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Transthoracic Transdiaphragmatic Approach for Hepatectomy of Couinaud's Segments VII and VIII

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Abstract. For hepatectomy of Couinaud's segment VII or VIII, severe compression and mobilization of the liver is required to establish the operative field via the usual transabdominal approach. Compression of the cirrhotic liver impairs hepatic and systemic blood circulation, which may cause liver dysfunction. We adopted a transthoracic transdiaphragmatic approach for hepatectomy of segment VII or VIII in cirrhotic patients to establish a good operative field without compressing the liver. The aim of this study was to evaluate the benefits of this approach. Forty-four patients with hepatocellular carcinoma (HCC) complicating liver cirrhosis who underwent limited hepatectomy of Couinaud's segment VII or VIII were studied. The patients were randomized to two groups preoperatively: group I ($n = 22$), transabdominal approach; group II ($n = 22$), transthoracic transdiaphragmatic approach. There were no differences in preoperative liver function tests, hepatic functional reserve, or extent of tumor between the two groups. The operative time in group II was significantly shorter than that in group I (243 ± 50 versus 313 ± 80 minutes; $p < 0.01$). Operative blood loss in group II was also significantly smaller than that in group I (1190 ± 1098 versus 2679 ± 2267 g; $p < 0.01$). Serum lactate dehydrogenase levels on postoperative day 1 in group II were significantly lower than those in group I (587 ± 154 versus 791 ± 383 IU/L; $p < 0.05$). Major postoperative complications were significantly fewer in group II. It was concluded that the transthoracic transdiaphragmatic approach is a useful method for hepatectomy of segments VII and VIII in cirrhotic patients.

Most patients with hepatocellular carcinoma (HCC), especially in Asian countries, also have liver cirrhosis. Although major hepatic resection has usually been a contraindication in cirrhotic patients [1–3], patients with localized HCCs can be successfully treated by nonanatomic minor hepatectomy [4–7]. Resection of the cirrhotic liver, even if minor, is complicated because of accompanying portal hypertension and coagulation defects.

In the case of hepatectomy of Couinaud's segment VII or VIII, severe compression and mobilization of the liver are required to establish the operative field via the usual transabdominal approach. Because the cirrhotic liver is hard compared to normal liver poor mobility makes it difficult to obtain a good operative field. In addition, even mild compression and mobilization of the liver may cause torsion of the portal vein and inferior vena cava, resulting in hepatic and systemic circulatory impairment [3, 8]. Restricted operative field makes the operation difficult and increases operative time and blood loss. Intraoperative hepatic ischemia may cause postoperative hepatic dysfunction. To alleviate these difficulties, we adopted a transthoracic transdiaphragmatic approach for hepatectomy of Couinaud's segment VII and VIII in patients with HCC complicating cirrhosis. We assumed that this new approach would reduce surgical stress and decrease the postoperative morbidity and mortality associated with hepatectomy. The purpose of this study was to evaluate the benefits of the transthoracic transdiaphragmatic approach for hepatectomy in cirrhotic patients.

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Materials and Methods

During the 5-year period from January 1990 to December 1994, a total of 102 patients with HCC underwent hepatectomy at the Nara Medical University Hospital. Preoperative assessment for the extent of the tumor and cirrhotic change of the liver was performed by ultrasonography, computed tomography (CT), and hepatic angiography. These evaluations revealed that the HCC was located within Couinaud's segment VII or VIII in 46 patients. Two of these patients who had no cirrhotic change were excluded from the study. The remaining 44 patients with complicating cirrhosis who underwent limited hepatectomy of Couinaud's segment VII or VIII were preoperatively randomized to two groups after informed consent was obtained: Patients in group I underwent the transabdominal approach ($n = 22$), and patients in group II underwent the transthoracic transdiaphragmatic approach ($n = 22$) for hepatectomy.

The transabdominal approach in group I was performed with a Mercedes incision that included a bilateral subcostal incision extended to the right flank and a median incision to the lower edge of the sternum with the patient supine. Mobilization of the right lobe by dissecting the coronary ligament of the liver and retroperitoneal tissue along the inferior vena cava was required to obtain an operative field for hepatectomy of segment VII or VIII. Compression of the mobilized right lobe was also required during hepatectomy.

