ORIGINAL ARTICLE

A Thoracoabdominal Hepatectomy and a Transdiaphragmatic Hepatectomy for Patients With Cirrhosis and Hepatocellular Carcinoma

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Objective: To evaluate the results of a thoracoabdominal hepatectomy and a transdiaphragmatic hepatectomy for hepatocellular carcinoma in patients with impaired liver function.

Design: Retrospective study.

Setting: A university hospital in Japan.

Patients: Twenty-seven patients who from 1991 to 1996 underwent a thoracoabdominal hepatectomy for hepatocellular carcinoma located mainly in the superior portion of the liver and 20 patients who underwent a transdiaphragmatic hepatectomy for hepatocellular carcinoma located near the diaphragm.

Main Outcome Measures: Morbidity, survival, and disease-free survival after each operation. Comparisons were then made with 183 patients who had undergone an ordinary transabdominal hepatectomy during the same period.

Results: In the thoracoabdominal hepatectomy group, 17 patients underwent a partial resection, 4 patients underwent a subsegmentectomy, and another 6 patients underwent either a segmentectomy or a procedure that was greater in size than a segmentectomy, whereas all of the patients in the transdiaphragmatic group underwent a partial resection. The morbidities in the thoracoabdominal group included pleural effusion in 6 patients (22%); intra-abdominal infection in 5 patients (19%); and hepatic failure in 3 patients (11%), of whom 1 died (mortality rate, 4%). In the transdiaphragmatic group, only 2 patients (10%) had non–life-threatening complications. The cumulative survival rates and the disease-free survival rates of the patients at 3 years were 51% and 24% in the thoracoabdominal hepatectomy group and 62% and 30% in the transdiaphragmatic hepatectomy group; no significant differences were observed when these findings were compared with those of patients who had undergone a transabdominal hepatectomy.

Conclusion: The outcomes of the patients undergoing thoracoabdominal hepatectomy and those undergoing a transdiaphragmatic hepatectomy were generally satisfactory in spite of the fact that these procedures were performed on patients with cirrhosis and impaired liver function.

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RECENTLY THERE have been many remarkable advances in the resection of hepatocellular carcinoma (HCC).[1-6] Despite such advances, a high incidence of postoperative complications and mortality continues to be reported. The operative indications for patients with impaired liver function also remain controversial. At our institution, the mortality rate among the patients who had undergone liver resections for HCC from 1985 to 1993 was 2% (6/280 patients); most of the patients who died had a low hepatic functional reserve and had undergone a large resection with excessive manipulation of the liver.[6] Therefore, a limited resection of the liver in patients with cirrhosis and HCC has become the established operative procedure when hepatic functional reserves are low.[7,8]

We have been performing a thoracoabdominal hepatectomy for HCC, especially when the tumor is located in the superior portion of the right hepatic lobe in patients with cirrhosis. We have also recently reported a new approach for liver surgery, transdiaphragmatic hepatectomy, which is a useful technique for patients with cirrhosis and HCC located near the diaphragm.[9] These procedures are expected to lessen the degree of operative invasion in patients with cirrhosis by taking the shortest and most direct approach from the skin incision to the tumor without excessive mobilization of the liver, while also performing as small a liver resection as possible. In this article, we evaluate the results of a thoracoabdominal hepatectomy while also further evaluating transdiaphragmatic hepatectomy for patients with cirrhosis and HCC who have

PATIENTS AND METHODS

Two hundred sixty-six patients underwent a hepatic resection for HCC in the Department of Surgery II, Kyushu University Hospital, Fukuoka, Japan, from August 1991 to January 1996. Of these, 27 patients underwent a thoracoabdominal hepatectomy and 20 patients underwent a transdiaphragmatic hepatectomy; these 47 patients were enrolled in the current study. Three of the 27 patients undergoing a thoracoabdominal hepatectomy and 12 of the 20 patients undergoing a transdiaphragmatic hepatectomy had already undergone repeated hepatic resection for recurrent HCC. The preoperative clinical characteristics of these patients are given in **Table 1**. Most of them had a history of intra-abdominal surgery, including repeated hepatectomy, and that was the result of having cirrhosis or other severe diseases such as diabetes mellitus or esophageal varices. The rate of liver cirrhosis was high, with 52% of all patients with HCC who were operated on at our institution having some degree of cirrhosis, as previously reported.[6]

