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Original Article

Feasibility of hepatectomy in elderly patients with hepatocellular carcinoma

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Abstract: The aim of this study was to evaluate the feasibility of hepatectomy in elderly patients with hepatocellular carcinoma (HCC). A total of 1,142 patients, undergoing hepatectomy for HCC from January 2010 to December 2013, were recruited into this retrospective study. Samples were classified into three groups according to age: young group (< 65 years), young-old group (65-79 years), and old-old group (≥ 80 years). Compared to the young group, lower BMI, lower hepatitis B virus infection rate, higher ASA grade, and Child-Pugh grade A were more frequent both in young-old and old-old groups. Rate of overall complications was elevated along with increasing age. Rate of severe complications, similar in the young (5.1%) and young-old (5.8%) groups, sharply surged in the old-old group (18.8%). Multivariate analysis displayed that risk of overall complications was strongly associated with age, Child-Pugh grade, ASA grade, and multiple comorbidities. Rates of overall survival (OS) were 31.9%, 57.1% and 63.0% in young, young-old, and old-old groups, respectively. These suggest that OS rates reduce with age. Multivariate analysis also showed that OS rate was negatively related to the number of tumors, satellite nodule, vascular invasion, portal vein thrombosis, TNM stage, and BCLC stage. When adjusted for confounding factors, young-old age was not a risk factor for poor outcomes but old-old age was. Thus, hepatectomy is relatively safe and beneficial for the young-old, while the decision to conduct hepatectomy for the old-old should be made carefully.

Keywords: Hepatocellular carcinoma, hepatectomy, elderly, complications, overall survival

Introduction

Hepatocellular carcinoma (HCC), representing almost 90% of primary liver cancer cases, is the fifth most common tumor and third leading cause of cancer-related mortality, worldwide [1]. Recently, cancer statistics have displayed that incidence of liver cancer increases about 4% and 3% in men and women per year, respectively [2]. As the aging population's life expectancy has elevated greatly in recent decades, the proportion of elderly diagnosed with HCC is soaring [3].

In recent years, a series of surveys on the short-term safety and long-term benefits of surgical hepatectomy for HCC in the elderly have been conducted. Although some researchers have reported that there is significantly higher morbidity and mortality after hepatectomy for HCC in the elderly than in the young [3, 4], others have suggested that the elderly could safely undergo hepatectomy [5-8]. Thus, the feasibility of hepatectomy in the elderly with HCC remains controversial.

The aim of this retrospective study, designed by age stratification, was to investigate the feasibility of hepatectomy in the elderly with HCC. This study found the age threshold for adverse outcomes by comparing clinicopathological features, complications, postoperative hospital durations, and mortality.

Patients and methods

Patients

We, retrospectively, accumulated 1,142 patients with HCC that experienced hepatectomy, from January 2010 to December 2013, at the Department of Surgery in Eastern Hepatobiliary Surgery Hospital (Shanghai, China). Imaging examinations including ultrasonography, com-

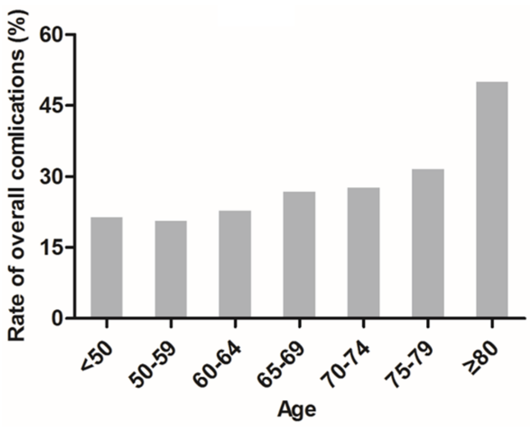

Figure 1. Variations of overall complications with advancing age after surgery.

