Original article

Comparison of Outcome of Hepatectomy with Thoraco-abdominal or Abdominal Approach

Atsushi Nanashima, Syuuichi Tobinaga, Takafumi Abo,

Hiroaki Takeshita, Shigekazu Hidaka, Terumitsu Sawai,

Takeshi Nagayasu

Division of Surgical Oncology, Nagasaki University Graduate School of Biomedical Sciences, Nagasaki, Japan

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Reprint request to*:* Atsushi Nanashima, Division of Surgical Oncology, Nagasaki University Graduate School of Biomedical Sciences, 1-7-1 Sakamoto, Nagasaki 852-8501, Japan

Tel: +81-95-819-7304. Fax: +81-95-819-7306

E-mail: a-nanasm@net.nagasaki-u.ac.jp

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ABBREVIATIONS: Thoracoabdominal approach (TAA); Abdominal approach (AA)

Abstract

Background/Aims: Thoraco-abdominal approach is a suitable choice for hepatectomy to secure good view for mobilization. Aim of this study was to assess efficacy of thoraco-abdominal approach (TAA).

Methodology: We compared clinicopathological data, surgical results and postoperative complications of 425 consecutive patients who underwent hepatectomy via abdominal (AA) (n=147) or TAA (n=278).

Results: Blood loss and operating time were significantly higher in TAA than AA group (970 vs. 830ml and 408 vs. 372 minutes)($P<0.05$). Prevalence of pleural effusion were significantly higher in TAA than AA group (24 vs. 9%) ($P<0.01$). However, proportions of patients who developed hepatic complications such as biloma (14 vs. 23%), and wound infection (8 vs.25%) were significantly less in TAA than AA group ($P<0.05$). Hospital stay after hepatectomy and mortality were similar between both groups. Presence of chronic viral hepatitis, lower platelet count, higher level of serum hyaluronic acid, larger blood loss and TAA correlated significantly with thoracic complications ($P<0.05$). Multivariate analysis showed that increased blood loss ($P=0.011$), but not TAA, was a significant determinant of thoracic complications ($P=0.08$).

Conclusions: TAA can be considered a relatively safe approach for hepatectomy with minimal abdominal complications nevertheless of frequent pleural effusion.

INTRODUCTION

Prognosis of patients who undergo hepatic resection has markedly improved in recent years due to advances in surgical techniques and improvements in anaesthesia and peri-operative management (1, 2). To achieve safe hepatectomy, it is important to secure good operating view for mobilizing target liver lesion because surgical procedures under a limited view often result in large bleeding or vascular injury (3). Selection of the incisional approach is important to obtain a good operating view for hepatectomy and various approaches have been discussed (3, 4). Thoracotomy combined with laparotomy seems to be a useful choice for hepatectomy in the subphrenic areas or right lateral sector of the liver (4-6). The J-shape incision and right oblique incision entering the inter-costal space for thoracotomy have been proposed (5-9). While thoracic complications following thoracotomy have been discussed, the overall usefulness of these approaches has been reported (5). To our knowledge, evidence for or against hepatectomy through thoraco-abdominal approach (TAA) has not yet been presented.

The understanding of the advantages and disadvantages of thoracotomy would help select the best approach for hepatectomy. The aim of the present retrospective study was to assess the efficacy of the TAA for hepatic resection.

METHODOLOGY

The subjects were 425 consecutive patients with various liver diseases who underwent hepatectomy in the Division of Surgical Oncology, Nagasaki University Graduate School of Biomedical Sciences (NUGSBS) from 1994 to 2008. The study protocol was approved by the Human Ethics Review Committee of NUGSBS and a written informed consent for treatment was obtained from each patient. The present study was retrospectively analyzed but not randomized controlled study. Clinical data were consecutively retrieved from the NUGSBS database.

Subjects were divided into two groups based on the laparotomy; the abdominal approach (AA) group (n=278) and the TAA group (n=147). The AA using the J-shape incision is a standard approach (**Figure 1**), which consists of an upper median incision and transverse incision along the 10th intercostal space (9). For right-side hepatectomy for a large tumour, e.g., a tumour that directly invaded the right diaphragm, J-shape thoraco-laparotomy with an incision along the 9th intercostal space was selected. The TAA by the oblique incision along the 7th intercostal space (**Figure 2**) was selected for right lateral sectionectomy and limited resection of segment 7 or 8. Median laparotomy was selected for limited resection in segments 2-4 and left lateral segmentectomy. None of the hepatectomy procedures was performed by subcostal incision. Patients who underwent laparoscopic hepatectomies (n=22) during the study period were excluded because of differences of invasiveness. Parenchymal dissection was accomplished by the combination of the forceps fracture method and ultrasonic dissector under intermittent vascular clamping at hepato-duodenal ligament, the so-called ‘Pringle’s maneuver’(10, 11).

