Outcomes of patients with advanced liver disease undergoing cardiac surgery

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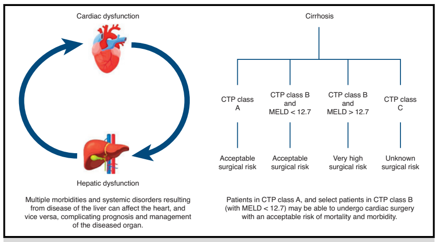
ABSTRACT

Objective: Liver disease (LD) is considered a risk factor for inferior outcomes in general and cardiac surgery, yet current cardiac surgery risk estimators exclude LD, and literature on the topic remains scant. We sought to evaluate whether the presence of advanced LD is associated with inferior outcomes following cardiac surgery.

Methods: This single-center, retrospective, observational study included 285 patients diagnosed with LD who underwent cardiac surgery in 2010 to 2020. The cohort contained 3 groups, Child-Turcotte-Pugh (CTP) class A (n = 219), CTP early-class B (n = 34), and CTP advanced-class B (n = 32). A model for end-stage liver disease score of 12.7 points (determined using a receiver-operating characteristic curve analysis on 30-day mortality) dichotomized class B into early- and advanced-groups. Univariate and multivariate logistic regression analyses were performed to identify predictors of 30-day mortality.

Results: Patients in CTP advanced-class B had the longest length of stay (14 days), highest incidence of prolonged ventilation (46.9%), renal failure (21.9%), 30-day mortality (18.8%), and in-hospital mortality (18.8%). Incidence of ≥1 postoperative complication was higher in CTP advanced-class B (59.4%), compared with CTP class A (37.9%) and CTP early-class B (38.2%). Multivariate logistic regression analysis demonstrated that female sex (odds ratio, 3.01; 95% CI, 1.07-8.77; $P = .037$) and peripheral vascular disease (odds ratio, 4.01; 95% CI, 1.33-12.2; $P = .013$) were independent predictors of 30-day mortality in patients with advanced LD.

Conclusions: Severity of LD influences perioperative outcomes following cardiac surgery. Our data suggest that patients in CTP class A and selected patients in CTP class B (model for end-stage liver disease score <12.7) can undergo surgery with acceptable risk. (JTCVS Open 2023;16:532-9)



Co-existence of cardiac and liver dysfunction.

CENTRAL MESSAGE

Patients with cirrhosis in CTP class A and patients in CTP class B with a MELD score <12.7 may be candidates for cardiac surgery with an acceptable risk of postoperative morbidity and mortality.

PERSPECTIVE

An enhanced stratification of preoperative liver function may further inform postoperative outcomes and should be included in risk assessment for cardiac surgery.

Advanced liver disease (LD) is a major preoperative risk factor in abdominal surgery, with a direct correlation between the severity of LD, as determined by the Child-Turcotte-Pugh (CTP) classification or the model for end-stage liver disease (MELD) score, and surgical outcomes. However, it is not accounted for in risk estimators for cardiac surgery, and literature on the topic remains scarce.[1] It is well documented that there is overlapping involvement of the heart and liver in multiple systemic disorders, such as inflammation, infections, and substance abuse disorder.[2,3] Mortality of patients with cirrhosis after cardiac surgery is rarely due to impairment of cardiac function.[4] Rather, morbidity and mortality in these cases tend to be a result of complications related to underlying LD, such as coagulopathy, increased susceptibility to bacterial infections, portal hypertension, and thrombocytopenia.[5-7] The eligibility of patients with

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Institutional Review Board number: Yale IRB No. 2000020356 (initial approval March 2, 2017, initial effective March 2, 2017, effective January 17, 2023).

Read at the 103rd Annual Meeting of The American Association for Thoracic Surgery, Los Angeles, California, May 6-9, 2023.

Received for publication Feb 28, 2023; revisions received June 16, 2023; accepted for publication July 6, 2023; available ahead of print Aug 11, 2023.