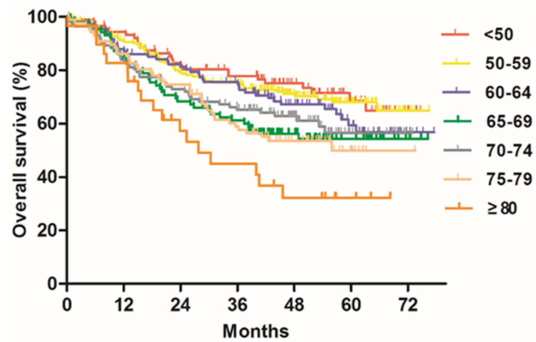

Figure 2. Cariations of overall survival rates with advancing age after surgery.

puted tomography (CT) scan, and magnetic resonance imaging (MRI) were used to evaluate resectability of each tumor mass. Liver function, including biochemistry tests and Child-Pugh grading, was also carefully assessed. All patients signed informed consent forms and this study was approved by the Institutional Research Ethics Committee of Eastern Hepatobiliary Surgery Hospital.

Data collection

Data was collected from medical records. Parameters used in this study were as follows: (1) Preoperative clinicopathological features included gender, age, hepatitis B and C virus infection, Child-Pugh grade, Body Mass Index (BMI), American Society of Anesthesiology (ASA) grade, and comorbidities; (2) Postoperative data included tumor size, tumor encapsulation, number of tumor, satellite nodules, vascular invasion, portal vein thrombosis, tumor node metastasis (TNM) classification, Barcelona Clinic Liver Cancer (BCLC) stage, postoperative complications, postoperative hospital duration, in-hospital death, and overall survival (OS).

Definitions

OS was defined as the duration from initiation of hepatectomy to date of death or last follow up, whichever occurred first. Complications were defined by grade II and higher, according to Clavien-Dindo classification [9], within 30 days after surgical resection. In-hospital mortality was defined as death within 30 days after surgery.

Follow up

Follow up period was calculated from the time of the operation to the day of last follow up visit or death. All patients were followed up every 2-3 months for the first 2 years after hepatectomy. Patients were then evaluated every 3-6 months. The follow up evaluation embraced physical examinations, blood chemistry tests, alpha fetoprotein (AFP), and imaging examinations. Follow up was until March 2017.

Statistical analysis

Statistical analysis was performed with SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). Continuous data are shown as mean ± standard deviation and categorical data are expressed as numbers and percentages. To assess the relationship between age at surgery and clinicopathological features, one-way ANOVA and X^2 test were performed for continuous and categorical variables, respectively. Univariate and multivariate Cox regression models were conducted to evaluate the prognostic value of all parameters. OS for HCC patients was assessed by Kaplan-Meier method and compared using log-rank test. The criterion for statistical significance was $P < 0.05$.

Results

Grouping

A total of 1,142 patients, undergoing hepatectomy of HCC, were included in this study from January 2010 to December 2013. First, all samples were divided into 7 groups by age (< 50, 50-59, 60-64, 65-69, 70-74, 75-79, ≥ 80 years). As age advanced, the risk of postoperative overall complications elevated and