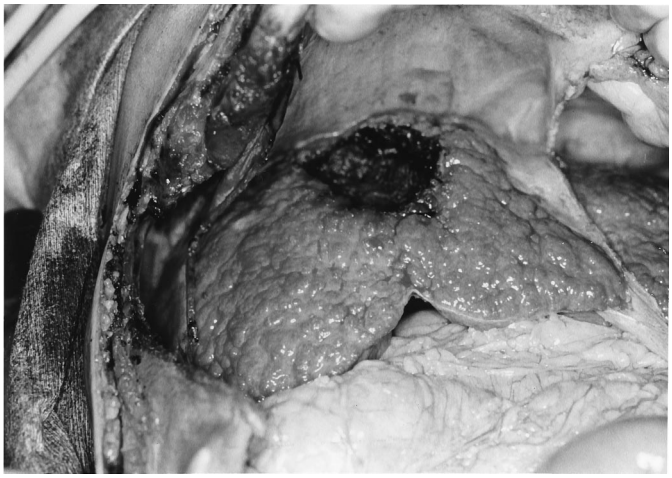

Fig. 1. Operative field with the transthoracic transdiaphragmatic approach. The diaphragm has already been divided, and the intrathoracic space can be seen at the left. A hepatocellular carcinoma in segment VIII of the cirrhotic liver has been resected under favorable vision without mobilizing the liver.

For the transthoracic transdiaphragmatic approach, patients were placed in a left semilateral position. A right anterolateral thoracotomy was made through the seventh or eighth intercostal space. The optimal intercostal space was selected using preoperative ultrasonography by searching for the shortest approach to the tumor. The right anterolateral thoracotomy incision was extended anteriorly to the middle of the abdomen through the costal arch into the abdominal muscle. The costal cartilage was cut, and the intercostal artery and vein were ligated and divided. By widening the wound with a retractor, the whole right diaphragm was visualized from the intrathoracic space. The right upper intraperitoneal space was also opened with this incision. After confirming the optimal site for incision of the diaphragm by intraoperative ultrasonography, the diaphragm was divided peripherally toward the inferior vena cava using gastrointestinal anastomosis. Thus the anterior surface of the right lobe of the liver was placed under direct vision without manipulating the liver (Fig. 1). The operation in the hepatic hilum could be easily performed with this approach. After hepatectomy, the divided diaphragm was repaired with tight sutures to separate the intrathoracic space from the intraperitoneal space completely. A suction drain was placed in the intrathoracic space, and the area was continuously drained with a pressure of -10 cm H_2O postoperatively. This drain was removed within 7 days.

In both groups I and II intraoperative ultrasonography was used to assess the extent of the hepatic tumor and its relation with the surrounding vessels. Cholecystectomy was performed in all patients in both groups. Nodal biopsy in the hepatoduodenal ligament was not done. Parenchymal transection of the liver was performed using an ultrasonic surgical apparatus (CUSA). The Pringle maneuver was not performed in any of the patients. The right hemihepatic inflow occlusion was performed in three patients of group I and six patients of group II by clamping the right main trunk of Glison's sheath. For this maneuver, the right main trunk of Glison's sheath was encircled and taped. Inflow occlusion was performed during hepatic parenchymal transection and released every 20 minutes to allow 5 minutes of perfusion. A closed drain was placed on the cut surface of the liver.

Preoperative hepatic function in both groups was assessed by serum albumin, bilirubin, aspartate aminotransferase (AST), aspartate alanine aminotransferase (ALT), lactate dehydrogenase (LDH), hepaplastin test, indocyanine green dye retention test at 15 minutes ($ICGR_{15}$), and Child's classification. The operative data, blood loss, and operative time were compared between groups. Damage to the hepatocytes caused by the operative procedure were assessed by serum bilirubin, AST, ALT, and LDH levels on postoperative days 1, 4, and 5. The serum albumin level and hepaplastin test on postoperative days 4 and 5 were also compared between the two groups. Postoperative complications, operative mortality, and length of the postoperative hospital stay were compared as well. Of the postoperative complications, a major complication was defined as one that was life-threatening, that significantly impaired the general condition of the patient, or that required surgical treatment. Mortality was defined as death occurring in the hospital or within 30 days after operation.

Numerical values were expressed as the mean $\pm$ standard deviation (SD) and were compared using Student's t-test. The chi-square test was applied to comparisons of categolized data. A value of $p < 0.05$ was considered significant.

Results

Preoperative variables of patients in the two groups are shown in Table 1. Age and sex showed no significant difference, and location, size, and number of the tumors were comparable between the two groups. Although the preoperative total bilirubin levels were higher in group II, the other preoperative liver function tests did not show significant differences.

Intraoperative data are shown in Table 2. Operative blood loss in group II was significantly less than that in group I. The operative time in group II was also significantly shorter than that in group I.

