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Original Article

Association of cirrhosis severity with outcomes after hip fracture repairs: A propensity-score matched analysis using a large inpatient database

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ABSTRACT

Background: Advanced cirrhosis is associated with increased mortality in certain surgeries, but the impact of cirrhosis severity on outcomes in patients with hip fractures remains unclear.

Methods: In a large nationwide administrative database of hospitalized patients, we compared post-operative outcomes in patients with hip fractures across different Child-Pugh classes of cirrhosis in Japan. Using the Japanese Diagnosis Procedure Combination Database, we identified 833,648 eligible patients diagnosed with hip fractures and underwent surgery between July 2010 and March 2021. Three sets of 1:1 propensity-score matching were performed for four groups: non-cirrhosis cases and Child-Pugh classes A, B, and C. We compared in-hospital mortality, length of stay, hospitalization fees, readmission, and complications in non-cirrhosis cases vs. Child-Pugh class A, Child-Pugh class A vs. B, and Child-Pugh class B vs. C.

Results: Propensity-score matching created 1065 pairs for non-cirrhosis vs. Child-Pugh class A, 1012 for Child-Pugh class A vs. B, and 489 for Child-Pugh class B vs. C. In-hospital mortality did not differ between non-cirrhosis cases and those with Child-Pugh class A. However, in-hospital mortality was significantly higher in patients with Child-Pugh class B than in those with class A (1.5 % vs. 5.9 %; RD 4.45 %; 95 % CI: 2.79%–6.10 %), and higher in patients with Child-Pugh class C compared with class B (6.3 % vs. 28.4 %; RD 22.09 %; 95 % CI: 17.54%–26.63 %). Patients in more severe Child-Pugh classes had longer hospital stays, higher hospitalization fees, and higher complication rates.

Conclusion: Patients with hip fractures and cirrhosis who are at high risk of poor postoperative outcomes could be identified. This study highlights the significantly higher in-hospital mortality observed in patients with Child-Pugh class C cirrhosis undergoing hip fracture surgery compared to those with class B. These findings underscore the need for careful risk-benefit discussions, considering the severity of cirrhosis, surgical risks, and care goals for each patient.

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1. Introduction

The global burden of cirrhosis has been highlighted in recent data [1]. Due to improved management, patients with cirrhosis are

living longer, even with advanced disease [2]. Older cirrhosis patients are now facing hip fractures and other comorbidities [2]. Despite advances in surgical care, perioperative mortality remains high for patients with cirrhosis undergoing surgery [3,4]. Prognostic scores for liver disease, such as the Child-Pugh classification and the model for end-stage liver disease (MELD), have been correlated with outcomes. A recent review of 87 studies using the Child-Pugh classification or MELD suggested that surgery is relatively safe for patients with Child-Pugh class A. Mortality was

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<5–10 % for non-hepatic abdominal surgery in Child-Pugh class A, 10–40 % in class B, and 20–100 % in class C [3]. In another study, cardiac surgery was deemed appropriate for Child-Pugh class A patients and selected class B patients. However, the in-hospital mortality risk for Child-Pugh class C was 67 % [4].

As the aging population grows, the number of hip fracture surgeries is also increasing. Hip fractures significantly reduce a patient's quality of life and physical function, and they are associated with high one-year mortality. A review showed a global one-year mortality of 22 % after hip fracture repair [5]. A single-center study reported that patients with hip fractures treated non-operatively had four times higher one-year mortality compared to those who underwent surgery [6]. Therefore, hip fracture surgery is essential. Most hip fractures occur in people over 65, and as the population ages, the number of older patients with both cirrhosis and hip fractures is increasing [7].

Tseng et al. evaluated postoperative outcomes in 347,363 patients with hip fractures, including 2071 with cirrhosis, from the US Nationwide Inpatient Sample. Those with cirrhosis had a higher in-hospital mortality rate than those without cirrhosis [8]. Chang et al. analyzed data from 117,129 patients with hip fractures, including 4048 with cirrhosis, from Taiwan's National Health Insurance database, finding that cirrhosis patients had 2–3 times higher mortality rates three years after surgery [9]. Montomoli et al. studied 152,180 patients with hip fractures, including 1866 with cirrhosis, from Danish registries; cirrhosis patients had higher 30-day and 1-year mortality than those without cirrhosis, with excess mortality attributed to complications of the fracture event rather than preexisting comorbidities [10]. Only one study, with a limited sample size, focused on cirrhosis severity and hip fracture mortality. Hundersmarck et al. analyzed 99 patients with hip fractures and cirrhosis, stratified by MELD scores and compensation or decompensation status. One-year mortality was 55 % for MELD scores of 20–40 and 53 % for decompensated patients, compared with 16 % for MELD scores of 6–9 and 15 % for compensated patients. All in-hospital deaths were related to liver failure [11].

The association between the severity of cirrhosis and postoperative outcomes in patients with hip fractures requires further elucidation in a larger cohort. Understanding the impact of cirrhosis severity on outcomes helps guide the decision between surgical and non-surgical management. This real-world observational study uses a nationwide inpatient database to analyze the effect of cirrhosis severity on postoperative outcomes in patients with hip fractures.