Table 1. Demographic and clinicopathological features of all patients

Factors	Total (n = 1142)	Young group (n = 886)	Young-old group (n = 224)	Old-old group (n = 32)	*P*
Age at operation (years)	61.2 ± 7.4	52.6 ± 13.2	73.7 ± 7.5	82.4 ± 1.6	< 0.001*
Gender					0.386
Male	920	713 (80.5)	184 (82.1)	23 (71.9)	
Female	222	173 (19.5)	40 (17.9)	9 (28.1)	
BMI, kg/m^2	21.56 ± 2.72	22.06 ± 2.92	21.43 ± 2.88	20.89 ± 2.67	0.007*
HBs Ag					< 0.001*
Positive	836	691 (78.0)	137 (61.2)	8 (25.0)	
Negative	306	195 (22.0)	87 (38.8)	24 (75.0)	
HCV Ab					0.227
Positive	104	74 (8.4)	27 (12.0)	3 (9.4)	
Negative	1038	812 (91.6)	197 (88.0)	29 (90.6)	
AFP (ng/ml)					< 0.001*
≥ 400	680	571 (64.4)	103 (46.0)	6 (18.8)	
< 400	462	315 (35.6)	121 (54.0)	26 (81.2)	
Liver cirrhosis					0.001*
Positive	873	696 (78.5)	159 (71.0)	18 (56.3)	
Negative	269	190 (21.5)	65 (29.0)	14 (43.7)	
Liver function					
ALT (U/l)	41.6 ± 28.4	45.2 ± 34.7	38.6 ± 25.4	35.9 ± 21.2	0.427
AST (U/l)	50.8 ± 31.7	53.4 ± 35.3	49.6 ± 29.7	47.2 ± 30.3	0.553
TBIL (μmol/l)	18.6 ± 14.5	19.7 ± 15.4	17.9 ± 14.8	17.2 ± 13.2	0.214
Albumin (g/l)	37.8 ± 5.1	38.4 ± 5.4	37.7 ± 4.8	36.6 ± 4.4	0.156
Child-Pugh grading					0.003*
grade A	957	725 (81.8)	202 (90.2)	30 (93.8)	
grade B	185	161 (18.2)	22 (9.8)	2 (6.2)	
ASA grade					< 0.001*
I	454	385 (43.4)	69 (30.8)	0 (0)	
II	544	403 (45.5)	121 (54.0)	20 (62.5)	
III	144	98 (11.1)	34 (15.2)	12 (37.5)	
Comorbidity					0.001*
No	780	627 (60.8)	138 (61.6)	15 (47.9)	
Yes	362	259 (29.2)	86 (38.4)	17 (53.1)	
Detail of comorbidity					
Hypertension	206	133 (15.0)	65 (29.0)	8 (25.0)	< 0.001*
Diabetes	138	84 (9.5)	47 (20.1)	7 (21.9)	< 0.001*
Pulmonary diseases	49	35 (4.0)	9 (4.0)	5 (15.6)	0.006*
Cardiac diseases	40	25 (2.8)	12 (5.4)	3 (9.4)	0.034*
Neurological diseases	26	18 (2.0)	8 (3.6)	0 (0)	0.263
Renal diseases	15	9 (1.0)	6 (2.7)	0 (0)	0.119
Tumor size	8.0 ± 5.2	8.4 ± 4.8	7.6 ± 3.9	6.9 ± 3.6	0.243
Tumor encapsulation					< 0.001*
Complete	526	372 (42.0)	132 (58.9)	22 (68.7)	
Incomplete	616	514 (58.0)	92 (41.1)	10 (31.3)	
Number of tumor					0.039*
Solitary	902	688 (77.7)	184 (82.1)	30 (93.8)	
Multiple	240	198 (22.3)	40 (17.9)	2 (6.2)	
Satellite nodule					0.133
Present	338	274 (30.9)	58 (25.9)	6 (18.8)	
Absent	804	612 (69.1)	166 (74.1)	26 (81.2)	
Vascular invasion					0.261
Present	195	159 (17.9)	33 (14.7)	3 (9.4)	
Absent	947	727 (82.1)	191 (85.3)	29 (90.6)	
Portal vein thrombosis					0.791
Present	186	147 (16.6)	35 (15.6)	4 (12.5)	
Absent	956	739 (83.4)	189 (84.4)	28 (87.5)	

TNM stage					0.249
I	675	516 (58.2)	139 (62.1)	20 (62.5)	
II	314	239 (27.0)	64 (28.6)	11 (34.4)	
III	103	88 (9.9)	14 (6.2)	1 (3.1)	
IV	50	43 (4.9)	7 (3.1)	0 (0)	
BCLC stage					0.682
A	712	546 (61.6)	146 (65.2)	20 (62.5)	
B	341	267 (30.1)	63 (28.1)	11 (34.4)	
C	89	73 (8.2)	15 (6.7)	1 (3.1)	

Continuous data are expressed as mean ± standard deviation. HBsAg, hepatitis B surface antigen; HCV Ab, hepatitis C antibody; AFP, alpha-fetoprotein; ALT, alanine aminotransferase; AST, aspartate aminotransferase; TBIL, total bilirubin; BMI, Body Mass Index; ASA, American Society of Anesthesiologists; TNM, Tumor-Node-Metastasis; BCLC, Barcelona Clinic Liver Cancer.

