Hepatectomy for Hepatocellular Carcinoma in Patients with End-Stage Renal Disease on Hemodialysis

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Hepatectomy for Hepatocellular Carcinoma in Patients with End-Stage Renal Disease on Hemodialysis

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Purposes: Whether hepatectomy is justified in patients with hepatocellular carcinoma (HCC) on hemodialysis (HD) for end-stage renal disease (ESRD) is unclear. This study evaluated clinical characteristics and outcomes in patients with HCC on HD for ESRD who underwent hepatectomy.

Methods: Hepatectomy was performed in 17 patients in an ESRD group and 181 in a non-ESRD group. We compared clinical characteristics and outcomes between these groups.

Results: Compared with the non-ESRD group, the ESRD group had a significantly higher rate of diabetes mellitus, higher serum creatinine levels, lower levels of hemoglobin, aspartate aminotransferase, and alanine aminotransferase, and a lower indocyanine green retention rate at 15 min. There were no significant differences between the 2 groups in other clinical characteristics, laboratory data, surgical outcomes, pathological findings, or overall postoperative morbidity or mortality. However, the incidence of postoperative pneumonia, gastrointestinal bleeding, and intra-abdominal bleeding was significantly higher in the ESRD group. The 5-year disease-free survival rate was 44.3% in the ESRD group and 24.0% in the non-ESRD group (p=0.4483), and the 5-year survival rates were 76.4% and 65.1% (p=0.2291), respectively. HD and serum creatinine levels were not significant prognostic factors for survival and recurrence.

Conclusion: Hepatectomy for HCC in patients with ESRD on HD may be associated with increased risk of postoperative pneumonia, gastrointestinal bleeding, and intra-abdominal bleeding, but is feasible if careful surgical and perioperative management are provided.

Key Words: hepatocellular carcinoma, hepatectomy, end-stage renal disease, hemodialysis

Introduction

Hepatectomy has been recognized as one of the most effective treatments for patients with hepatocellular carcinoma (HCC) and has become a safe operation with a relatively low mortality rate.[1-4] Patients with end-stage renal disease (ESRD) on hemodialysis (HD) have a higher incidence of viral hepatitis infection and HCC than the general population, and HCC is a significant risk factor for morbidity and mortality in patients who are receiving

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HD.[5-7] In addition, the risk of malignant disease is higher in patients with ESRD than in those without ESRD.[8] Major surgery can now be performed in patients with ESRD because of recent advances in surgical techniques and perioperative management.[9-12] Several authors have reported morbidity rates of 5% to 36% and mortality rates of 0% to 10% in dialysis patients who underwent elective abdominal surgery,[9-12] but hepatectomy for HCC in patients with ESRD remains risky due to various serious complications. Few studies have evaluated hepatectomy for HCC in patients with ESRD on HD.[13-16] The aim of this retrospective study was to evaluate the clinical characteristics and short- and long-term outcomes of hepatectomy for HCC in patients with ESRD on HD.

Materials and Methods

This study was approved by the Institutional Ethics Review Board at the Tokyo Women's Medical University (No. 5158) and conducted in accordance with the principles invoked in the Helsinki Declaration. Between January 1998 and December 2010, 17 patients with ESRD on HD underwent initial curative hepatectomy for HCC (ESRD group) at the Department of Surgery, Institute of Gastroenterology, Tokyo Women's Medical University Hospital, while 181 patients without ESRD underwent initial curative hepatectomy for HCC (non-ESRD group). We compared the clinical characteristics and the short- and long-term hepatectomy outcomes between the 2 groups. The indications for hepatectomy and the surgical procedures were determined according to tumor size, number, and type; liver function including indocyanine green retention rate at 15 min ($ICGR_{15}$); and the allowable extent of hepatic resection, evaluated using a logarithmic graph based on the $ICGR_{15}$.[17-18] The criteria for hepatectomy and the surgical procedure did not differ significantly between the ESRD and non-ESRD groups. The terminology used to describe the anatomic characteristics of the liver and resection were in accordance with the recommendations of the Terminology Committee of the International Hepato-Pancreato-Biliary Association in 2000.[19] Patients with simple nodular HCC without satellite nodules with a diameter of ≤3 cm underwent segmentectomy, subsegmentectomy, or limited resection. Patients with large, simple nodular HCC and satellite nodules underwent sectionectomy or hemihepatectomy. Major hepatectomy was defined as the resection of 2 or more segments, while minor hepatectomy was defined as the resection of fewer than 2 segments, including limited resection. Curative resection was defined as complete tumor removal, with negative macroscopic and microscopic findings. Hepatectomy with Glissonean pedicle transection at the hepatic hilum was usually performed.[20-22] Liver parenchymal transection was performed using a Cavitron Ultrasonic Surgical Aspirator (CUSA System, Valleylab Inc, Boulder, CO, USA) during an intermittent Pringle maneuver with 10-15 min of inflow occlusion and 5 min of reperfusion.