The surgical procedures for the thoracoabdominal hepatectomy are described as follows. With the patient placed in a left semilateral position, a right anterolateral thoracotomy incision is made along the 7th intercostal space with an extension of the skin incision near the navel. Then, a laparotomy and dissection of the diaphragm is made. After performing a cholecystectomy, the glissonian pedicle of hepatic segment that contains the tumor is exposed and clamped at the hepatic hilum for vascular control.[10] All liver resections, such as partial resection, subsegmentectomy, or segmentectomy are performed in the ischemic area of the liver, either with or without mobilizing the right lobe of the liver, by means of an ultrasonic dissector.[11] When the whole ischemic area is not resected, 15-minute vascular occlusion and 5-minute declamping are repeated during the resection to prevent any ischemic damage to the liver tissue.[6] The surgical procedures for a transdiaphragmatic hepatectomy of HCC located near the diaphragm have already been described.[9] Briefly, after placing the patient in a left semilateral position, an anterolateral thoracotomy incision is made. The optimal intercostal space for thoracotomy (the shortest approach to the tumor) is selected using preoperative ultrasonography. The diaphragm is opened after confirming the location of the tumor by transdiaphragmatic ultrasonography. A partial hepatectomy is then performed through the diaphragm using an ultrasonic dissector either with or without a microwave tissue coagulator[12] and without any vascular control.

All patients were followed up satisfactorily at the surgical clinic of Kyushu University Hospital on a monthly basis after the operation.[6]

The survival analyses were determined using the Kaplan-Meier method[13] and the log-rank test.[14] We compared the findings with those of the 183 patients who had undergone an ordinary transabdominal hepatectomy for HCC, but excluded 36 patients in whom the tumor could not be completely resected. All *P* values less than .05 were considered to be statistically significant. The data are presented as mean±SD.

impaired liver function, and discuss the indications for these procedures.

RESULTS

The location and number of the tumors and the operations performed are listed in **Table 2**. In the thoracoabdominal hepatectomy group, most of the tumors were located in the S7 or S8 subsegment of the liver (Couinaud classification); however, in the transdiaphragmatic hepatectomy group, most of the tumors were located near the diaphragm in the S8 subsegment. The surgical procedures varied in the thoracoabdominal group according to the location of the tumors. In the transdiaphragmatic hepatectomy group, all operations were partial resections. As a result, the resected liver volume was smaller and the operative time shorter in the transdiaphragmatic hepatectomy group than in the thoracoabdominal hepatectomy group. In the transdiaphragmatic hepatectomy group, 60% of all cases were repeated hepatectomies for recurrent HCC. The postoperative complications of the 2 groups are listed in **Table 3**. The incidence of morbidity in the thoracoabdominal hepatectomy group was 44%. However, in the transdiaphragmatic hepatectomy group, only 2 patients had postoperative complications. The cumulative survival rates of the patients in the thoracoabdominal hepatectomy group, transdiaphragmatic hepatectomy group, and the hepatectomy with an ordinary transabdominal approach group were 82%, 89%, and 82% at 1 year and 51%, 62%, and 59% at 3 years, respectively

Table 1. Preoperative Clinical Characteristics*

	Thoracoabdominal Hepatectomy Group (n=27)	Transdiaphragmatic Hepatectomy Group (n=20)
Mean (±SD) age, y	59±10	64±8
Sex, M/F	22/5	14/6
History of intra-abdominal surgery, No. (%)	16 (59)	18 (90)
HBsAg positive, No. (%)	5 (19)	2 (10)
HCVAb positive, No. (%)	21 (78)	15 (75)
Cirrhosis,† No. (%)	20 (74)	16 (80)
Diabetes mellitus, No. (%)	8 (30)	5 (25)
Esophageal varices, No. (%)	7 (26)	4 (20)
Liver function values, mean±SD		
Albumin, g/L	34±5	36±3
Prothrombin time, s	12.2±0.5	12.2±0.6
γ-Globulin, %	22±8	22±5
Total bilirubin, mg/dL (μmol/L)	1.0±0.3 (17.1±5.1)	0.9±0.3 (15.4±5.1)
AST, U/L	65±28	76±43
ALT, U/L	75±45	68±43
Indocyanine green retention rate at 15 min, %	27.1±11.7	24.4±10.3

**HBsAg indicates hepatitis B surface antigen; HCVAb, anti–hepatitis C virus antibody; AST, aspartate aminotransferase; and ALT, alanine aminotransferase.*

†Pathological diagnosis based on operative specimens.