Table 2. Short- and long-term outcomes after hepatectomy

Factors	Total (n = 1142)	Young group (n = 886)	Young-old group (n = 224)	Old-old group (n = 32)	*P*
Overall complications	298 (26.1)	189 (21.3)	63 (28.1)	16 (50.0)	< 0.001*
Severe complications[a]	64 (5.6)	45 (5.1)	13 (5.8)	6 (18.8)	0.004*
Detail of complications					
Surgical complications	65 (5.7)	51 (5.8)	12 (5.4)	2 (6.3)	0.962
Bile leakage	15 (1.3)	11 (1.2)	3 (1.3)	1 (3.1)	0.655
Wound infection	20 (1.8)	15 (1.7)	4 (1.8)	1 (3.1)	0.831
Bleeding	20 (1.8)	17 (1.9)	3 (1.3)	0 (0)	0.626
Intra-abdominal abscess	9 (0.8)	7 (0.8)	2 (0.9)	0 (0)	0.867
Medical complications	290 (25.4)	197 (22.2)	73 (32.6)	20 (62.5)	< 0.001*
Respiratory	162 (14.2)	102 (11.5)	49 (21.9)	11 (34.4)	< 0.001*
Hydrothorax	123 (10.8)	82 (9.3)	35 (15.6)	6 (18.8)	0.007*
Pneumonia	47 (4.1)	24 (2.7)	16 (7.1)	7 (21.9)	< 0.001*
Respiratory failure	20 (1.8)	11 (1.2)	5 (2.2)	4 (12.5)	< 0.001*
Liver failure	34 (3.0)	24 (2.7)	8 (3.6)	2 (6.3)	0.431
Ascites	119 (10.4)	92 (10.4)	21 (9.4)	6 (18.8)	0.267
Renal failure	29 (2.5)	21 (2.4)	6 (2.7)	2 (6.3)	0.387
Sepsis	14 (1.2)	8 (0.9)	4 (1.8)	2 (6.3)	0.018*
Cardiac	16 (1.4)	7 (0.8)	7 (3.1)	2 (6.3)	0.002*
Others	11 (1.0)	8 (0.9)	3 (1.3)	0 (0)	0.713
In-hospital mortality	8 (0.7)	4 (0.5)	3 (1.3)	1 (3.1)	0.090
Postoperative hospital stays, days	10 (8.0-14.0)	10 (7.0-13.0)	12 (8.0-16.0)	13 (10.0-18.0)	< 0.001*
Long-term outcomes					
Deaths	544 (47.6)	403 (45.5)	119 (53.1)	22 (68.8)	0.007
Cancer-related deaths	507 (44.4)	382 (43.1)	108 (48.2)	17 (53.1)	0.235
Non-cancer-related deaths	37 (3.2)	21 (2.4)	11 (4.9)	5 (12.5)	< 0.001*
Loss to follow-up	23 (2.0)	15 (1.7)	8 (3.6)	0 (0)	0.144

*Statistically significant ($P < 0.05$). [a]Clavien-Dindo grade ≥ III.

OS rate reduced. The rate of overall complications began to increase and surged at ages of 65 and 80 years, respectively (**Figures 1** and **2**). Therefore, age at surgery was grouped into: young group (< 65 years), young-old group (65-79 years), and old-old group (≥ 80 years).

Clinicopathological features

The sociodemographic and clinical characteristics are shown in **Table 1**. Mean age at operation was 52.6 ± 13.2 years in the young group, 73.7 ± 7.5 years in young-old group, and 82.4 ± 1.6 years in old-old group. There were no signifi-