In our hospital, the volume of the liver to be resected is estimated pre-operatively based on the results of indocyanine green retention rate at 15 min (ICG R15) using the formula of Takasaki et al (12). The liver volume, excluding the tumour (cm^3), is measured by computed tomography (CT) volumetry (13). Essentially, the planned hepatectomy is performed when the permitted resected volume of the liver is greater than the estimated resected volume of the liver. The hepatic uptake ratio of 99m-technetium-galactosyl serum albumin liver scintigraphy (LHL15) was calculated to help in the decision making on the indication for hepatectomy (14, 15). In cases where the permitted resected volume was less than the estimated volume or the estimated volume was more than 65% in patients with normal liver and 50% in those with cirrhosis, pre-operative portal vein embolization (PVE) was performed (16). The clinical data, conventional liver function tests, surgical records, patient outcome and postoperative complications were analysed between groups.

Continuous data were expressed as mean ± SD. Data of the two groups were compared using one-way analysis of variance (ANOVA) or the Mann-Whitney's U-test. The Chi-square test was used to compare categorical data. Potentially predictive variables were identified using a significance level of $P < 0.05$ by univariate analysis. The identified factors were then entered into multivariate logistic regression analysis, and a two-tailed P value <0.05 was considered significant. Statistical analyses were performed using the STATISTICA™ software (StatSoft, Tulsa, OK). Cut-off values for age, operating time and blood loss were set up by the median value in the present data. Cut-off values of ICGR15, LHL15 by 99mTc-GSA and serum hyaluronic acid level were set up by the receiver operating characteristic (ROC) analysis in our preliminary studies (15, 17).

RESULTS

The subjects were 300 men and 125 women with a median age of 64.2 years (range, 24-86 years). The liver diseases warranting hepatic resection were hepatocellular carcinoma (n=159), metastatic liver carcinoma (n=159), intrahepatic cholangiocarcinoma (n=33), gall bladder carcinoma (n=23), extrahepatic bile duct carcinoma (n=28), benign liver disease (n=22) and liver trauma (n=1). Background liver pathology included chronic viral hepatitis (n=161) with cirrhosis in 66 of these (caused by hepatitis B virus in 91, hepatitis C virus in 65, and both viruses in 5), obstructive jaundice (n=17) and fatty liver (n=4). Liver biopsies of 243 patients showed normal liver histology. Child-Pugh classification was A in 408 patients and B in 17.

In this cohort, 247 patients underwent the J-shape incision for hepatectomy, 50 underwent subcostal incision, 56 underwent upper median incision, and 72 underwent the right oblique incision. Furthermore, partial resection was performed in 139 patients, segmentectomy in 39, sectionectomy in 91, hemihepatectomy in 84, and extended hemihepatectomy in 72 patients. Combined resection of major vessels was performed in 16 patients (3.8%). Post-operative hepatectomy-associated complications were recorded in 215 patients (50.6%): persistent ascites or pleural effusion (defined as massive ascites unresponsive to diuretics for more than 2 weeks) in 93 patients, biloma in 85, and hepatic failure (defined by a total bilirubin of >3 mg/dl on postoperative day 7 or death without other cause) in 23 patients. Thoracic complications including pleural effusion and atelectasis of the lung were observed in 60 patients. Ten patients died of hepatic failure within 30 days. Eighty one patients experienced wound infection.

Table 1 shows patient characteristics for both the AA and TAA group. The proportion of patients with normal liver was higher in the laparotomy group and that with chronic hepatitis was higher in the thoraco-laparotomy group. With regard to liver diseases, the proportion of patients with hepatocellular carcinoma was higher in the thoraco-laparotomy group than in the laparotomy group. **Table 2** shows data extracted from the surgical records. Subcostal and upper median incisions were performed only in the laparotomy group, while right oblique incision was performed in only the thoraco-laparotomy group. Equal proportions of patients of the two groups underwent the J-shape incision. Sectionectomy was more frequently performed in the two groups while partial resection was less frequently conducted in the TAA group than in the AA group. Blood loss and operating time were significantly higher in the TAA group than in the AA. **Table 3** lists the post-operative complications for both groups. The proportion of patients who developed post-operative complications including pleural effusion was significantly higher in the TAA group than in the AA group. On the other hand, the proportions of patients with post-operative biloma, uncontrolled ascites and wound infection were significantly lower in the TAA group than the AA group.