Protocol for perioperative management of HD

All patients regularly received HD 3 times per week, with nafamostat mesilate within 24 h before the operation. The first postoperative HD session was performed on postoperative day 2, using nafamostat mesilate. The second postoperative session of HD was performed on postoperative day 4 using conventional methods, with addition of heparin if the patient was free of events.

Clinical characteristics

The following clinical characteristics were recorded and analyzed: age, sex, hepatitis B surface antigen (HBs-Ag), hepatitis C virus antibody (HCV-Ab), presence or absence of diabetes mellitus, laboratory data including complete blood count (hemoglobin, platelet count), results of biochemical analyses including total bilirubin (T-bil), albumin (Alb), aspartate aminotransferase (AST), alanine aminotransferase (ALT), prothrombin time (PT), creatinine, and $ICGR_{15}$, tumor marker (serum α-fetoprotein), Child-Pugh grade, liver cirrhosis, tumor size and number, and intra- and postoperative factors including surgical procedure, operative time, blood loss, intraoperative blood transfusion, morbidity, mortality, and duration of hospital stay (days) after hepatectomy. Pathological factors including macroscopic tumor type, histological grade, vascular invasion, and intrahepatic metastasis were evaluated according to the General Rules for the Clinical and Pathological Study of Primary Liver Cancer, issued by the Liver Cancer Study Group of Japan.[23] Survival duration was defined as the time from liver surgery to the date of death or last contact. The me-

Table 1 Background characteristics of patients with HCC who underwent hepatectomy in the ESRD and non-ESRD groups.

	ESRD (n=17)	non-ESRD (n=181)	p-value
Age (years)	66.0 (41-79)	67.0 (16-83)	0.757
Sex (male/female)	15/2	144/37	0.390
HBs-Ag (+)	2 (11.8%)	29 (16.0%)	0.459
HCV-Ab (+)	10 (58.8%)	95 (52.5%)	0.617
Liver cirrhosis (+)	5 (29.4%)	74 (40.9%)	0.356
Child-Pugh grade (A/B/C)	14/3/0	155/23/3	0.745
A	14 (82.4%)	155 (85.7%)	0.714
Diabetes mellitus (+)	9 (52.9%)	41 (22.7%)	<0.0001

HCC, hepatocellular carcinoma; ESRD, end-stage renal disease; non-ESRD, non-end-stage renal disease; HBs-Ag, hepatitis B surface antigen; HCV-Ab, hepatitis C virus antibody.

Table 2 Laboratory data of patients with HCC who underwent hepatectomy in the ESRD and non-ESRD groups.

	ESRD (n=17)	non-ESRD (n=181)	p-value
T-bil (mg/dl)	0.3 (0.1-0.6)	0.6 (0.2-27.7)	0.311
Alb (g/dl)	3.8 (2.9-4.3)	3.8 (2.4-4.9)	0.702
AST (IU/L)	20 (7-60)	49 (12-214)	<0.0001
ALT (IU/L)	18 (5-50)	44 (11-232)	<0.0001
PT (%)	95.3 (63-100)	86.8 (45-100)	0.179
Plt ($\times 10^4/\mu L$)	14.8 (8.2-31.2)	13.2 (3.7-41)	0.256
Hb (g/dl)	10.0 (8.7-12.9)	13.3 (9.0-16.3)	<0.0001
Cre (mg/dl)	9.69 (6.18-15.79)	0.77 (0.39-2.49)	<0.0001
$ICGR_{15}$ (%)	11.0 (1-23)	15.0 (3-71)	0.037
AFP (ng/ml)	5.0 (1-2,630)	26 (1-1,625,800)	0.708

HCC, hepatocellular carcinoma; ESRD, end-stage renal disease; non-ESRD, non-end-stage renal disease; T-bil, total bilirubin; Alb, albumin; AST, aspartate aminotransferase; ALT, alanine aminotransferase; PT, prothrombin time; Plt, platelet count; Hb, hemoglobin; Cre, creatinine; $ICGR_{15}$, indocyanine green retention rate at 15 minutes; AFP, α-fetoprotein.

dian follow-up was 22 months (range, 5-86 months).