Table 3. Univariate and multivariate analysis of overall complications

Factors	Univariate analysis		Multivariate analysis	
	HR (95% CI)[a]	*P*	HR (95% CI)[a]	*P*
Age				
Old-old vs. Young	4.624 (2.253-8.384)	0.000*	3.264 (2.833-6.376)	< 0.001*
Young-old vs. Young	1.628 (1.127-2.536)	0.013*	1.452 (1.249-2.338)	0.036*
Gender				
Male vs. Female	1.226 (0.927-2.376)	0.084		
BMI < 18.5 kg/m^2				
Yes vs. No	1.405 (1.026-2.365)	0.634		
HBs Ag				
Positive vs. Negative	1.079 (0.786-2.146)	0.439		
HCV Ab				
Positive vs. Negative	1.362 (0.746-3.366)	0.642		
AFP (ng/ml)				
≥ 400 vs. < 400	1.583 (0.992-2.753)	0.049*		
Liver cirrhosis				
Positive vs. Negative	2.736 (1.529-4.956)	0.006*	1.976 (1.832-3.591)	0.031*
Child-Pugh grade				
B vs. A	1.746 (1.477-4.268)	0.023*	1.672 (1.747-3.659)	0.037*
ASA grade				
III vs. II, I	3.157 (1.996-6.682)	0.000*	2.746 (2.086-4.237)	0.006*
Comorbidity				
Multiple vs. None	2.868 (1.521-4.869)	0.000*	2.652 (1.713-4.247)	0.005*
Single vs. None	1.457 (0.943-2.358)	0.085	1.385 (0.985-1.926)	0.082
TBIL (μmol/l)				
≥ 34 vs. < 34	2.757 (1.996-6.682)	0.042*		
Albumin (g/l)				
≥ 35 vs. < 35	1.448 (0.796-3.237)	0.073		
Tumor size (cm)				
≥ 5 vs. < 5	1.257 (0.662-2.027)	0.324		
Tumor encapsulation				
Incomplete vs. Complete	1.016 (0.795-2.342)	0.253		
Number of tumor				
Multiple vs. Solitary	1.361 (0.774-2.771)	0.094		
Satellite nodule				
Present vs. Absent	1.014 (0.648-3.125)	0.775		
Vascular invasion				
Present vs. Absent	1.541 (0.842-2.951)	0.244		
portal vein thrombosis				
Present vs. Absent	1.433 (0.726-3.147)	0.378		
TNM stage				
III vs. I	1.358 (0.793-2.146)	0.559		
II vs. I	1.179 (0.574-2.354)	0.435		
BCLC stage				
C vs. A	1. 542 (0.936-3.167)	0.448		
B vs. A	1.346 (0.747-2.635)	0.435		

*Statistically significant (*P* < 0.05). [a]HR, Hazard Ratio; CI, Confidence Interval.

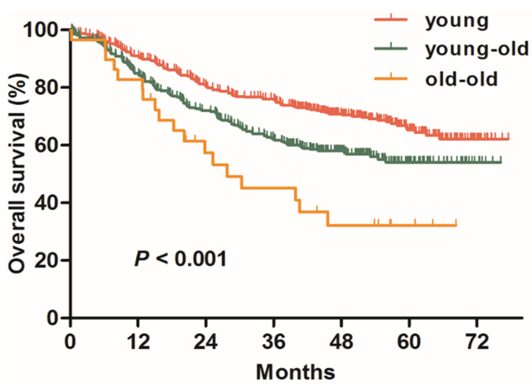

Figure 3. Kaplan-Meier survival curves for overall survival of the three groups (young, young-old, old-old groups).

cant differences in gender, HCV Ab, tumor size, number of tumor, satellite nodule, vascular invasion, portal vein thrombosis, TNM stage, and BCLC stage among these three groups. BMI (P = 0.007) and the positive rate of hepatitis B surface antigen (HBs Ag) (P < 0.001) decreased gradually with increasing age. In contrast, the incidence of comorbidity increased gradually with advancing age (P < 0.001). By comparison, ASA grade III was more frequent in the old-old group than in the other two groups (P < 0.001). Rate of Child-Pugh grade A was relatively higher in young-old and old-old groups (P = 0.003).

Short-term surgical outcomes

As presented in **Table 2**, incidences of overall complications were 21.3%, 28.1% and 50.0% in the young, young-old, and old-old groups, respectively. Risk of overall complications in the old-old group was approximately 2.4-fold higher than in the young group (P < 0.001). Additionally, incidence of severe complications, which showed no significant difference between young and young-old groups (5.1% and 5.8%, respectively; P = 0.663), was extremely high in the old-old group (18.8%, P = 0.004). Among these three groups, no statistically significant differences were observed in surgical complication incidence (P = 0.962). Differences of incidence of medical complications were significant among all groups (P < 0.001). In particular, respiratory complications (11.5% in the young group, 21.9% in young-old group, and 34.4% in the old-old group; P < 0.001) were the most frequent manifestation among all medical complications. There were no significant differences in in-hospital mortality rate among these three groups (P = 0.090). However, the duration of hospitalization after the operation prolonged with increasing age (P < 0.001). Furthermore, age (old-old *vs*. young, HR = 3.264, P < 0.001; young-old *vs*. young, HR = 1.452, p = 0.036), Child-Pugh grade (B *vs*. A, HR = 1.672, P = 0.023), ASA grade (III *vs*. II and I, HR = 2.746, P = 0.006) and multiple comorbidities (HR = 2.652, P = 0.005) were independent risk factors for overall complications (**Table 3**).