We also analyzed the relationships between various parameters and complications after hepatectomy by thoraco-laparotomy or laparotomy (**Table 4**). Univariate analysis showed that chronic viral hepatitis, lower platelet count (<100,000/mm^3), higher level of serum hyaluronic acid (≥150 ng/ml), large blood loss during surgery (≥800 ml) correlated significantly with complications after TAA. These parameters were then entered into multivariate analysis (**Table 5**), which identified large blood loss as the only significant factor associated with thoracic complications. TAA tended to correlate only marginally with post-operative complications but not significant.

Discussion

Previous reports showed various risk factors associated with post-hepatectomy complications such as liver failure, uncontrolled ascites and intra-abdominal infection (1-3, 18-21). Liver surgeons carefully select the extent or type of hepatectomy according to the preoperative functional liver reserve to avoid post-hepatectomy complications (13). A fine balance must be achieved between tumour curability and operative risk in some patients scheduled for hepatectomy, and surgeons often debate the most important or reliable predictive parameters to minimise complications before proceeding with surgery (13, 22, 23) For hepatic resection, the thoracotomy and thoraco-abdominal approaches have been proposed as a short access to the target lesions in the liver (4-9). A number of reports indicated that these procedures limit the mobilization of the liver, and thus lead to minimization of postoperative ascites and reduction of operation time (4-7). Based on these reports, we conducted hepatic resection under thoracotomy or thoracoscopic support (4, 9). However, it must be careful to select this approach because thoracotomy would be associated with postoperative pulmonary dysfunction or thoracic complications (5). On the other hand, in the majority of Western institutes, TAA incision is rarely applied for hepatectomy to avoid thoracic morbidity (24) and, however, only thoracotomy itself seems not to be an invasive procedure by experiences of thoracic surgeons at our institutes. To our knowledge, a full assessment of the complications following hepatectomy conducted under thoracotomy, by comparison with conventional laparotomy, has not been fully performed at this stage. To clarify efficacy or feasibility of TAA for hepatectomy, the present study was designed to examine the feasibility and disadvantages of thoracotomy-assisted hepatectomy.

The present study showed limited indication for TAA in patients with hepatocellular carcinoma or those with chronic liver dysfunction. Since the right oblique incision was applied in 72 patients, the majority of patients with hepatocellular carcinoma located in the right posterior sector or subphrenic segment 8 underwent thoracotomy. When the J-shape incision was made, thoracotomy was conducted in patients who underwent right-side hemi-hepatectomy or right tri-sectionectomy for large liver or biliary tumours. J-shape incision with thoracotomy was recommended by Makuuchi et al.(5) The advantage of this procedure is safety of hepatectomy through easy mobilization of the entire liver under good operative view. However, this approach might not be a popular incision in the Western institutes (24). Since the TAA group comprised a larger proportion of patients with chronic hepatitis or cirrhosis than the AA group, preoperative liver function tests were similar between the two groups. Therefore, patients with well-preserved liver function were mainly selected for TAA. Blood loss was significantly larger and operating time was longer in the TAA group compared with the AA group; which were probably due to the large hepatectomy with J-shape TAA. In patients with TAA with right oblique incision, blood loss and operating time seemed to lower than those who underwent right-side hepatectomy under laparotomy, in agreement with our previous reports (9, 25). Closure of thoracotomy or insertion of a thoracic tube might be needed based on our experience.