2. Materials and methods

2.1. Data source

We used the diagnosis procedure combination (DPC) database of the DPC study group funded by the Ministry of Health, Labour and Welfare (MHLW) of Japan, in collaboration of the study group. The DPC/per-diem payment system (PDPS) is Japan's inpatient payment system for acute care. It provides data to standardize and improve the quality of care for hospitalized patients [12]. The database contains DPC data from approximately 1200 hospitals nationwide. The DPC data includes discharge summaries and International Classification of Diseases 10th Revision (ICD-10) codes classifying the primary diagnosis, the trigger diagnosis, the most and second-most medical-resource-intensive diagnoses, comorbidities, complications during hospitalization, and various disease-specific severity classifications [12]. This data includes the Child-Pugh classification for cirrhosis and patient information such as age, sex, body mass index (BMI), medical procedures claims data, and daily drug administration records. The DPC employs the Child-

Pugh classification for cirrhosis and does not include the MELD score. Its variables are designated to be registered at the most critical point during hospitalization.

2.2. Study population

We identified all hospital admissions for eligible patients. The study included patients who met all the following criteria: (1) admitted with hip fractures (ICD-10 codes S72.0–S72.2) except for open fractures (ICD-10 codes S72.01, S72.11, and S72.21) or cases of “suspected hip fracture”, (2) underwent surgery for hip fractures, (3) had complete DPC files related to medical services and medications, and (4) were admitted and discharged between July 1, 2010, and March 31, 2021. We excluded patients if any of the Child-Pugh classification variables were registered as 0, which were considered unclassifiable. We categorized patients into four groups: those without a registered Child-Pugh classification (considered as non-cirrhosis cases in this study) and those in Child-Pugh classes A, B, and C.

2.3. Variables

The Child-Pugh classification includes five variables: albumin, bilirubin, prothrombin time, ascites, and encephalopathy, each scored 1–3. If any diagnoses in the DPC data were related to pre-defined cirrhosis diagnoses, registration of the Child-Pugh classification was mandatory. BMI was categorized into six groups (<18.5, 18.5–22.4, 22.5–24.9, 25.0–29.9, ≥30.0 kg/m², and missing). Elixhauser comorbidities were coded using Quan's protocol [13,14]. The protocol defines “liver disease” as follows: ICD-10 codes of B18, I85, I98.2, K70, K71.1, K71.3, K71.4, K71.5, K71.7, K72, K73, K74, K76.0, K76.2, K76.3, K76.4, K76.5, K76.6, K76.7, K76.8, K76.9, and Z94.4. This study considered cases without registered Child-Pugh classification as cases without cirrhosis. Consequently, even if patients without cirrhosis had liver diseases, these were distinct from cirrhosis.

2.4. Outcomes

The primary outcome was in-hospital mortality. Secondary outcomes were the length of stay, postoperative length of stay, hospitalization fees, 30-day readmission ratio, and postoperative complications. Complications included surgical-site infection (SSI), blood transfusion, acute liver failure, upper gastrointestinal bleeding (UGIB), respiratory failure, venous thromboembolism (VTE), acute coronary syndrome (ACS), heart failure (HF), acute kidney injury (AKI), urinary tract infection (UTI), and sepsis (Supplementary Table 1) [15]. Clinically, a syndrome marked by sudden hepatic decompensation and organ failures in patients with pre-existing chronic liver disease is defined as acute-on-chronic liver failure. This database study used the ICD-10 codes K70.4, K72.0, K72.1, and K72.9 to identify acute liver failure. While these codes are assumed to indicate acute-on-chronic liver failure in patients with pre-existing chronic liver disease, no specific disease codes correspond to acute-on-chronic liver failure in the ICD-10 codes. Consequently, the term “acute liver failure” is used in this article.

2.5. Statistical analyses

We used three sets of propensity-score matching to address selection bias across the four groups: non-cirrhosis and Child-Pugh classes A, B, and C. We compared three pairs: non-cirrhosis vs. Child-Pugh class A, class A vs. class B, and class B vs. class C.

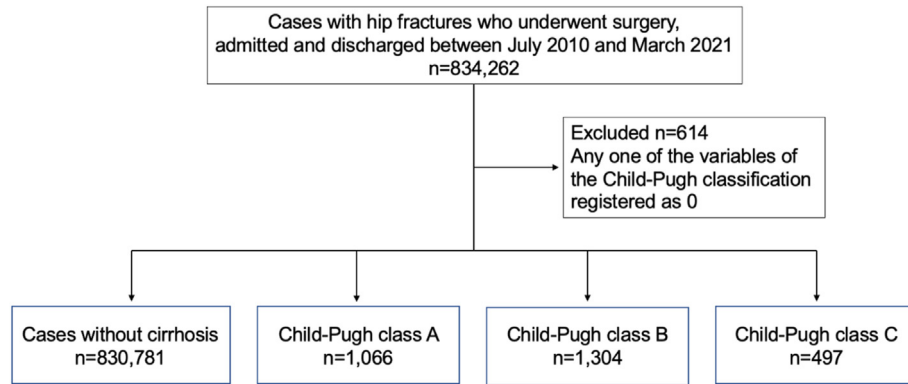


Fig. 1. Study flow chart.

One-to-one nearest neighbor propensity-score matching without replacement was performed using the MatchIt package in R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). We calculated three sets of propensity scores corresponding to the likelihood of being classified as Child-Pugh class A, B, or C in each pair. These propensity scores were based on multivariable logistic regression models, including demographic and clinical characteristics such as age, sex, BMI categories, 30 Elixhauser comorbidities, and anticoagulant and antiplatelet use. These variables were based on prior studies and expert opinions to predict cirrhosis severity [16–18].

We used a caliper width of 0.2 times the propensity score logit's standard deviation for matching. Balance after matching was evaluated by the absolute standardized mean difference, with a value ≤ 0.1 indicating well-balanced matching. We calculated risk differences (RD) and risk ratios (RR) to estimate outcomes for each matched pair. Standard errors (SEs) of RD and RR, clustered robust SEs, were estimated using generalized linear models with log link functions. All analyses were performed using R version 4.2.1.