Statistical analysis

Data are presented as percentages or medians with ranges. The Mann-Whitney U test and Fisher's exact test were used to compare intergroup differences. The overall and disease-free survival rates were calculated with the Kaplan-Meier method, while survival rates were compared using the log-rank test. The potential predictors of survival and disease-free survival were evaluated using a multivariate analysis, Cox proportional hazards model. P values <0.05 were considered to indicate statistical significance. All statistical analyses were performed using the JMP 14 statistical software package (SAS Institute Inc., Cary, NC, USA).

Results

Comparison of background characteristics and laboratory data

The background characteristics of patients with HCC who underwent hepatectomy in the ESRD and non-ESRD groups are shown in **Table 1**. The ESRD group comprised 15 men and 2 women, with a median age of 66 years (range, 41-79). All patients in this group received HD for ESRD. The causes of ESRD were diabetic nephropathy in 9 patients, nephrotic syndrome in 3, immunoglobulin A nephropathy in 3, sclerotic kidney syndrome in 1, and unknown in 1. The median HD duration was 48 months (range, 1-291). In the ESRD group, markers for hepatitis were positive in 12 patients (70.6%; HCV-Ab positive in 10, HBs-Ag positive in 2). A significantly higher proportion of patients in the ESRD group than in the non-ESRD group had diabetes mellitus. There were no cases with cardiac dysfunction in the ESRD group. Other background characteristics did not differ significantly between the 2 groups. The laboratory data of patients in the ESRD and non-ESRD groups are shown in **Table 2**. The ESRD group had a significantly higher mean serum creatinine level and significantly lower hemoglobin, serum AST, serum ALT, and $ICGR_{15}$ levels than the non- ESRD group. There were no significant intergroup differences in any other laboratory variables.

Comparison of surgical outcomes and pathological findings

The surgical outcomes in the ESRD and non-ESRD groups are shown in **Table 3**. There were no significant intergroup differences in surgical procedure, operative time, operative blood loss, or intraoperative blood transfusion. The pathological findings in the ESRD and non-ESRD groups are shown in **Table 4**. Tumor size, tumor number, macroscopic tumor type, histological grade, vascular invasion, and intrahepatic metastasis were similar between the groups.

Table 3 Surgical outcomes in patients with HCC who underwent hepatectomy in the ESRD and non-ESRD groups.

	ESRD (n=17)	non-ESRD (n=181)	p-value
Surgical procedure			
Major hepatectomy	13 (76.5%)	111 (61.3%)	0.217
Minor hepatectomy	4 (23.5%)	70 (38.7%)	0.202
Sectionectomy or larger resection	7 (41.2%)	83 (45.9%)	0.711
Operative time (min)	190 (140-300)	203 (74-760)	0.329
Blood loss (ml)	780 (130-1,690)	880 (6-9,300)	0.294
Blood transfusion (n)	7 (41%)	55 (30.4%)	0.359

HCC, hepatocellular carcinoma; ESRD, end-stage renal disease; non-ESRD, non-end-stage renal disease.

Table 4 Pathological findings in patients with HCC who underwent hepatectomy in the ESRD and non-ESRD groups.

	ESRD (n=17)	non-ESRD (n=181)	p-value
Tumor size (cm)	4.5 (1.3-9.8)	5.0 (1-19)	0.781
Solitary tumor	14 (82%)	126 (69.6%)	0.270
Macroscopic tumor type simple nodular	10 (59%)	78 (43.1%)	0.212
Histological grade			
well/moderate/poor	1/15/1	12/156/13	0.814
moderate	15 (88%)	156 (86.2%)	
Vascular invasion	3 (18%)	47 (26%)	0.335
Intrahepatic metastasis	1 (5.9%)	30 (16.6%)	0.217

HCC, hepatocellular carcinoma; ESRD, end-stage renal disease; non-ESRD, non-end-stage renal disease; well, well-differentiated adenocarcinoma; moderate, moderately-differentiated adenocarcinoma; poor, poorly-differentiated adenocarcinoma.