The present study showed more frequent postoperative complications in patients who underwent TAA than the other group. With regard to the thoracic complications, thoracotomy might cause pleural effusion after hepatectomy. On the other hand, intra-abdominal complications and wound infection were less frequently encountered in the TAA group. These results highlight the advantage of TAA. We speculate that the better operative view during hepatectomy could underline the low morbidity, although thoracotomy did not adversely affect the outcome after hepatectomy. Previous reports also indicated the lack of severe complications following thoracotomy per se (4-8). The present study focused on the relationship between thoracic morbidity and thoracotomy. Univariate analysis showed that chronic hepatitis or liver dysfunction, blood loss and thoracotomy correlated with thoracic complications. Serum HA level reflects the function of hepatic sinusoids and is a sensitive marker of liver endothelial cell dysfunction after liver ischaemia (26). Measurement of serum HA level is therefore considered useful for evaluating liver damage and fibrosis. Yachida et al. (27), Das et al.(28) and our group (17) emphasized the significance of serum HA levels in predicting postoperative ascites and hepatic failure. We reported previously that high serum HA level was also a significant predictor of hepatic complications, and that levels exceeding 150 ng/ml should negate hepatectomy (17). A low platelet count is also a sensitive marker of chronic liver dysfunction and post-hepatectomy morbidity (29). In the present study, multivariate analysis showed that increased blood loss was the only independent predictor of thoracic complications post-thoracotomy for hepatectomy. Greenburg et al.(30) reported that blood transfusion in response to large intraoperative blood loss causes postoperative complications. Excessive blood loss warrants intraoperative hydration, which might lead to pleural effusion. As discussed in the Introduction, thoracotomy tends to be associated with thoracic complications. Therefore, careful perioperative management is necessary in patients with chronic liver dysfunction planned for hepatectomy via TAA (31). This should include avoidance of over-hydration and respiratory rehabilitation to avoid pulmonary atelectasis (32). Since 2004, we have been using an L-shaped short thoracic tube by placing it between the lung bed and right diaphragm because long-term compression atelectasis of the lower lung by pleural effusion was often observed in the period between 1994 and 2003. Using this method, thoracic complications might be short-lived. Finally, thoracotomy-associated thoracic complications should be avoided as much as possible by physiological support. Our results showed that thoracotomy itself is not a life-threatening procedure even in patients with liver dysfunction who undergo hepatic resection. Taking a balanced view of safety of hepatectomy and minimum abdominal morbidity, TAA for hepatectomy is a suitable surgical option.

Reducing the above complications will need improved management modalities in addition to better evaluation of preoperative risks.

The present study examined the utility and complications of the TAA procedure in 425 patients undergoing hepatic resection between 1994 and 2008. Patients' characteristics, surgical records and postoperative morbidity were compared between patients who underwent hepatectomy by TAA and by AA. The results showed that TAA was conducted mainly in patients with hepatocellular carcinoma with chronic liver dysfunction and that it was associated with thoracic complications such as pleural effusion. On the other hand, post-operative biloma, uncontrolled ascites and wound infection were significantly lower in the TAA group than the AA group. Hospital stay was similar between both groups. Multivariate analysis showed that large intraoperative blood loss was the only significant determinant of postoperative complication but not TAA itself. Hepatectomy via TAA is still a useful procedure for a better operative view with less hepatic complications nevertheless of frequent pleural effusion.

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FIGURE LEGENDS

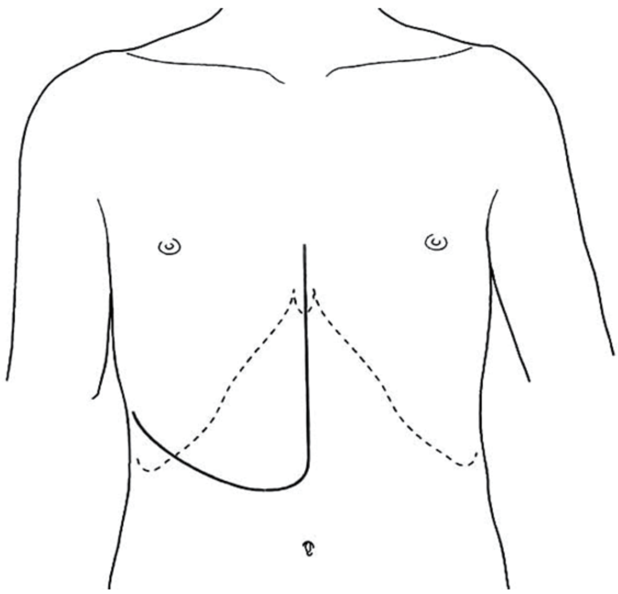

FIGURE 1 The abdominal approach using the J-shape incision consisted of an upper median incision and transverse incision along the 10th intercostal space. In case of J-shape with thoraco-laparotomy, an incision along the 9th intercostal space was selected.