Table 2. Operative Data

Variable	Thoracoabdominal Hepatectomy Group (n=27)	Transdiaphragmatic Hepatectomy Group (n=20)
Liver subsegment location,*		
No. of tumors		
S1	1	0
S2	1	1
S3	1	1
S4	1	3
S5	8	0
S6	9	0
S7	10	2
S8	16	15
Mean (±SD) tumor size,† cm	2.8±1.2	2.5±1.3
Operative procedures, No. (%)		
Partial resection	17 (63)	20 (100)
Subsegmentectomy‡	4 (15)	0 (0)
Anterior segmentectomy	1 (4)	0 (0)
Posterior segmentectomy	4 (15)	0 (0)
Right lobectomy	1 (4)	0 (0)
Repeated hepatectomy,§ No. (%)	3 (11)	12 (60)
Mean (±SD) resected liver volume, g	146±122	38±30
Mean (±SD) operative time, min	312±99	210±62
Mean (±SD) operative blood loss, g	2026±1566	1548±1491

*Couinaud classification.
†Maximum size of main tumor.
‡Two S5, 1 S7, and 1 S8 resections.
§Hepatectomy for recurrent hepatocellular carcinoma.

Table 3. Postoperative Complications*

	Thoracoabdominal Hepatectomy Group (n=27)	Transdiaphragmatic Hepatectomy Group (n=20)
Any complication		
No	15 (56)	18 (90)
Yes	12 (44)	2 (10)
Ascites	4 (15)	0 (0)
Pleural effusion	6 (22)	0 (0)
Bile leakage	1 (4)	0 (0)
Intra-abdominal infection	5 (19)	1 (5)
Postoperative bleeding	0 (0)	1 (5)
Hepatic failure†	3 (11)	0 (0)
Hospital death	1 (4)	0 (0)

*All data are given as number (percentage).
†Consisting of hyperbilirubinemia and hepatic encephalopathy of more than grade 2 either with or without disseminated intravascular coagulopathy.

(**Figure 1**). No statistically significant differences were found among these rates. The disease-free survival rates of the patients in the thoracoabdominal hepatectomy group, transdiaphragmatic hepatectomy group, and the hepatectomy with an ordinary transabdominal approach group were 80%, 38%, and 72% at 1 year and 24%, 30%, and 34% at 3 years, respectively (**Figure 2**). No statistically significant differences were seen among the 3 groups.

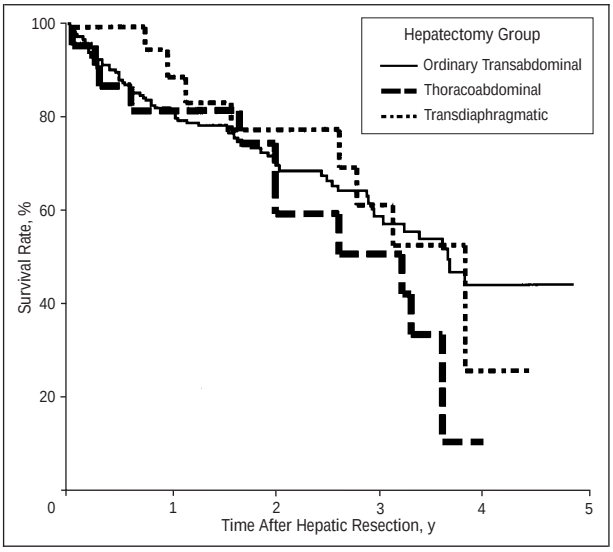

Figure 1. *The cumulative survival rates classified according to the operative procedures (thoracoabdominal hepatectomy [n=27]; transdiaphragmatic hepatectomy [n=20]; and hepatectomy with the ordinary transabdominal approach [n=183]).*

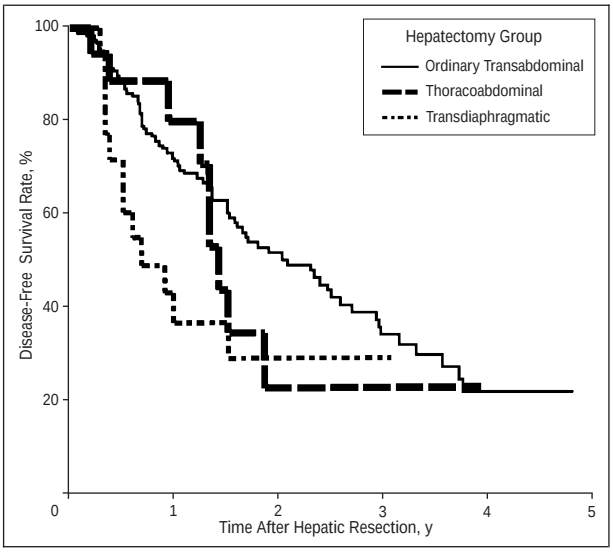

Figure 2. *The cumulative disease-free survival rates classified according to the operative procedures (thoracoabdominal hepatectomy [n=27]; transdiaphragmatic hepatectomy [n=20]; and hepatectomy with the ordinary transabdominal approach [n=183]).*