Long-term survival

At the median time point of follow-up (48.5 months, ranging from 0.15-72.2 months), 507 patients (44.4%) died from cancer-related issues. No remarkable differences were observed among these three groups (P = 0.235). However, deaths caused by non-cancer-related reasons elevated with advancing age (2.4% in the young group, 4.9% in the old-young group, and 12.5% in the old-old group, P < 0.001) (**Table 2**). On the contrary, the rate of OS reduced with age (**Figures 2** and **3**). By multivariate analysis, it was found that age (old-old *vs*. young, HR = 2.712, P = 0.003), number of tumor (multiple *vs*. solitary, HR = 1.764, P = 0.015), satellite nodule (HR = 2.147, P = 0.033), vascular invasion (HR = 2.742, P = 0.001), portal vein thrombosis (HR = 3.144, P = 0.021), TNM stage (III *vs*. I, HR = 4.582, P < 0.001; II *vs*. I, HR = 2.798, P < 0.001), and BCLC stage (C *vs*. A, HR = 5.136, P < 0.001; B *vs*. A, HR = 3.178, P < 0.001) were negatively associated with OS rate (**Table 4**).

Discussion

With an explosion of the aging population, elderly suffering from HCC is expected to rise. Over the past few decades, accumulative research has been performed to detect the cut-off age for HCC patient's ability to sustain surgical resection [10-20], but the conclusions are debatable. No general consensus exists on outcomes of hepatectomy performed in the elderly. Authors have variably defined the elderly as greater than 65, greater than 70, or greater than 80. Here, all samples were divided into 3 groups by age: young group (< 65 years), young-old group (65-79 years), and old-old group (≥ 80 years).

In this study, it was shown that the elderly had lower BMI, higher ASA grades, and more comorbidities, suggesting that the elderly usually

Table 4. Univariate and multivariate analysis of overall survival

Factors	Univariate analysis		Multivariate analysis	
	HR (95% CI)[a]	*P*	HR (95% CI)[a]	*P*
Age				
Old-old vs. Young	1.962 (1.529-2.516)	< 0.001*	2.712 (1.977-4.975)	0.003*
Young-old vs. Young	1.536 (1.185-1.965)	0.001*	1.265 (0.897-1.735)	0.105
Gender				
Male vs. Female	1.428 (1.077-2.192)	0.023*		
BMI < 18.5 kg/m^2				
Yes vs. No	1.224 (0.877-1.733)	0.138		
HBs Ag				
Positive vs. Negative	1.397 (0.985-3.184)	0.395		
HCV Ab				
Positive vs. Negative	1.273 (0.896-1.589)	0.232		
AFP (ng/ml)				
≥ 400 vs. < 400	1.487 (0.895-2.774)	0.036*		
Liver cirrhosis				
Positive vs. Negative	1.366 (0.954-3.156)	0.074		
Child-Pugh grade				
B vs. A	1.659 (1.534-4.287)	0.037*		
ASA grade				
III vs. II, I	1.565 (1.111-2.304)	0.085		
Comorbidity				
Multiple vs. None	1.215 (0.936-1.728)	0.191		
Single vs. None	1.197 (0.745-1.592)	0.237		
TBIL (μmol/l)				
≥ 34 vs. < 34	1.527 (1.092-3.822)	0.067		
Albumin (g/l)				
≥ 35 vs. < 35	1.434 (0.946-3.36)	0.083		
Tumor size (cm)				
≥ 5 vs. < 5	1.175 (0.662-2.524)	0.058		
Tumor encapsulation				
Incomplete vs. Complete	1.866 (1.369-4.247)	0.027*		
Number of tumor				
Multiple vs. Solitary	1.631 (1.374-4.953)	0.044*	1.764 (1.278-4.272)	0.015*
Satellite nodule				
Present vs. Absent	2.441 (1.586-6.356)	0.004*	2.147 (1.685-5.258)	0.033*
Vascular invasion				
Present vs. Absent	2.874 (1.893-7.224)	0.000*	2.742 (1.842-5.516)	0.001*
Portal vein thrombosis				
Present vs. Absent	3.516 (1.872-8.731)	0.002*	3.144 (2.058-6.972)	0.021*
TNM stage				
III vs. I	5.358 (3.798-12.465)	< 0.001*	4.582 (3.985-10.547)	< 0.001*
II vs. I	3.182 (1.697-5.237)	< 0.001*	2.798 (1.875-4.993)	< 0.001*
BCLC stage				
C vs. A	6.637 (3.246-14.628)	< 0.001*	5.136 (3.782-13.046)	< 0.001*
B vs. A	3.774 (1.586-6.172)	< 0.001*	3.178 (1.768-5.259)	< 0.001*