2.6. Ethical consideration

This research has been approved by the authors' affiliated institutions and conducted in accordance with the Ethical Guidelines for Medical and Health Research Involving Human Subjects of the MHLW, Japan. According to these guidelines, the Ethics Committee

waived the need for written informed consent since the study did not utilize human biological specimens, and all information was anonymized.

3. Results

3.1. Study population

This study included 834,262 patients who underwent hip fracture surgery during the study period. We excluded 614 patients with missing variables in the Child-Pugh classification, resulting in 833,648 eligible patients (Fig. 1).

3.2. Patient characteristics and outcomes

3.2.1. Before propensity-score matching

Before matching, there were 830,781 patients without cirrhosis, 1066 patients with Child-Pugh class A, 1304 with Child-Pugh class B, and 497 with Child-Pugh class C. Tables 1 and 2 show patient characteristics and outcomes before matching.

The study population consisted of patients undergoing surgery, and mean ages (standard deviation) tended to decrease with increasing Child-Pugh class severity. Patients with Child-Pugh class A had a mean age of 78.3 (9.9) years, those with class B had a mean of 78.3 (9.6) years, and those with class C had a mean of 76.9 (10.0) years. Rates of metastatic cancer increased with Child-Pugh severity: 0.8 % for class A, 0.9 % for class B, and 3.6 % for class C.

Table 1
Study population before propensity-score matching.

	Cases without cirrhosis		Child-Pugh class					
			A		B		C	
N	830,781		1066		1304		497	
Demographics								
Age mean, SD	82.3	(10.2)	78.3	(9.9)	78.3	(9.6)	76.9	(10.0)
Sex -female	645,245	(77.7 %)	812	(76.2 %)	948	(72.7 %)	342	(68.8 %)
BMI <18.5	220,518	(26.5 %)	254	(23.8 %)	275	(21.1 %)	96	(19.3 %)
18.5–22.4	336,810	(40.5 %)	427	(40.1 %)	507	(38.9 %)	185	(37.2 %)
22.5–24.9	124,259	(15.0 %)	175	(16.4 %)	261	(20.0 %)	106	(21.3 %)
25.0–29.9	74,156	(8.9 %)	116	(10.9 %)	155	(11.9 %)	69	(13.9 %)
30.0–	10,510	(1.3 %)	19	(1.8 %)	34	(2.6 %)	15	(3.0 %)
missing	64,528	(7.8 %)	75	(7.0 %)	72	(5.5 %)	26	(5.2 %)
Congestive heart failure	68,830	(8.3 %)	62	(5.8 %)	89	(6.8 %)	34	(6.8 %)
Cardiac arrhythmias	56,110	(6.8 %)	43	(4.0 %)	86	(6.6 %)	23	(4.6 %)
Valvular disease	46,983	(5.7 %)	32	(3.0 %)	69	(5.3 %)	16	(3.2 %)
Pulmonary circulation disorders	3903	(0.5 %)	4	(0.4 %)	9	(0.7 %)	1	(0.2 %)
Peripheral vascular disorders	10,870	(1.3 %)	11	(1.0 %)	13	(1.0 %)	0	(0.0 %)
Hypertension	299,953	(36.1 %)	414	(38.8 %)	384	(29.4 %)	88	(17.7 %)
Paralysis	3643	(0.4 %)	2	(0.2 %)	0	(0.0 %)	1	(0.2 %)

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Table 1 (continued)

	Cases without cirrhosis				Child-Pugh class			
			A		B		C	
Other neurological disorders	37,253	(4.5 %)	42	(3.9 %)	34	(2.6 %)	7	(1.4 %)
Chronic pulmonary disease	33,271	(4.0 %)	37	(3.5 %)	41	(3.1 %)	12	(2.4 %)
Diabetes, uncomplicated	123,624	(14.9 %)	219	(20.5 %)	237	(18.2 %)	93	(18.7 %)
Diabetes, complicated	27,918	(3.4 %)	51	(4.8 %)	97	(7.4 %)	26	(5.2 %)
Hypothyroidism	9697	(1.2 %)	25	(2.3 %)	36	(2.8 %)	7	(1.4 %)
Renal failure	39,016	(4.7 %)	69	(6.5 %)	100	(7.7 %)	33	(6.6 %)
Liver disease	30,427	(3.7 %)	930	(87.2 %)	1155	(88.6 %)	435	(87.5 %)
Peptic ulcer disease excluding bleeding	24,991	(3.0 %)	43	(4.0 %)	53	(4.1 %)	17	(3.4 %)
AIDS/HIV	80	(0.0 %)	0	(0.0 %)	0	(0.0 %)	1	(0.2 %)
Lymphoma	2336	(0.3 %)	5	(0.5 %)	3	(0.2 %)	2	(0.4 %)
Metastatic cancer	4098	(0.5 %)	8	(0.8 %)	12	(0.9 %)	18	(3.6 %)
Solid tumor without metastasis	32,282	(3.9 %)	125	(11.7 %)	188	(14.4 %)	101	(20.3 %)
Rheumatoid arthritis/collagen vascular disease	18,600	(2.2 %)	46	(4.3 %)	33	(2.5 %)	5	(1.0 %)
Coagulopathy	2551	(0.3 %)	32	(3.0 %)	65	(5.0 %)	28	(5.6 %)
Obesity	412	(0.0 %)	0	(0.0 %)	3	(0.2 %)	0	(0.0 %)
Weight loss	778	(0.1 %)	0	(0.0 %)	3	(0.2 %)	1	(0.2 %)
Fluid and electrolyte disorders	16,580	(2.0 %)	23	(2.2 %)	33	(2.5 %)	14	(2.8 %)
Blood loss anemia	8105	(1.0 %)	11	(1.0 %)	19	(1.5 %)	6	(1.2 %)
Deficiency anemia	31,744	(3.8 %)	52	(4.9 %)	81	(6.2 %)	28	(5.6 %)
Alcohol abuse	2587	(0.3 %)	26	(2.4 %)	52	(4.0 %)	28	(5.6 %)
Drug abuse	35	(0.0 %)	0	(0.0 %)	0	(0.0 %)	0	(0.0 %)
Psychoses	32,883	(4.0 %)	20	(1.9 %)	25	(1.9 %)	8	(1.6 %)
Depression	26,278	(3.2 %)	36	(3.4 %)	33	(2.5 %)	7	(1.4 %)
Anticoagulant use	222,278	(26.8 %)	227	(21.3 %)	304	(23.3 %)	98	(19.7 %)
Antiplatelet use	163,128	(19.6 %)	121	(11.4 %)	100	(7.7 %)	28	(5.6 %)