Table 5 Postoperative morbidity and mortality in patients with HCC who underwent hepatectomy in the ESRD and non-ESRD groups.

	ESRD (n=17)	non-ESRD (n=181)	p-value
Morbidity	7 (41.2%)	59 (32.6%)	0.473
Ascites or pleural effusion	2 (11.8%)	27 (14.9%)	0.532
Bile leakage	0	21 (11.6%)	0.136
Intra-abdominal abscess	0	6 (3.3%)	0.579
Prolonged jaundice	0	5 (2.8%)	0.635
Pneumonia	2 (11.8%)	3 (1.7%)	0.011
Gastrointestinal bleeding	1 (5.9%)	1 (0.6%)	0.036
Intra-abdominal bleeding	1 (5.9%)	1 (0.6%)	0.036
Shunt infection, obstruction	1 (5.9%)		
Hospital stay (days)	15 (11-69)	15 (7-83)	0.337
Mortality	0	6 (3.3%)	0.446

HCC, hepatocellular carcinoma; ESRD, end-stage renal disease; non-ESRD, non-end-stage renal disease.

Comparison of postoperative morbidity and mortality

Postoperative morbidity and mortality rates in the ESRD and non-ESRD groups are shown in **Table 5**. In the ESRD group, postoperative morbidity was observed in 7 patients (41.2%), with massive ascites or pleural effusion in 2 (11.8%), pneumonia in 2 (11.8%), gastrointestinal bleeding from duodenal ulcer in 1 (5.9%), shunt infection and obstruction in 1 (5.9%), and intra-abdominal bleeding in 1 (5.9%); no surgical site infection was observed, including intra-abdominal abscess and sepsis. Although overall morbidity rates did not differ significantly between the 2 groups (41.2% vs. 32.6%; p=0.473), the ESRD group had significantly higher rates of pneumonia (11.8% vs. 1.7%; p=0.011), gastrointestinal bleeding (5.9% vs. 0.6%; p=0.036), and intra-abdominal bleeding (5.9% vs. 0.6%; p=0.036) than the non-ESRD group. One case had intra-abdominal bleeding from the cut surface of the liver on postoperative day 1, requiring hemostasis at relaparotomy. This case was considered a surgery-related complication. Only the development of shunt infection and obstruction in 1 case was considered a postoperative HD-related complication. There were no

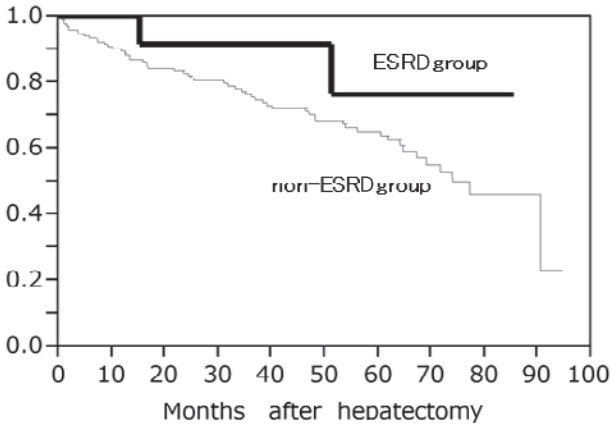

Figure 1 Overall survival after hepatectomy for HCC in the ESRD and non-ESRD groups (p=0.2291).
HCC, hepatocellular carcinoma; ESRD group, patients with end-stage renal disease; non-ESRD group, patients without end-stage renal disease.