*Statistically significant ($P < 0.05$). [a]HR, Hazard Ratio; CI, Confidence Interval.

have worse nutrient conditions and bodily function. In concordance with a previous study [12], it was found that more young patients had hepatitis B virus (HBV) infection rate. This reason is because, in the Asia-Pacific region, most people are infected with HBV in early childhood and HBV-related HCC usually occurs in their fifties. Consistently, the malignant degree in the elderly with HCC is lower than in young patients. Elderly with HCC are less often related to advanced tumor factors, including complete tumor encapsulation and solitary tumors. In comparison to the young group, risks of satellite nodules, vascular invasion, and portal vein thrombosis were lower than those in the young-old and old-old groups but no significant differences were observed in pathological characteristics. In this series, given that elderly HCC patients were carefully selected before surgery, they always had a higher proportion of liver function and belonged to Child-Pugh A grading.

Regarding outcomes, this study showed that incidence of postoperative hospitalization mortality was similar among all groups. Risk of overall complications, however, increased remarkably with age. Multivariate analysis suggested that age, ASA grade, and multiple comorbidities were independent risks for complications. A series of survives has also demonstrated that age is the main negative risk for occurrence of complications after hepatectomy [2, 4, 13]. Higher risk of postoperative complications in the elderly can be attributed to underlying diseases and generally worse bodily function. Moreover, this study's results showed that risk of severe complications, similar in the young and young-old groups, was markedly higher in old-old patients. It can be explained by the sharp increase in medical complications in old-old patients. In addition, the increase of respiratory complications could be responsible for the dramatic elevation of severe complications in the old-old group. Inhibition of the cough reflex after the operation, reduced respiratory muscles activity, and worse reserve ability of the elderly can be attributed to high risk of respiratory complications. Collectively, hepatectomy is relatively safe for young-old patients. However, considering that most severe postoperative complications occur in the old-old, hepatectomy for old-old patients is relatively risky.

Surgical resection promotes the long-term survival of HCC patients. However, long-term outcomes after hepatectomy in the elderly remain controversial. Some studies have shown that postoperative morbidity and/or mortality are increased after hepatectomy in elderly patients [4, 14-16], while others have suggested that hepatectomy is beneficial both for the young and elderly [17-20]. In this present study, significant differences were found in OS rate among all three groups. Multivariate analysis showed that number of tumors, satellite nodules, portal vein thrombosis, vascular invasion, TNM stage, and BCLC stage were independent risks for OS rate. After adjusting for confounding factors, it was found that old-old age (≥ 80 years) was a strong independent risk for OS rate (HR = 2.712), while young-old age (65-79 years) was no longer a risk for OS rate, suggesting that young-old patients may acquire a similar benefit from hepatectomy as young patients (< 65 years). In the old-old group, cancer-related mortality did not differ significantly from the young and young-old groups but non-cancer-related deaths increased dramatically, possibly accounting for the differences in OS rate. Old-old patients are often fragile, lacking physiological reserves with reduced resistance to adverse comorbidity. Therefore, for old-old patients, the benefits from hepatectomy are limited.

There were several limitations to this study. First, it was a retrospective study performed in only one specialized surgical hospital. In addition, the sample size of old-old patients was relatively small. It should be noted that the elderly were closely opted for hepatectomy. Many elderly patients give up on surgical resection because of cultural settings, financial status, or social tradition. Therefore, a large-scale multicenter prospective survey should be conducted in the future.

In conclusion, young-old HCC patients (65-79 years) can sustain and benefit from hepatectomy but this option for old-old HCC patients (≥ 80 years) should be made cautiously due to high incidence of postoperative complications and poor OS rate. In order to ensure safety and benefit from hepatectomy, careful monitoring, comprehensive assessment, and training of pulmonary functions are useful tools for the elderly with HCC.

Disclosure of conflict of interest

None.

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