AIDS/HIV, acquired immune deficiency syndrome/human immunodeficiency virus; BMI, body mass index; SD, standard deviations.

Table 2

Outcomes before propensity-score matching.

	Cases without cirrhosis		Child-Pugh class					
			A		B		C	
N	830,781		1066		1304		497	
Outcome								
In-hospital death	13,741	(1.7 %)	15	(1.4 %)	75	(5.8 %)	141	(28.4 %)
Length of stay mean, SD	35.9	(26.8)	39.0	(27.9)	41.9	(31.2)	52.5	(38.9)
Postoperative days mean, SD	30.9	(25.7)	33.3	(25.7)	35.8	(31.2)	45.9	(37.5)
30-day readmission	28,663	(3.5 %)	59	(5.5 %)	111	(8.5 %)	51	(10.3 %)
Hospitalization fee mean JPY, SD	1,772,150	(863,700)	1,943,972	(996,936)	2,093,716	(1,096,777)	2,528,731	(1,443,841)
Complications								
Surgical								
SSI	423	(0.1 %)	2	(0.2 %)	1	(0.1 %)	1	(0.2 %)
Blood transfusion	314,300	(37.8 %)	524	(49.2 %)	841	(64.5 %)	393	(79.1 %)
Non-surgical		(0.0 %)		(0.0 %)		(0.0 %)		(0.0 %)
Acute liver failure	86	(0.0 %)	31	(2.9 %)	90	(6.9 %)	88	(17.7 %)
UGIB	24,506	(2.9 %)	137	(12.9 %)	153	(11.7 %)	88	(17.7 %)
Respiratory failure	33,831	(4.1 %)	42	(3.9 %)	57	(4.4 %)	48	(9.7 %)
VTE	31,761	(3.8 %)	43	(4.0 %)	45	(3.5 %)	17	(3.4 %)
ACS	10,759	(1.3 %)	13	(1.2 %)	9	(0.7 %)	3	(0.6 %)
Heart failure	11,454	(1.4 %)	15	(1.4 %)	29	(2.2 %)	7	(1.4 %)
Stroke	6076	(0.7 %)	5	(0.5 %)	5	(0.4 %)	0	(0.0 %)
AKI	1402	(0.2 %)	3	(0.3 %)	7	(0.5 %)	11	(2.2 %)
UTI	28,943	(3.5 %)	43	(4.0 %)	50	(3.8 %)	20	(4.0 %)
Sepsis	11,294	(1.4 %)	28	(2.6 %)	35	(2.7 %)	34	(6.8 %)

ACS, acute coronary syndrome; AKI, acute kidney injury; JPY, Japanese yen; SD, standard deviations; SSI, surgical site infection; UGIB, upper gastrointestinal bleeding; UTI, urinary tract infection; VTE, venous thromboembolism.

The rate of solid tumors without metastasis was also higher in more severe Child-Pugh classes: 11.7 % in class A, 14.4 % in class B, and 20.3 % in class C. Coagulopathy, including thrombocytopenia, was higher in more severe Child-Pugh classes: 3.0 % in class A, 5.0 % in class B, and 5.6 % in class C (Table 1).

Patients in more severe Child-Pugh classes had higher in-hospital mortality and complication rates. Mortality was 1.4 % in class A, 5.8 % in class B, and 28.4 % in class C, while rates of complications such as acute liver failure were 2.9 %, 6.9 %, and 17.7 %, respectively (Table 2).

3.2.2. After propensity-score matching

After matching, there were 1065 pairs (non-cirrhosis vs. Child-Pugh class A), 1012 pairs (Child-Pugh class A vs. B), and 489 pairs (Child-Pugh class B vs. C) (Table 3). The matched case ratios were 99.9 %, 77.6 %, and 98.4 %, respectively. The characteristics in each pair before and after the propensity-score matching are shown in Supplementary Tables 2–4. Absolute values of standardized differences for each variable were ≤ 0.1 after matching.

In-hospital mortality was 1.7 % in non-cirrhosis patients and 1.4 % in Child-Pugh class A patients (RD -0.28 %; 95 % CI: -1.34%–

Table 3
Study population after propensity-score matching.