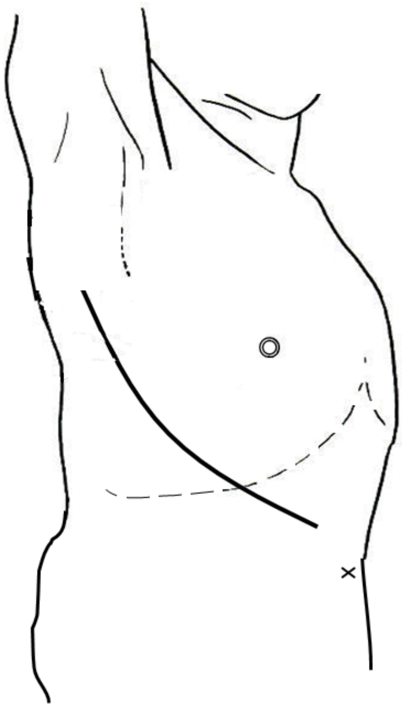

FIGURE 2 The thoracoabdominal approach by right oblique incision along the 7th intercostal space.

TABLE 1 Patient Demographics and Preoperative Liver Function Tests in Patients who Underwent Hepatectomy with or without Thoracotomy.

	AA group (n=278)	TAA group (n=147)	*P* Value [a]
Age, median, years	66.5 (24-86)	63 (28-82)	0.43
Sex, Male	187 [67]	112 [76]	.10
Female	91 [33]	35 [24]	
Background liver disease			
Normal	171 [61.6]	72 [49.3]	
Alcoholic hepatitis	3 [1.1]	0	
Non-alcoholic fatty liver	1 [0.4]	0	
Chronic viral hepatitis	48 [17.1]	47 [31.9]	0.009
Cirrhosis	46 [16.4]	20 [13.0]	
Jaundice	9 [3.4]	8 [5.8]	
Background liver disease			
Benign	19 [6.8]	3 [2.0]	
Trauma	1 [0.4]	0	
Hepatocellular carcinoma	90 [32.3]	69 [46.9]	
Intrahepatic cholangiocarcinoma	26 [9.3]	7 [4.8]	0.012
Metastatic liver carcinoma	106 [38.4]	53 [36.1]	
Bile duct carcinoma	17 [6.1]	11 [7.5]	
Gallbladder carcinoma	19 [6.8]	4 [2.7]	
Child-Pugh classification			
A	267 [96.2]	141 [96.4]	0.99
B	11 [3.8]	6 [3.6]	
Preoperative liver function			
ICGR15 (%)	10.8 (0-47)	10.4 (0-39)	0.72
LHL15 by 99mTc-GSA	0.93 (0.80-0.96)	0.94 (0.63-0.94)	0.11
Total bilirubin (mg/dl), median (range)	0.81 (0.2-1.8)	0.93 (0.1-1.9)	0.50
Prothrombin activity (%), median (range)	91 (56-133)	95 (60-136)	0.26
Platelet count (/mm^3), median (range)	19.1 (5.2-28.5)	19.4 (5.0-32.4)	0.29
Serum hyaluronic acid (ng/ml), median (range)	74 (4-173)	72 (18-361)	0.18

Numbers in parentheses represent range value and those in square brackets represent percentages. [a] By the Student t-test and chi-square test.

ICGR15, indocyanine green retention rate at 15 min; LHL15, ratio of liver activity to heart and liver activity at 15 min; Tc-GSA, Technetium-galactosyl serum albumin, ALT, alanine aminotransferase. AA, abdominal approach and TAA, thoraco-abdominal approach.

TABLE 2 Operative Details in Patients who Underwent Hepatectomy with or without Thoracotomy.

	AA group (n=278)	TAA group (n=147)	*P* Value [a]
Incision			
J-shape	172 [61.8]	75 [50.8]	<0.001
Subcostal	50 [18.0]	0	
Median	56 [20.2]	0	
Right oblique	0	72 [49.2]	
Extent of hepatectomy			
Hemihepatectomy	94 [33.8]	62 [42.2]	<0.001
Sectionectomy	41 [14.5]	50 [34.0]	
Segmentectomy	28 [10.1]	11 [7.5]	
Partial resection	115 [41.4]	24 [16.3]	
Vascular resection with anastomosis			
No	264 [95.0]	145 [98.6]	0.088
Yes	14 [5.0]	2 [1.4]	
Blood loss (ml), median (range)	830 (33-7150)	970 (10-4120)	0.008
Operating time (minutes), Median (range)	372 (92-1230)	408 (137-921)	0.038

Numbers in parentheses represent range value and those in square brackets represent percentages. [a] By the Student t-test. AA, abdominal approach and TAA, thoraco-abdominal approach.

