, Postoperative)

	Hernia Gr. (n=48)	No hernia Gr. (n=578)	P value
Incision type (Med/J-sharp/XX/R-T)	6/11/11/20	89/222/195/72	<0.0001
Repeat Hx (Y/N)	13/35	50/528	<0.0001
Op. duration (min)	412±156	419±145	0.7485
Blood loss (ml)	1298±1262	1531±2240	0.4786
Transfusion (ml)	313±712	486±1007	0.4611
Proportion resected (%)	21.9±15.3	30.5±20.4	0.0078
Tumor diameter (mm)	39.6±32.3	48.0±43.4	0.2182
Sutures (silk/non-silk)	19/29	323/255	0.0293
SSI (Y/N)	9/39	63/516	0.1003
Ascites (Y/N)	9/39	27/551	<0.0001

HCC Hepatocellular carcinoma, *LM* liver metastasis, *OT* other liver disease; *Hx* hepatectomy, *SSI* surgical site infection

Table 7 Multivariate Analysis of Factors Contributing to Postoperative Infections, by Logistic Regression Analysis

	Variable	ARR	P value
Incisional type	rT	4.775 (2.313–9.857)	<0.0001
Ascites	+	4.373 (1.590–12.029)	0.0043
BMI	>25	4.573 (2.279–9.173)	<0.0001
Repeat Hx	+	4.081 (1.774–9.388)	0.0009
Steroids	+	48.845 (5.413–440.797)	0.0005

Values in parentheses are 95% confidence intervals.
ARR Adjusted relative risk

Liver resection sometimes requires a wide incision. Many patients who underwent liver resection were concerned about wound complications, especially incisional hernia. Most studies addressing the optimal incision for hepatic surgery focused on whether a thoracoabdominal incision is beneficial.[18] However, thoracoabdominal incisions are associated with higher rates of pulmonary complications such as atelectasis, pneumonia, and pleural effusion. There are few data that address which abdominal incision is best suited for partial hepatectomy. D'Angelica et al.[7] reported that the common incisions utilized for partial hepatectomy have been the Mercedes incision and extended right subcostal (ERSC) incision. He reported that an ERSC incision provides adequate, safe access and is associated with fewer long-term wound complications. We generally use a median or J-shaped incision. However, for large tumors, the incision is extended to the left lateral abdomen (reversed T incision) or downward (RTVE incision). A reversed T incision is often used for large tumors in the left lobe and an RTVE incision for those in the right lobe. In the evaluation of incisional hernias in this study, the reversed T incision including the Mercedes incision should be avoided if possible due to the high incidence of postoperative incisional hernias.

The exact mechanism responsible for the higher rate of hernia development with a reversed T incision is unknown. It has previously been speculated that factors that predispose incisions to hernia include ischemia[19] and infection.[20] In our study, ischemia may have been an important, potentially avoidable cause because SSI was not a risk factor of incisional hernia. An area of relative ischemia at the trifurcation point from the midline fascia to anterior and posterior sheaths of the rectus abdominis may have contributed to impaired healing and led to the development of a hernia. Considering that the most frequent site of incisional hernias was the trifurcation point, ischemia may be the main cause. In addition, postoperative tension in the abdominal wall may have aggravated this area, resulting in a delay in wound healing. Thus, in hepatectomy, the addition of a transverse incision to obtain a better visual field is necessary, and the median incision should be continuous with the transverse incision. When a good visual field cannot be obtained by this method, the median incision should be extended downward. The Mercedes and reversed T incisions, which are transverse extensions, are associated with a higher incidence of hernias. Therefore, the incision of the left rectus abdominis should not be made except in unavoidable cases such as giant tumors of the left lobe.

We concluded that the incidence of incisional hernia after a reversed T incision is significantly higher than that on other incisions. If incision extension is necessary, the midline incision should be extended to the subumbilical region.

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