	After matching											
	Child-Pugh class			Child-Pugh class			Child-Pugh class			Child-Pugh class		
	Cases without cirrhosis	A	SMD	A	B	SMD	B	C	SMD			
N	1065	1065		1012	1012		489	489				
Demographics												
Age mean, SD	78.9 (10.4)	78.3 (9.9)	0.058	78.3 (9.9)	78.4 (10.2)	0.010	77.2 (10.0)	76.9 (10.0)	0.032			
Sex -female	831 (78.0 %)	811 (76.2 %)	0.045	766 (75.7 %)	740 (73.1 %)	0.059	335 (68.5 %)	338 (69.1 %)	0.013			
BMI <18.5	245 (23.0 %)	254 (23.8 %)	0.020	242 (23.9 %)	218 (21.5 %)	0.057	83 (17.0 %)	95 (19.4 %)	0.064			
18.5–22.4	433 (40.7 %)	427 (40.1 %)	0.011	410 (40.5 %)	390 (38.5 %)	0.040	190 (38.9 %)	183 (37.4 %)	0.029			
22.5–24.9	172 (16.2 %)	175 (16.4 %)	0.008	167 (16.5 %)	199 (19.7 %)	0.082	113 (23.1 %)	104 (21.3 %)	0.044			
25.0–29.9	115 (10.8 %)	115 (10.8 %)	<.001	111 (11.0 %)	114 (11.3 %)	0.009	63 (12.9 %)	67 (13.7 %)	0.024			
30.0–missing	24 (2.3 %)	19 (1.8 %)	0.033	19 (1.9 %)	23 (2.3 %)	0.028	14 (2.9 %)	14 (2.9 %)	<.001			
Congestive heart failure	76 (7.1 %)	75 (7.0 %)	0.004	63 (6.2 %)	68 (6.7 %)	0.020	26 (5.3 %)	26 (5.3 %)	<.001			
Cardiac arrhythmias	71 (6.7 %)	62 (5.8 %)	0.035	58 (5.7 %)	74 (7.3 %)	0.064	28 (5.7 %)	34 (7.0 %)	0.050			
Valvular disease	47 (4.4 %)	43 (4.0 %)	0.019	43 (4.2 %)	64 (6.3 %)	0.093	21 (4.3 %)	23 (4.7 %)	0.020			
Pulmonary circulation disorders	27 (2.5 %)	32 (3.0 %)	0.029	32 (3.2 %)	42 (4.2 %)	0.053	11 (2.2 %)	16 (3.3 %)	0.062			
Peripheral vascular disorders	3 (0.3 %)	4 (0.4 %)	0.016	4 (0.4 %)	8 (0.8 %)	0.052	1 (0.2 %)	1 (0.2 %)	<.001			
Hypertension	12 (1.1 %)	11 (1.0 %)	0.009	10 (1.0 %)	12 (1.2 %)	0.019	0 (0.0 %)	0 (0.0 %)	–			
Paralysis	421 (39.5 %)	414 (38.9 %)	0.013	376 (37.2 %)	363 (35.9 %)	0.027	79 (16.2 %)	88 (18.0 %)	0.049			
Other neurological disorders	0 (0.0 %)	2 (0.2 %)	0.061	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–			
Chronic pulmonary disease	36 (3.4 %)	42 (3.9 %)	0.030	33 (3.3 %)	32 (3.2 %)	0.006	6 (1.2 %)	7 (1.4 %)	0.018			
Diabetes, uncomplicated	35 (3.3 %)	37 (3.5 %)	0.010	34 (3.4 %)	38 (3.8 %)	0.021	14 (2.9 %)	12 (2.5 %)	0.025			
Diabetes, complicated	227 (21.3 %)	219 (20.6 %)	0.018	202 (20.0 %)	205 (20.3 %)	0.007	86 (17.6 %)	92 (18.8 %)	0.032			
Hypothyroidism	35 (3.3 %)	50 (4.7 %)	0.072	51 (5.0 %)	66 (6.5 %)	0.064	33 (6.7 %)	25 (5.1 %)	0.069			
Renal failure	23 (2.2 %)	25 (2.3 %)	0.013	25 (2.5 %)	31 (3.1 %)	0.036	7 (1.4 %)	7 (1.4 %)	<.001			
Liver disease	65 (6.1 %)	69 (6.5 %)	0.015	68 (6.7 %)	80 (7.9 %)	0.046	32 (6.5 %)	32 (6.5 %)	<.001			
Peptic ulcer disease excluding bleeding	929 (87.2 %)	929 (87.2 %)	<.001	885 (87.5 %)	891 (88.0 %)	0.018	433 (88.5 %)	429 (87.7 %)	0.025			
AIDS/HIV	44 (4.1 %)	43 (4.0 %)	0.005	40 (4.0 %)	46 (4.5 %)	0.029	18 (3.7 %)	17 (3.5 %)	0.011			
Lymphoma	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–			
Metastatic cancer	5 (0.5 %)	5 (0.5 %)	<.001	3 (0.3 %)	3 (0.3 %)	<.001	2 (0.4 %)	2 (0.4 %)	<.001			
Solid tumor without metastasis	4 (0.4 %)	8 (0.8 %)	0.050	8 (0.8 %)	10 (1.0 %)	0.021	9 (1.8 %)	12 (2.5 %)	0.042			
Rheumatoid arthritis/collagen vascular disease	131 (12.3 %)	125 (11.7 %)	0.017	124 (12.3 %)	133 (13.1 %)	0.027	87 (17.8 %)	101 (20.7 %)	0.073			
Coagulopathy	45 (4.2 %)	46 (4.3 %)	0.005	35 (3.5 %)	31 (3.1 %)	0.022	3 (0.6 %)	5 (1.0 %)	0.045			
Obesity	28 (2.6 %)	31 (2.9 %)	0.017	32 (3.2 %)	45 (4.4 %)	0.067	28 (5.7 %)	28 (5.7 %)	<.001			
Weight loss	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–			
Fluid and electrolyte disorders	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–	1 (0.2 %)	1 (0.2 %)	<.001			
Blood loss anemia	24 (2.3 %)	23 (2.2 %)	0.006	23 (2.3 %)	31 (3.1 %)	0.049	12 (2.5 %)	14 (2.9 %)	0.025			
Deficiency anemia	7 (0.7 %)	11 (1.0 %)	0.041	11 (1.1 %)	13 (1.3 %)	0.018	4 (0.8 %)	6 (1.2 %)	0.041			
Alcohol abuse	52 (4.9 %)	52 (4.9 %)	<.001	51 (5.0 %)	55 (5.4 %)	0.018	26 (5.3 %)	27 (5.5 %)	0.009			
Drug abuse	20 (1.9 %)	26 (2.4 %)	0.039	26 (2.6 %)	38 (3.8 %)	0.068	33 (6.7 %)	27 (5.5 %)	0.051			
Psychoses	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–	0 (0.0 %)	0 (0.0 %)	–			
Depression	19 (1.8 %)	20 (1.9 %)	0.007	18 (1.8 %)	24 (2.4 %)	0.042	5 (1.0 %)	8 (1.6 %)	0.054			
Anticoagulant use	46 (4.3 %)	36 (3.4 %)	0.049	30 (3.0 %)	29 (2.9 %)	0.006	9 (1.8 %)	7 (1.4 %)	0.032			
Antiplatelet use	223 (20.9 %)	227 (21.3 %)	0.009	219 (21.6 %)	251 (24.8 %)	0.075	83 (17.0 %)	97 (19.8 %)	0.074			
	122 (11.5 %)	121 (11.4 %)	0.003	97 (9.6 %)	95 (9.4 %)	0.007	25 (5.1 %)	28 (5.7 %)	0.027			