Postoperative values of serum LDH levels on postoperative day 1 in group II were significantly lower than those in group I. AST and ALT levels on day 1 were relatively lower in group II but were not statistically significant. Total bilirubin levels in group II were comparable to those in group I on days 1, 4, and 5, whereas preoperative values in group II were significantly higher than those in group I. ALT levels on days 4 and 5 in group II were significantly lower than those in group I. The hepaplastin test on days 4 and 5 were somewhat better in group II than in group I. Arterial PO_2 and PCO_2 on day 1 as a marker of postoperative respiratory function were comparable in the two groups (Table 3).

Postoperative complications were observed in 12 patients in group I and in 9 patients in group II. As significant complications, liver failure, intraabdominal abscess, pneumonia, enteritis due to methicillin-resistant *Staphylococcus aureus*, and ileus were seen in group I (Table 4). On the other hand, in group II the most common postoperative complication was pleural effusion, with no major complications observed. Morbidity due to major complications was significantly lower in group II than in group I. Operative death occurred in two patients with liver failure in group I. The length of the postoperative hospital stay in group II was somewhat shorter than that for group I.

Table 1. Characteristics of patients.

Variable	Group I (n = 22)	Group II (n = 22)
Age (years)	58 ± 8	57 ± 12
Sex (M/F)	19/3	17/5
Location of the tumor (segment VII/VIII)	7/15	7/15
Tumor size (cm)		
≤ 2.0	6	7
2.1–5.0	13	12
5.1+	3	4
Mean	3.3 ± 2.9	3.4 ± 1.8
No. of tumors		
Solitary	21	20
Two or more	1	2
Preoperative functional capacity of the liver		
Total bilirubin (μmol/L)	12 ± 5	16 ± 6*
AST (IU/L)	57 ± 42	54 ± 36
ALT (IU/L)	64 ± 48	54 ± 36
LDH (IU/L)	323 ± 70	331 ± 62
Albumin (g/L)	3.6 ± 0.3	3.7 ± 0.5
Hepaplastin test (%)	67 ± 12	65 ± 17
$ICGR_{15}$ (%)	18 ± 7	21 ± 10
Child's classification		
A	15	13
B	7	6
C		3
Hepatic inflow occlusion[a]		
Performed	3	6
Not performed	18	15

Values are means ± SD. Others indicate number of patients.
AST: aspartate aminotransferase; ALT: aspartate alanine aminotransferase; LDH: lactate dehydrogenase; $ICGR_{15}$: indocyanine green dye retention test at 15 minutes.
[a]Right hemihepatic inflow occlusion during hepatectomy.
*$p < 0.05$ compared with group I.

Table 2. Intraoperative clinical parameters.

Parameter	Group I (n = 22)	Group II (n = 22)
Operative blood loss (g)	2679 ± 2267	1190 ± 1098*
Operative time (min)	313 ± 80	243 ± 50*

Values are means ± SD.
*$p < 0.01$ compared with group I.

Discussion

Even if the extent of hepatectomy is limited, hepatectomy of cirrhotic livers remains highly complicated in terms of operative procedure and postoperative management [1]. Hepatectomy of segments VII and VIII in the cirrhotic liver, especially near the confluence of the hepatic veins, is technically most difficult because mobilization and severe compression of the right lobe are required to arrive at the operative field using the transabdominal approach [8]. The transthoracic transdiaphragmatic approach is useful for establishing the operative field of segments VII and VIII without mobilization and severe compression of the right lobe. In addition, it is easier with this approach to control the hepatic vein and the inferior vena cava.

Table 3. Postoperative laboratory data.

Laboratory test	Group I (n = 22)	Group II (n = 22)
First postoperative day		
Total bilirubin (μmol/L)	29 ± 15	29 ± 17
AST (IU/L)	201 ± 129	159 ± 93
ALT (IU/L)	158 ± 120	122 ± 92
LDH (IU/L)	791 ± 383	587 ± 153*
Respiratory function[a]		
Arterial PO_2 (mmHg)	133 ± 42	151 ± 34
Arterial PCO_2 (mmHg)	42 ± 5	42 ± 5
Fourth postoperative day		
Total bilirubin (μmol/L)	1.6 ± 0.9	1.4 ± 0.6
AST (IU/L)	151 ± 298	57 ± 12
ALT (IU/L)	122 ± 91	73 ± 51*
LDH (IU/L)	586 ± 550	392 ± 58
Albumin (g/L)	3.7 ± 0.5	3.6 ± 0.4
Hepaplastin test (%)	62 ± 23	70 ± 15
Fifth postoperative day		
Total bilirubin (μmol/L)	1.5 ± 1.1	1.5 ± 0.6
AST (IU/L)	111 ± 194	47 ± 10
ALT (IU/L)	86 ± 54	53 ± 26*
LDH (IU/L)	517 ± 325	444 ± 124
Albumin (g/L)	3.6 ± 0.3	3.8 ± 0.5
Hepaplastin test (%)	59 ± 20	67 ± 17