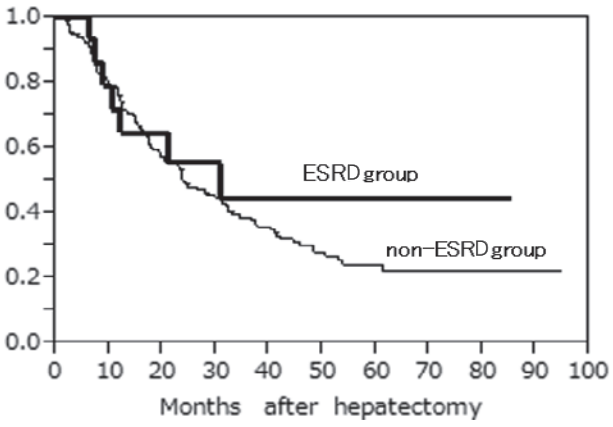

Figure 2 Disease-free survival after hepatectomy for HCC in the ESRD and non-ESRD groups (p=0.4483).
HCC, hepatocellular carcinoma; ESRD group, patients with end-stage renal disease; non-ESRD group, patients without end-stage renal disease.

cases of in-hospital mortality in the ESRD group. The median postoperative hospital stay was 15 days (range, 11-69 days) in the ESRD group. Postoperative mortality and length of hospital stay (days) did not differ significantly between the 2 groups.

Comparison of overall survival and disease-free survival rates

Overall survival and disease-free survival rates are shown in **Figure 1, 2**. The overall survival rates at 1, 3, and 5 years were 100%, 91.7%, and 76.4% in the ESRD group and 88.9%, 75.6%, and 65.1% in the non-ESRD group, respectively. The disease-free survival rates at 1, 3, and 5 years were 64.6%, 44.3%, and 44.3% in the ESRD group and 75.4%, 38.6%, and 24.0% in the non-ESRD group, respectively. There were no significant intergroup differences in overall or disease-free survival rates.

Prognostic factors for survival and recurrence in univariate and multivariate analyses

In univariate analysis, serum Alb level <3.5 (p=0.005), prothrombin time <80 (p=0.002), platelet count $<10 \times 10^4$ (p=0.001), and serum alpha-fetoprotein level ≥100 (p =0.009) were significant prognostic factors for overall survival (**Table 6**). In multivariate analysis, these were not significant. In univariate analysis, platelet count $<10 \times 10^4$ (p=0.005) was a significant prognostic factor for disease-free survival. In multivariate analysis, it was not significant (**Table 7**). HD and serum creatinine level were not significant prognostic factors for survival and recurrence.

Discussion

This study was performed to evaluate the clinical characteristics and short- and long-term outcomes of hepatectomy for HCC in patients with ESRD on HD. We compared the long-term outcomes of hepatectomy for HCC in patients with and without ESRD. Overall or disease-free survival rates did not differ between the ESRD and non-ESRD groups. HD and the serum creatinine level were not significant prognostic factors for survival and recurrence. However, the incidence of postoperative pneumonia, gastrointestinal bleeding, and intra-abdominal bleeding was significantly higher in the ESRD group. Our findings suggest that hepatectomy for HCC is feasible in patients with ESRD on HD, provided that careful surgical and perioperative management for pneumonia and bleeding is performed.

The Renal Data Registry Committee of the Japanese Society for Dialysis Therapy reported that causes of death in patients with ESRD include infectious diseases (26.5%), cardiac failure (24.9%), and malignant tumors (12.5%).[24] ESRD has also been associated with increased risk of surgical complications, including infection, electrolyte disturbances, fluid overload, cardiac failure, anemia, and bleeding tendency. More patients with ESRD

Table 6 Univariate and multivariate analyses of prognostic factors for overall survival.

Variable		Univariate	Multivariate	
		p-value	Odds ratio (95% CI)	p-value
Age (years)	<70 vs ≥70	0.051		
Sex	male vs female	0.310		
HBs-Ag	positive vs negative	0.191		
HCV-Ab	positive vs negative	0.794		
Liver cirrhosis	present vs absent	0.238		
Diabetes mellitus	present vs absent	0.256		
HD	present vs absent	0.229		
Alb (g/dl)	<3.5 vs ≥3.5	0.005	1.136 (0.599-2.104)	0.689
ALT (IU/L)	<50 vs ≥50	0.502		
PT (%)	<80 vs ≥80	0.002	1.363 (0.730-2.519)	0.327
Plt ($\times 10^4/\mu L$)	<10 vs ≥10	0.001	1.467 (0.787-2.717)	0.226
Hb (g/dl)	<10 vs ≥10	0.633		
Cre (mg/dl)	<2.0 vs ≥2.0	0.408		
ICGR15 (%)	<20 vs ≥20	0.515		
AFP (ng/ml)	<100 vs ≥100	0.009	1.711 (0.991-2.916)	0.053
Major hepatectomy	present vs absent	0.606		
Blood loss (ml)	<1,000 vs ≥1,000	0.172		
Tumor size (cm)	<3 vs ≥3	0.778		
Histological grade moderate	present vs absent	0.807		
Vascular invasion	present vs absent	0.163		
Intrahepatic metastasis	present vs absent	0.624		

HD, hemodialysis.