COMMENT

A limited hepatic resection has been shown to be a useful surgical procedure for a relatively small HCC in patients with cirrhosis, with a low rate of morbidity and no decrease in the long-term survival rate after operation.[7] In addition, the short surgical margin (<10 mm wide) of the resected specimen in the limited hepatic resection was not linked to any early recurrence in the patients with a relatively small HCC.[8] These facts are considered to expand the surgical indications for patients with cirrhosis and a relatively small HCC. However, in cases of HCC located in the superior portion or near the diaphragm of the liver, even a limited hepatic resection is difficult to perform through the transabdominal approach. With a narrow operative field, exces-

sive mobilization is needed in patients with cirrhosis and portal hypertension, but this mobilization is thought to cause liver injury after the operation.[9] Therefore, the largest advantage of the transthoracic hepatectomy with a thoracoabdominal or transdiaphragmatic approach is that it lessens the degree of operative invasion in the cirrhotic liver by taking the most direct, shortest distance from the skin incision to the tumor with a small degree of liver mobilization and no bowel manipulation. In this study, 60% of all cases of transdiaphragmatic hepatectomy were repeated hepatectomies for recurrent HCC. Repeated hepatectomy remains the most effective therapeutic modality for recurrent HCC.[15-19] However, a repeated hepatectomy is sometimes difficult to perform because of intra-abdominal adhesion from a previous operation. The transthoracic approach in hepatic surgery is considered to be useful in such patients.

As for morbidity, few complications have been recognized in such patients undergoing a transdiaphragmatic hepatectomy. Stimpson et al[20] reported that a thoracotomy was one of the factors that raised the postoperative morbidity. However, a thoracotomy alone is not the risk factor for postoperative complications, even in patients with impaired liver function. In the thoracoabdominal hepatectomy group, 44% of the patients had postoperative complications, including 1 patient who died in the hospital. The difference in the incidence of complications between the 2 groups was considered to be caused by the different volumes of the resected liver. However, the incidence of such complications in the thoracoabdominal hepatectomy group was almost the same as that of all patients who had undergone an ordinary transabdominal hepatectomy.[6] As the liver function of the patients in the thoracoabdominal hepatectomy group was more impaired than that of all patients undergoing an ordinary transabdominal hepatectomy, the surgical indications for the patients with cirrhosis and HCC could be expanded by a thoracoabdominal approach.

The use of the vascular occlusion method at the hepatic pedicle during resection[10,21] has apparently contributed to the improved results in hepatic surgery by minimizing blood loss. However, the tolerable period of normothermic ischemia is limited, depending on the extent of liver injury from the disease. In the normal liver, the longest period of normothermic ischemia tolerated during major liver resections has been found to be 90 minutes.[22,23] In cirrhotic livers, hepatic vascular exclusion is feasible as long as it is kept to a time limit of 60 minutes.[24] However, in an experimental study using the rat liver, the maximum period of ischemia without irreversible damage was 15 minutes.[25] It is thus considered that normothermic ischemia should be avoided as much as possible in cirrhotic livers with severly impaired function. Regarding transdiaphragmatic hepatectomy, a partial hepatectomy was performed through the diaphragm without any vascular control and without any manipulation of the intraperitoneal organs. These causes are considered to be the reason why morbidity was less frequent in the patients undergoing transdiaphragmatic hepatectomy.

The most useful indication for the thoracoabdominal approach is considered to be a posterior segmentectomy of the liver. In a posterior segmentectomy through the transabdominal approach, the surgeon is forced to cut the liver beneath its frontal plane. However, using the thoracoabdominal approach with the patient placed in a left semilateral position, a wide operative field can be obtained and it is easy to perform manipulation, even near the inferior vena cava or the right hepatic vein. The outcomes of the thoracoabdominal hepatectomy for HCC located in the superior portion of the liver and of the transdiaphragmatic hepatectomy for HCC located near the diaphragm have generally been satisfactory, despite being performed on patients with cirrhosis and impaired liver function.