Values are means ± SD.
AST: aspartate aminotransferase; ALT: aspartate alanine aminotransferase; LDH: lactate dehydrogenase.
[a]Under the condition of oxygen inhalation, 3 to 5 L/min, from the face mask.
*$p < 0.05$ compared with group I.

Table 4. Postoperative clinical parameters.

Parameter	Group I (n = 22)	Group II (n = 22)
Complications	Liver failure[a] (2) Abscess formation[a] (1) Bile leakage (2) Pneumonia[a] (1) MRSA enteritis[a] (1) Ileus[a] (1) Pleural effusion (5) Wound infection (1)	Pleural effusion (9) Wound infection (1)
Morbidity	55% (12)	41% (9)
Morbidity due to major complication	18% (4)	0*
Operative mortality[b]	9% (2)	0
Hospital stay[c] (days)	46 ± 15[d]	41 ± 17

Numbers in parentheses indicate the number of patients.
MRSA: methicillin-resistant *Staphylococcus aureus*.
[a]Major complication.
[b]Cause of death of the two patients was liver failure.
[c]Length of the postoperative hospital stay (mean ± SD).
[d]Two patients were excluded owing to operative death.
*$p < 0.05$ compared with group I.

There have been few reports that compared the benefit of the transthoracic transdiaphragmatic approach with that of the transabdominal approach [8, 9]. Shimada et al. [8] reported six cases of repeat hepatectomy for recurrent HCC and two cases of primary hepatectomy with the transdiaphragmatic approach; and they emphasized its usefulness for repeat hepatectomy. On the other hand, Stimson et al. [9] reported that thoracotomy was one of the

factors that increased postoperative morbidity, but many of the patients they studied did not have cirrhosis. The present study is the first that reveals the superiority of the transthoracic transdiaphragmatic approach to the transabdominal approach in patients with cirrhosis.

The incidence of major complications including hepatic failure was significantly lower in patients with the transthoracic transdiaphragmatic approach, and the severity of liver cirrhosis was comparable in the two groups. The significantly shorter operative time with the transthoracic transdiaphragmatic approach is due to a favorable operative field with this approach. Decreased operative blood loss can be attributed to the fact that hepatic congestion was effectively alleviated because this approach did not require compression and mobilization of the liver. Significantly lower postoperative serum LDH levels on day 1 and ALT on days 4 and 5 in patients with the transthoracic transdiaphragmatic approach might indicate the well maintained intraoperative hepatic blood circulation compared to that using the transabdominal approach [8]. The hepaplastin test on days 4 and 5, as a marker of synthetic liver function, was also somewhat better in patients with the transthoracic transdiaphragmatic approach than in those with the transabdominal approach. It was suggested that decreased surgical stress, indicated by the above-mentioned parameters, contributed to the uneventful postoperative course in patients with the transthoracic transdiaphragmatic approach. In addition, the hospital stay with the transthoracic transdiaphragmatic approach was somewhat shorter than that with the transabdominal approach.

A negative aspect of the transthoracic transdiaphragmatic approach was the high incidence of pleural effusion after removing the intrathoracic suction drain, although the pleural effusion in these patients disappeared with no treatment or could be treated by conservative therapy. Postoperative respiratory function, including arterial PO_2 and PCO_2, on day 1 was not impaired by thoracotomy. We believe that it is essential for a successful hepatectomy in patients with cirrhosis to avoid hepatic failure and life-threatening major complications.

The results of this study revealed that the transthoracic transdiaphragmatic approach decreases operative blood loss, operative time, postoperative liver dysfunction, and major complications. This new approach is a useful method for hepatectomy of Couinaud's segment VII and VIII in cirrhotic patients.