AIDS/HIV, acquired immune deficiency syndrome/human immunodeficiency virus; BMI, body mass index; SD, standard deviations; SMD, standardized mean difference.

0.78 %; RR 0.83; 95 % CI: 0.42–1.65). Mortality was significantly higher in Child-Pugh class B compared to class A (1.5 % vs. 5.9 %; RD 4.45 %; 95 % CI: 2.79–6.10 %; RR 4.00; 95 % CI: 2.27–7.05) and in class C compared to class B (6.3 % vs. 28.4 %; RD 22.09 %; 95 % CI: 17.54–26.63 %; RR 4.48; 95 % CI: 3.10–6.48) (Table 4 and Supplementary Tables 5–7).

Among secondary outcomes, overall and postoperative length of stay, 30-day readmission rates, and hospitalization fees were higher in patients with more severe Child-Pugh classes (Table 4 and Supplementary Tables 5–7). No significant differences were found in SSI, VTE, ACS, HF, stroke, or UTI rates between the groups. However, patients with Child-Pugh class C had higher rates of blood transfusion, acute liver failure, UGIB, respiratory failure, AKI, and sepsis compared to class B (Table 4 and Supplementary Table 7). Of these, acute liver failure was significantly higher in Child-Pugh class A compared to non-cirrhosis (0 % vs. 2.9 %; RD 2.91 %; 95 % CI: 1.90–3.92 %), in class B compared to class A (2.9 % vs. 7.0 %; RD 4.15 %; 95 % CI: 2.27–6.03 %; RR 2.45; 95 % CI: 1.60–3.74), and in class C compared to class B (9.0 % vs. 18.0 %; RD 9.00 %; 95 % CI: 4.71–13.28 %; RR 2.00; 95 % CI: 1.42–2.82) (Table 4 and Supplementary Tables 5–7).

4. Discussion

We compared postoperative outcomes in patients from a nationwide inpatient database with hip fractures undergoing surgery across Child-Pugh classes. Patients with more severe Child-Pugh classes had higher mortality, longer stays, and higher hospitalization fees. The differences were particularly significant between Child-Pugh classes B and C. No significant differences were observed in rates of SSI, VTE, ACS, HF, stroke, or UTI between the groups.

More severe Child-Pugh classes were associated with higher in-hospital mortality. A recent study stratifying patients with hip fractures and cirrhosis based on MELD scores found that cirrhosis severity was associated with higher postoperative mortality, and all in-hospital deaths were related to liver failure [11]. Elsewhere, a relationship between the development and outcome of acute-on-chronic liver failure after surgical interventions has been reported [19]. Acute complications like gastrointestinal bleeding, infections, development or worsening of ascites, encephalopathy, and non-obstructive jaundice led to acute decompensation. Acute decompensation may lead to acute-on-chronic liver failure and high

Table 4
Outcomes after propensity-score matching.