Table 7 Univariate and multivariate analyses of prognostic factors for disease-free survival.

Variable		Univariate	Multivariate	
		p-value	Odds ratio (95% CI)	p-value
Age (years)	<70 vs ≥70	0.866		
Gender	male vs female	0.897		
HBs-Ag	positive vs negative	0.986		
HCV-Ab	positive vs negative	0.412		
Liver cirrhosis	present vs absent	0.892		
Diabetes mellitus	present vs absent	0.941		
HD	present vs absent	0.449		
Alb (g/dl)	<3.5 vs ≥3.5	0.130		
ALT (IU/L)	<50 vs ≥50	0.963		
PT (%)	<80 vs ≥80	0.136		
Plt ($\times 10^4/\mu L$)	<10 vs ≥10	0.005	1.478 (0.942-2.282)	0.088
Hb (g/dl)	<10 vs ≥10	0.249		
Cre (mg/dl)	<2.0 vs ≥2.0	0.616		
ICGR15 (%)	<20 vs ≥20	0.584		
AFP (ng/ml)	<100 vs ≥100	0.378		
Major hepatectomy	present vs absent	0.967		
Blood loss (ml)	<1,000 vs ≥1,000	0.929		
Tumor size (cm)	<3 vs ≥3	0.709		
Histological grade moderate	present vs absent	0.785		
Vascular invasion	present vs absent	0.071		
Intrahepatic metastasis	present vs absent	0.630		

HD, hemodialysis.

are thus likely to require surgical treatment. Hepatectomy was therefore considered to be contraindicated in such patients. Kaibori et al.[25] evaluated 57 HCC patients with renal dysfunction, of whom only 5 were on HD, and found that postoperative morbidity rates did not differ between those with and without renal dysfunction after he-

patectomy. In contrast, Toshima et al.[26] evaluated 17 HCC cases with renal dysfunction (defined as serum creatinine >2.0 mg/dl), and reported that these patients had a significantly higher risk of postoperative massive ascites and pleural effusion than those without renal dysfunction after hepatectomy. However, these reports included only small numbers of patients on HD. There are only a few reports on hepatectomy for HCC in patients with ESRD on HD.[13-16]

Yeh et al.[14] reported a morbidity rate of 42.3% and a mortality rate of 11.5% in 26 patients with ESRD who received hepatectomy for HCC. The postoperative morbidity rate was significantly higher than in patients without ESRD, with a higher risk of postoperative massive ascites and pleural effusion, but the postoperative mortality rate did not differ significantly. Orii et al.[15] reported a morbidity rate of 58.8% and a mortality rate of 0% in 17 patients with ESRD who underwent hepatectomy for HCC. There were no significant differences in overall postoperative morbidity or mortality as compared with patients without ESRD. Only the incidence of circulatory insufficiency was higher in patients with ESRD. Yeh et al.[16] reported that patients with ESRD did not show an increase in overall postoperative complications, but did have a significantly higher risk of infection and heart-associated complications. These studies reported increased morbidity rates in patients with ESRD who underwent hepatectomy for HCC, but no significant differences in postoperative mortality were confirmed. In our study, overall postoperative morbidity rates (ESRD: 41.2% vs. non-ESRD: 32.6%; p=0.473) and mortality rates (ESRD: 0% vs. non-ESRD: 3.3%; p=0.446) did not differ significantly between the 2 groups. The results of our study were similar to those of previous studies.