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REFERENCES

1. The Liver Cancer Study Group of Japan. Predictive factors for long term prognosis after partial hepatectomy for patients with hepatocellular carcinoma in Japan. *Cancer*. 1994;74:2772-2780.
2. Chen M-F, Hwang T-L, Jeng L-B, Wang C-S, Jan Y-Y, Chen S-C. Postoperative recurrence of hepatocellular carcinoma: two hundred five consecutive patients who underwent hepatic resection in 15 years. *Arch Surg*. 1994;129:738-742.
3. S-Lai EC, Fan ST, Lo CM, et al. Hepatic resection for hepatocellular carcinoma: an audit of 343 patients. *Ann Surg*. 1995;221:291-298.
4. Vauthey JN, Klimstra D, Franceshi D, et al. Factors affecting long-term outcome after hepatic resection for hepatocellular carcinoma. *Am J Surg*. 1995;169:28-35.
5. Carlo VD, Ferrari G, Castoldi R, et al. Surgical treatment and prognostic variables of hepatocellular carcinoma in 122 cirrhotics. *Hepatogastroenterology*. 1995;42:222-229.
6. Takenaka K, Kawahara N, Yamamoto K, et al. Results of 280 liver resections for hepatocellular carcinoma. *Arch Surg*. 1996;131:71-76.
7. Kanematsu T, Takenaka K, Matsumata T, et al. Limited hepatic resection effective for selected cirrhotic patients with primary liver cancer. *Ann Surg*. 1984;199:51-56.
8. Yoshida Y, Kanematsu T, Matsumata T, et al. Surgical margin and recurrence after resection of hepatocellular carcinoma: further evaluation of limited hepatic resection. *Ann Surg*. 1989;209:297-301.
9. Shimada M, Matsumata T, Taketomi A, et al. A new approach for liver surgery: transdiaphragmatic hepatectomy for cirrhotic patients with hepatocellular carcinoma. *Arch Surg*. 1995;130:157-160.
10. Makuuchi M, Mori T, Gunvén P, et al. Safety of hemihepatic vascular occlusion during resection of the liver. *Surg Gynecol Obstet*. 1987;164:155-158.
11. Andrus CH, Kaminski DL. Segmental hepatic resection utilizing the ultrasonic dissector. *Arch Surg*. 1986;121:515-521.
12. Tabuse K, Katsumi M, Kobayashi Y, et al. Microwave surgery: hepatectomy using a microwave tissue coagulator. *World J Surg*. 1985;9:136-143.
13. Kaplan EL, Meier P. Nonparametric estimation from incomplete observation. *J Am Stat Assoc*. 1958;53:457-481.
14. Petro R, Pike MC. Conservatism of the approximation $\Sigma-(O-E)^2/E$ in the logrank test for survival data or tumor incidence data. *Biometrics*. 1973;29:579-584.
15. Huguet C, Bona S, Nordlinger B, et al. Repeat hepatic resection for primary and metastatic carcinoma of the liver. *Surg Gynecol Obstet*. 1990;171:398-402.
16. Suenaga M, Sugiura H, Kokuba Y, et al. Repeated hepatic resection for recurrent hepatocellular carcinoma in eighteen cases. *Surgery*. 1994;115:452-457.
17. Shimada M, Matsumata T, Taketomi A, et al. Repeat hepatectomy for recurrent hepatocellular carcinoma. *Surgery*. 1994;115:703-706.
18. Lee PH, Lin WJ, Tsang YM, et al. Clinical management of recurrent hepatocellular carcinoma. *Ann Surg*. 1995;222:670-676.
19. Nagasue N, Kohno H, Hayashi T, et al. Repeat hepatectomy for recurrent hepatocellular carcinoma. *Br J Surg*. 1996;83:127-131.
20. Stimpson RE, Pellegrini CA, Way LW. Factors affecting the morbidity of elective liver resection. *Am J Surg*. 1987;153:189-196.
21. Nagasue N, Yukaya H, Ogawa Y, et al. Segmental and subsegmental resections of the cirrhotic liver under hepatic inflow and outflow occlusion. *Br J Surg*. 1985;72:565-568.
22. Huguet C, Gavelli A, Chieco A, et al. Liver ischemia for hepatic resection: where is the limit? *Surgery*. 1992;111:251-259.
23. Hannoun L, Borie D, Delva E, et al. Liver resection with normothermic ischaemia exceeding 1 hour. *Br J Surg*. 1993;80:1161-1165.
24. Yamaoka Y, Ozawa K, Kumada K, et al. Total vascular exclusion for hepatic resections in cirrhotic patients: application of venovenous bypass. *Arch Surg*. 1992;127:276-280.
25. Horiuchi T, Muraoka R, Tabo T, Uchinami M, Kimura N. Tanigawa N. Optimal cycles of hepatic ischemia and reperfusion for intermittent pedicle clamping during liver surgery. *Arch Surg*. 1995;130:754-758.