	Child-Pugh class A vs cases without cirrhosis				Child-Pugh class B vs A				Child-Pugh class C vs B			
	RD, %	(95%CI)	RR	(95%CI)	RD, %	(95%CI)	RR	(95%CI)	RD, %	(95%CI)	RR	(95%CI)
Outcome												
In-hospital death	-0.28	(-1.34–0.78)	0.83	(0.42–1.65)	4.45	(2.79–6.10)	4.00	(2.27–7.05)	22.09	(17.54–26.63)	4.48	(3.10–6.48)
Length of stay mean	-0.12	(-2.56–2.33)	1.00	(0.94–1.06)	3.77	(1.09–6.45)	1.10	(1.03–1.17)	12.46	(8.41–16.52)	1.31	(1.20–1.43)
Postoperative days mean	-0.86	(-3.17–1.44)	0.98	(0.91–1.04)	3.31	(0.84–5.77)	1.10	(1.02–1.18)	11.89	(7.94–15.84)	1.35	(1.22–1.48)
30-day readmission	-1.13	(-3.14–0.89)	0.83	(0.60–1.16)	2.37	(0.18–4.56)	1.41	(1.02–1.95)	1.23	(-2.49–4.95)	1.13	(0.78–1.66)
Hospitalization fee mean JPY	83,471	(4155–162,788)	1.04	(1.00–1.09)	164,730	(73,062–256,399)	1.08	(1.04–1.14)	451,560	(292,234–610,886)	1.22	(1.14–1.30)
Complications												
Surgical												
SSI	0.19	(-0.07–0.45)	—	—	-0.10	(-0.43–0.24)	0.50	(0.05–5.52)	0.00	(-0.57–0.57)	1.00	(0.06–16.03)
Blood transfusion	9.86	(5.76–13.95)	1.25	(1.14–1.37)	14.82	(10.54–19.10)	1.30	(1.20–1.41)	15.34	(9.67–21.00)	1.24	(1.14–1.35)
Non-surgical												
Acute liver failure	2.91	(1.90–3.92)	—	—	4.15	(2.27–6.03)	2.45	(1.60–3.74)	9.00	(4.71–13.28)	2.00	(1.42–2.82)
UGIB	9.95	(7.67–12.23)	4.42	(3.01–6.50)	-0.99	(-3.82–1.85)	0.92	(0.74–1.16)	6.54	(2.08–11.01)	1.60	(1.16–2.23)
Respiratory failure	1.22	(-0.31–2.75)	1.45	(0.91–2.31)	0.79	(-0.92–2.50)	1.22	(0.80–1.86)	5.11	(2.01–8.21)	2.19	(1.34–3.59)
VTE	0.00	(-1.63–1.63)	1.00	(0.67–1.50)	-0.59	(-2.30–1.12)	0.86	(0.55–1.34)	0.00	(-2.27–2.27)	1.00	(0.52–1.92)
ACS	0.38	(-0.49–1.24)	1.44	(0.62–3.38)	-0.40	(-1.22–0.43)	0.64	(0.25–1.64)	0.00	(-0.98–0.98)	1.00	(0.20–4.96)
Heart failure	0.38	(-0.56–1.31)	1.36	(0.63–2.97)	0.69	(-0.49–1.87)	1.47	(0.76–2.83)	0.00	(-1.27–1.27)	1.00	(0.29–3.46)
Stroke	0.09	(-0.46–0.65)	1.25	(0.34–4.66)	-0.00	(-0.55–0.55)	1.00	(0.25–4.00)	—	—	—	—
AKI	0.09	(-0.32–0.51)	1.50	(0.25–8.98)	0.40	(-0.15–0.94)	3.00	(0.61–14.88)	1.64	(0.38–2.90)	9.00	(1.14–71.19)
UTI	-0.19	(-1.88–1.50)	0.96	(0.64–1.44)	-0.00	(-1.67–1.67)	1.00	(0.64–1.56)	0.82	(-1.52–3.16)	1.25	(0.66–2.37)
Sepsis	1.41	(0.26–2.56)	2.15	(1.13–4.09)	0.30	(-1.17–1.76)	1.11	(0.66–1.87)	4.09	(1.45–6.73)	2.43	(1.34–4.41)

ACS, acute coronary syndrome; AKI, acute kidney injury; CI, confidence interval; JPY, Japanese yen; RD, risk difference; RR, risk ratio; SD, standard deviations; SSI, surgical site infection; UGIB, upper gastrointestinal bleeding; UTI, urinary tract infection; VTE, venous thromboembolism. Bold indicates statistically significant.

mortality [20]. Similarly, we found higher mortality in Child-Pugh class C patients, particularly in those with complications such as acute liver failure, UGIB, sepsis, and respiratory failure. This is consistent with prior reports [11,19,20]. Furthermore, this study included only patients deemed suitable for surgery and subsequently underwent the procedure. It may result in a bias toward the null when comparing outcomes between patients in Child-Pugh classes B and C, making outcomes less likely to be statistically significant. Nevertheless, this study revealed that patients in Child-Pugh class C had worse outcomes than in class B.

Patients in more severe Child-Pugh classes had longer hospital stays and higher costs. This is consistent with findings from a recent study of orthopedic patients with decompensated cirrhosis [7]. Complications, which were more frequent in severe cases, likely explain these longer stays and higher costs [21].

While the rate of complications such as respiratory failure rates, including pneumonia, was higher in Child-Pugh class C patients, VTE, SSI, and UTI rates did not differ significantly between the groups. A previous study similarly found no differences in postoperative complications across different MELD score groups [11]. However, respiratory failure, including pneumonia, was more common in Child-Pugh class C patients, consistent with studies that found liver disease is a risk factor for postoperative pneumonia [22]. These associations are clinically plausible as cirrhosis patients have a higher infection risk from immune suppression. Altogether, our results align with those in these previous studies [22].