Postoperative pneumonia occurred in 2 patients (11.8%) in our study. Drolet et al.[27] evaluated 5,806 patients on HD who underwent colorectal surgery, and found that the rates of pulmonary (23%) and infectious (25%) complications after colorectal resection were significantly higher in those with ESRD. Some studies reported that dialysis treatment induces hypoxemia because of carbon dioxide diffusion through the dialysate, subsequently leading to hypocapnia and hypoventilation. These events may lead to a higher risk of developing atelectasis and pneumonia.[28, 29] Although there were no significant intergroup differences in platelet count and prothrombin time in our data, postoperative gastrointestinal bleeding (5.9%) and intra-abdominal bleeding (5.9%) rates were significantly higher in patients with ESRD. Patients with ESRD demonstrate coagulation abnormalities related to platelet dysfunction that lead to bleeding complications.[30] Therefore, the use of anticoagulants during HD sessions after hepatectomy should be monitored carefully. Hepatectomy is characterized by large fluid shifts in the perioperative period. Patients with ESRD are not able to correct for large volume shifts and hemodynamic changes associated with HD treatments. These lead to complications related to fluid overload, circulatory insufficiency, and cardiac failure. Orii et al.[15] reported that the incidence of circulatory insufficiency was higher in patients with ESRD. Yeh et al.[16] reported a significantly higher risk of heart-associated complications in patients with ESRD. Our study observed no episodes of circulatory insufficiency or cardiac failure and no significant differences in postoperative massive ascites and pleural effusion. Although the presence of hepatitis viral markers, liver cirrhosis, and Child-Pugh grade showed no significant intergroup differences, the ESRD group had significantly lower $ICGR_{15}$ levels than the non-ESRD group, possibly because our study selected patients with good liver function. Patients with ESRD have impaired immune function, characterized by induction of a proinflammatory state, and decreased number and function of lymphoid and phagocytic cells,[31, 32] leading to complications related to surgical site infection and sepsis. Although the criteria for hepatectomy and the surgical procedure did not differ significantly between the ESRD and non-ESRD groups, there were no episodes of surgical site infection in our study, including intra-abdominal abscess and sepsis.

Most authors[13-15, 26] reported that the 5-year survival and disease-free survival rates showed no significant differences between ESRD and non-ESRD groups. However, Orii et al.[15] reported that the 5-year survival and disease-free survival rates, respectively, were 55.3% and 36.1% in the ESRD group and 66.0% and 30.1% in the non-ESRD group. The disease-free survival rate did not differ significantly between the groups, but the overall survival rate was significantly lower in the ESRD group than in the non-ESRD group. The survival time after recurrence

was significantly shorter in the ESRD group than the in the non-ESRD group. Some authors have reported that rapid tumor progression might be caused by immunosuppression in patients with HCC who have ESRD.[15, 33] The incidence of malignant disease is higher in patients with ESRD than in the non-ESRD population.[8] Because cellular and humoral immune responses are suppressed in patients with ESRD,[34, 35] the risk of recurrence of HCC may also be increased by immunosuppression in patients with ESRD. Some authors have reported that elevated serum blood urea nitrogen, serum creatinine, and creatinine clearance <70 mg/min were risk factors associated with poor outcomes in patients with ESRD who underwent hepatectomy for HCC.[14, 25] However, there were no significant intergroup differences in overall or disease-free survival rates, and HD and serum creatinine levels were not significant risk factors for survival and recurrence in our study. Some authors have reported that liver function parameters included serum Alb level <3.5, platelet count $<8 \times 10^4$, prolonged prothrombin time-international normalized ratio (PT-INR) > 1.10, and serum alpha-fetoprotein level were risk factors associated with poor outcomes in patients who underwent hepatectomy for HCC.[3, 4, 36] The results of our study in univariate analysis were similar to those of studies. However, these were not significant risk factors in multivariate analysis, possibly because our study selected small number of patients.

This study had several limitations. This was a retrospective, single-center study of a relatively small number of patients with ESRD on HD. The patients in this study who underwent hepatectomy represent a narrowly selected group. However, hepatectomy for HCC should not be a contraindication in patients with ESRD.

Conclusion

Hepatectomy for HCC in patients with ESRD on HD may be associated with an increased risk for development of postoperative pneumonia, gastrointestinal bleeding, and intra-abdominal bleeding, but is feasible provided that careful surgical and perioperative management is provided. However, further investigation is needed to confirm the validity of our findings.

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