Résumé

Pour enlever les segments VII ou VIII selon Couinaud, le foie est soumis à une forte compression et mobilisation afin de bien visualiser les segments par voie trans-abdominale classique. La compression du foie cirrhotique gène la circulation hépatique et systémique, qui peut être à l'origine de troubles fonctionnels du foie. Nous avons adopté une voie d'abord trans-diaphragmatique pour pratiquer les segmentectomies VII ou VIII chez les patients cirrhotiques afin d'éviter les compressions. Le but de cette étude a été d'évaluer les avantages de cette voie d'abord chez 44 patients porteurs d'un carcinome hépatocellulaire du segment VII ou du segment VIII. Ces patients ont été randomisés en deux groupes en préopératoire: groupe I (n = 22): intervention par voie transabdominale; groupe II (n = 22): voie trans-thoracique, transdiaphragmatique. Il n'y avait aucune différence préopératoire dans les tests fonctionnels du foie, la réserve hépatique, ou l'étendue de la tumeur. La durée de l'intervention était plus courte dans le groupe II (243 ± 50 vs 313 ± 80 min, $p < 0.01$). La perte sanguine était significativement moindre dans le groupe II (1190 ± 1098 vs 2679 ± 2267g; $p < 0.01$). Les taux de LDH à J1 dans le groupe II étaient significativement plus bas que dans le groupe I (587 ± 154 vs 791 ± 383; $p < 0.05$). Il y a eu moins de complications majeures dans le groupe II. En conclusion, l'approche trans-thoracique trans-diaphragmatique est utile pour aborder les segments VII et VIII chez le patient cirrhotique.

Resumen

La hepatectomìa de los segmentos VII y VIII de Couinaud implica compresiòn severa y movilizaciòn del hìgado para establecer el campo operatorio cuando se utiliza el abordaje transabdominal usual. La compresiòn del hìgado cirròtico interfiere con la circulaciòn hepà tica y sistèmica, lo cual puede producir disfunciòn hepà tica. Hemos adoptado un abordaje transtoràcico transdiafragmàtico para la hepatectomìa de los segmentos VII u VIII en pacientes cirròticos, con el fin de establecer el campo operatorio y evitar la compresiòn del hìgado. El propòsito del presente estudio fue evaluar los beneficios de tal abordaje. Se estudiaron 44 pacientes con carcinoma hepatocelular y cirrosis hepàtica sometidos a hepatectomìa limitada de los segmentos VII y VIII de Couinaud, los cuales fueron randomizados preoperatoriamente a dos grupos: grupo I (n = 22), abordaje transabdominal; grupo II (n = 22), abordaje transdiafragmàtico. No hubo diferencias significativas en cuanto a las pruebas preoperatorias de funciòn hepàtic a, la reserva funcional hepàtica o la extensiòn del tumor, entre los dos grupos. El tiempo operatorio en el grupo II fue significativamente màs corto que en el grupo I (243 B1 50 vs. 313 B180 min; $P < 0.01$). La pèrdida de sangre durante la operaciòn en el grupo II fue significativamente menor que en el grupo I (1190 B11098 vs 2679 B12267 g; $P < 0.01$). Los niveles sèricos de deshidrogenasa làctica en el dìa postoperatorio l en el grupo II fueron significativamente mà s bajos que en el grupo I (587 B1154 vs. 791 B1383; $P < 0.05$). Se observaron menos complicaciones postoperatorias mayores en el grupo II. En conclusiòn, el abordaje transtorà-cico transdiafragmà tico parece ser un mètodo ùtil para realizar la hepatectomìa de los segmentos VII y VIII en pacientes cirròticos.

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Invited Commentary

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This report from one of the best hepatic surgery groups in Japan is worth careful reading. The authors have essentially eliminated any life-threatening complications with segment 7 or 8 resection of the cirrhotic liver by thoracoabdominal exposure. Even with this thoracoabdominal incision, many of us would not achieve the same good results as those of Ko et al.

The authors concluded that this significant improvement was solely due to the thoracoabdominal exposure, mainly because the "mean" blood loss was significantly less and the "mean" operating time shorter using a thoracoabdominal incision than an abdominal incision. These mean values with a large standard deviation might indicate that the values were strongly influenced by a few cases of accidental disaster. I wonder if there were significant differences in the "median" values between the two groups.

It is a basic requirement to obtain an excellent exposure for safe hepatic resection. However, for a segment 8 resection the thoracoabdominal incision may add little. As shown in their Figure 1 (thoracoabdominal exposure), segment 8 is an anterior segment and in front of the right hepatic vein. The same exposure can easily be obtained by the abdominal incision alone when the xiphoid process is excised.

It is difficult to believe that excellent surgeons such as the authors could lose more than 2500 ml of blood and could spend more than 5 hours doing a segment 8 resection when the tumor was more than 1 cm away from the right hepatic vein. It is worth studying the distance between the tumor and the major branches of veins in relation to the blood loss and the operating time. Nevertheless, the authors should be congratulated for their excellent results.