Our results also indicated higher rates of blood transfusion in patients with more advanced cirrhosis. Patients with advanced cirrhosis were reported to have a higher prevalence of coagulopathy and thrombocytopenia [23]. Although information on the severity of the coagulopathy and thrombocytopenia was unavailable, we adjusted coagulopathy, thrombocytopenia, anticoagulant, and antiplatelet use between groups using propensity scores. Therefore, more advanced cirrhosis may have increased bleeding tendency, which could not be explained by adjusted coagulopathy, thrombocytopenia, and the use of anticoagulants and antiplatelets. Patients in more severe Child-Pugh classes showed a higher ratio of UGIB, and patients with advanced cirrhosis were reported to have higher rates of bleeding and hematomas, even after minor invasive

procedures [23]. Our results with a higher ratio of blood transfusion in patients with more advanced cirrhosis may be explained by increased bleeding tendency and a higher ratio of UGIB and surgery by itself.

We found no statistically significant difference in the ACS, HF, or stroke rate. A previous study that analyzed patients with hip fracture with cirrhosis stratified based on MELD scores subgroups only evaluated rates of postoperative complications, including symptomatic thromboembolism, SSI, pneumonia, and UTI [11]. Our propensity-matched comparison may add details on rates of postoperative complications in patients with hip fractures with cirrhosis.

Another important consideration is the potential impact of fracture type and surgical approach on outcomes. Hip fractures can be classified into trochanteric fractures, typically treated with internal fixation, and femoral neck fractures, often managed with hemiarthroplasty. Additionally, femoral neck fractures, as intra-articular fractures, may be treated conservatively in high-risk patients, whereas conservative management of intertrochanteric fractures is more challenging [24]. While our study did not stratify outcomes based on fracture type or surgical approach, future research could address these differences to provide a more comprehensive understanding of how these factors influence outcomes in patients with cirrhosis undergoing hip fracture surgery. This remains an important research question that could yield valuable insights for orthopedic surgeons managing this complex patient population.

This study has several limitations. First, as a retrospective observational study, unmeasured covariates may exist. However, ethical issues make conducting a randomized controlled trial for our study population impossible. Second, we could not analyze the impact of cirrhosis etiology owing to data availability. Cirrhosis etiology may account for outcomes such as in-hospital mortality and acute liver failure. In a recent study, etiology did not appear to play a significant role in the development of acute-on-chronic liver failure after surgery, which was associated with high short-term mortality [19], although in another study, etiology was strongly related to acute-on-chronic liver failure [20]. Third, the DPC database did not include information on factors such as surgeon and

anesthesiologist volumes and a multidisciplinary collaboration system with surgeons and specialists in each hospital. A systematic review reported the surgeon volume–outcome relationship on 15 surgical procedures and conditions [25]. Elsewhere, those who received care from high-volume anesthesiologists had a lower risk of adverse postoperative outcomes than those who received care from low-volume anesthesiologists [26]. The importance of multidisciplinary management of patients with cirrhosis has been reported [27]. These factors may be associated with mortality and morbidities in our study population. The usage of an administrative database is the subject of the fourth limitation. Diagnoses recorded in the databases may not be as rigorously validated as those in planned prospective cohorts or registries. Specifically, the lack of validation studies for the Child-Pugh classification within the DPC database may introduce potential exposure misclassification. Misclassification of cirrhosis severity could affect the observed associations between Child-Pugh class and postoperative outcomes. Nevertheless, the DPC database has several mechanisms that enhance data quality [12]. Diagnoses are recorded by attending physicians based on clinical evaluations, and data entry follows a clearly defined reporting format. Additionally, mandatory data submission tied to reimbursement requirements supports adherence to standardized protocols, potentially reducing misclassification. In contrast, there is evidence supporting the reliability of the DPC database in coding postoperative complications. A validation study demonstrated that the sensitivity of identifying postoperative complications requiring interventions was 79.8 %, and the specificity was nearly 100 % [28].

Despite several limitations, this was a real-world observational study using a nationwide inpatient database with a large sample size. Our results suggest the importance of risk stratification by severity of cirrhosis to inform perioperative optimization and facilitate risk-benefit discussions. Patients with Child-Pugh classes A and B are known to be able to undergo most surgeries with a reasonable safety profile [3,4]. In fact, in-hospital mortality in Child-Pugh classes A and B in our study was similar to previously reported in-hospital mortality in patients with hip fractures ranging from 1.52 to 11.4 % [29,30]. On the other hand, like other surgeries, postoperative in-hospital mortality was higher in patients with higher Child-Pugh classes, notably in the Child-Pugh class C compared to class B. A recent systematic review reported a one-year mortality rate of 22 % after hip fracture repair with a range from 2.4% to 34.8 % [5]. A single-center study showed that patients with hip fractures who were treated nonoperatively had four times higher one-year mortality than the operative group [6]. However, our results showed patients with the Child-Pugh class C had significantly higher in-hospital mortality compared to class B. Shared decision-making is essential for patients in Child-Pugh class C. The decision-making process should consider surgical risk according to the severity of cirrhosis, the risk of treatment without surgery, the patient's frailty, and their wishes.

5. Conclusion

This propensity score-matched analysis of patients with concurrent hip fracture and cirrhosis undergoing surgery demonstrated that those with more severe Child-Pugh classes had worse postoperative outcomes, particularly higher in-hospital mortality and acute liver failure. In-hospital mortality in Child-Pugh class C was over four times higher than in class B. These findings highlight the need for individualized risk-benefit discussions for patients with advanced cirrhosis, particularly those in Child-Pugh class C. Multidisciplinary collaboration is essential to ensure comprehensive evaluation and care. For hospitals lacking such systems, patient transfer to appropriate facilities may be considered. With a

multidisciplinary team, surgeons and patients can engage in shared decision-making to determine the best treatment approach. Further research is needed to optimize the care of this high-risk population.

Data availability

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT (GPT-4o, by OpenAI) in order to enhance the readability and proofread the English text. After using this service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jos.2025.01.006>.

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