TABLE 3 Postoperative Liver Function Tests and Complications in Patients who Underwent Hepatectomy with or without Thoracotomy

	AA group (n=278)	TAA group (n=147)	P Value [a]
Complications			
No	151 [54.3]	59 [40.1]	0.007
Yes	127 [45.7]	88 [59.9]	
Thoracic complications			
No	253 [91.0]	112 [76.2]	<0.0001
Yes	25 [9.0]	35 [23.8]	
Pleural effusion	22 [7.9]	31 [21.1]	<0.0001
Atelectasis	14 [5.0]	9 [6.1]	0.81
Biloma			
No	214 [77.0]	126 [85.7]	0.044
Yes	64 [23.0]	21 [14.3]	
Uncontrolled ascites			
No	246 [88.5]	139 [94.6]	0.061
Yes	32 [11.5]	8 [5.4]	
Hepatic failure			
No	266 [95.7]	136 [92.5]	0.25
Yes	12 [4.3]	11 [7.5]	
Wound infection			
No	209 [75.2]	135 [91.8]	<0.001
Yes	69 [24.8]	12 [8.2]	
Length of hospital stay (days), median (range)	24 (6-152)	27 (7-297)	0.57
Hospital death			
No	274 [98.6]	141 [95.9]	0.11
Yes	4 [1.4]	6 [4.1]	

Numbers in parentheses represent range value and those in square brackets represent percentages. [a] By the Student t-test. AA, abdominal approach and TAA, thoraco-abdominal approach.

TABLE 4. Relationship between Various Clinicopathological Parameters and Postoperative Complications in Patients with and without Complications.

	Complications (-) (n=365)	Complications (+) (n=60)	*P* Value [a]
Age, years			
<65	166 [86.5]	26 [13.5]	0.87
≥65	199 [85.4]	34 [14.6]	
Sex			
Male	257 [86.4]	17 [13.6]	0.95
Female	108 [85.6]	43 [14.4]	
Background liver disease			
Normal	226 [90.0]	25 [10.0]	
Alcoholic hepatitis	3 [100]	0	
Non-alcoholic fatty liver	1 [100]	0	
Chronic viral hepatitis	74 [81.3]	17 [18.7]	0.025
Cirrhosis	46 [74.2]	16 [25.8]	
Jaundice	15 [88.2]	2 [11.8]	
ICGR15, %			
<15	251 [87.2]	37 [12.8]	0.35
≥15	114 [83.2]	23 [16.8]	
LHL15			
<0.90	38 [74.5]	13 [25.5]	0.23
≥0.90	327 [87.5]	47 [12.5]	
Platelet count, /mm^3			
<100,000	28 [70]	12 [30]	0.005
≥100,000	337 [87.4]	48 [87.4]	
Serum hyaluronic acid, ng/ml			
<150	283 [88.7]	36 [11.3]	0.006
≥150	82 [77.4]	24 [22.6]	
Child-Pugh classification			
A	351 [86.2]	56 [13.8]	0.30
B	14 [77.8]	4 [22.2]	
Extent of hepatectomy			
Hemihepatectomy	133 [84.7]	24 [15.3]	0.38
Sectionectomy	74 [81.3]	17 [18.7]	
Segmentectomy	33 [86.8]	5 [13.2]	
Partial resection	125 [89.3]	14 [10.7]	
Operating time, minutes			
<390	183 [86.7]	28 [13.3]	.72
≥390	182 [85.1]	32 [14.9]	
Blood loss, ml			
<800	175 [90.2]	19 [9.8]	.027
≥800	190 [82.3]	41 [17.7]	
Inclusion of thoracotomy			
AA	253 [91.0]	25 [9.0]	<0.001
TAA	112 [76.2]	35 [23.8]	

Values in square brackets represent percentages.

[a] By the chi-square test. For abbreviations, see Table 1.

TABLE 5. Results of Multivariate Analysis for Postoperative Thoracic Complications.

	Odds ratio (95% CI)	*P* Value
Background of liver		
Normal, alcoholic, non-alcoholic	1	
Chronic viral hepatitis, cirrhosis	1.93 (0.80-4.64)	0.14
Jaundice	2.08 (0.34-12.81)	0.43
Platelet count, /mm^3		
≥100,000	1	
<100,000	1.38 (0.67-2.83)	0.38
Serum hyaluronic acid, ng/ml		
<150	1	
≥150	1.28 (0.52-3.16)	0.59
Blood loss, ml		
<800	1	
≥800	3.23 (1.31-7.96)	0.011
Existence of thoracotomy		
Laparotomy	1	
Thoraco-laparotomy	1.98 (0.92-4.23)	0.080