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2666-2736

https://doi.org/10.1016/j.xjon.2023.07.001

Abbreviations and Acronyms

CABG = coronary artery bypass graft
CTP = Child-Turcotte-Pugh
LD = liver disease
LOS = length of stay
MELD = model for end-stage liver disease

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cirrhosis for major cardiac surgery has increased due to dramatic advancements in medical management and life expectancy of patients with advanced LD,[8,9] including medical therapy for portal hypertension and viral hepatitis, endoscopic treatment of esophageal varices, and availability of transjugular intrahepatic portosystemic shunt.[8] This study aims to assess whether the presence of advanced LD is associated with inferior surgical outcomes following cardiac surgery.

MATERIALS AND METHODS

Study Design and Inclusion Criteria

We performed a single-center, retrospective cohort study including all adult patients with LD who underwent coronary artery bypass graft (CABG), aortic valve replacement, mitral valve replacement, or mitral valve repair at Yale-New Haven Hospital between 2010 and 2020. During this period, a total of 9098 open heart procedures were performed. The prevalence of patients with LD was 4.68% (426 patients). This includes the small number of patients who underwent reoperation. Patients were excluded if they were younger than age 18 years, or if the severity of LD could not be assessed by retrospective chart review.

Patient Cohort and Data Collection

Preoperative, operative, and postoperative data were collected from the Society of Thoracic Surgeons database and Yale-New Haven Hospital electronic health records. The Institutional Review Board of Yale approved the study protocol and publication of data according to institutional review board No, 2,000,020,356 (initial approval March 2, 2017, initial effective March 2, 2017, effective January 17, 2023). The patients provided informed written consent for the publication of the study data. A total of 285 patients were included in the final study population. Patients were stratified into three groups by severity of LD based on classification and values of the validated severity scores, CTP, and MELD. A receiver-operating characteristic curve analysis was used to identify a cutoff value of the MELD score to dichotomize CTP class B into 2 groups.

LD Severity Score Definition

The preoperative severity of each patient's LD was determined using the CTP classification and MELD score. The CTP score was calculated using the following variables, with each variable being assigned 1 to 3 points:

TABLE 1. Child-Turcotte-Pugh scoring

Variable	1 point	2 points	3 points
Encephalopathy	None	Grade 1-2 (or precipitant induced)	Grade 3-4 (or chronic)
Ascites	None	Mild/moderate (diuretic responsive)	Severe (diuretic refractory)
Total bilirubin (mg/dL)	<2	2-3	>3
Albumin (g/dL)	>3.5	2.8-3.5	<2.8
PT (sec prolonged)	<4	4-6	>6
or PT-INR	<1.7	1.7-2.3	>2.3

PT, Prothrombin time; *PT-INR*, international normalized ratio of prothrombin time.

encephalopathy, ascites, total serum bilirubin level, serum albumin level, and prothrombin time-international normalized ratio (PT-INR). The resulting score yielded each patient's CTP classification (Table 1). Class A (5-6 points) indicates well-compensated LD, class B (7-9 points) indicates LD of moderate severity, and class C (10-15 points) indicates severe LD.[10-12] The MELD score was calculated using the following formula: MELD $= 11.2\times\log_e$ (PT-INR) $+ 9.57\times\log_e$ (creatinine [mg/dL]) $+ 3.78\times\log_e$ (bilirubin [mg/dL]) $+ 6.43$.[13]

Outcomes

The primary outcomes of this study were 30-day and in-hospital all-cause mortality. Secondary outcomes were defined as per Society of Thoracic Surgeons guidelines for reporting mortality and morbidity after cardiac valve interventions.[14] An additional outcome included a composite outcome of postoperative complications consisting of surgical site infection, stroke, sepsis, prolonged ventilation, renal failure, reoperation for bleeding, and readmission. Renal failure was defined as an increase in serum creatinine level 3.0-times greater than baseline, serum creatinine ≥4 mg/dL, or a new requirement for dialysis postoperatively.

Statistical Analysis

Following the assessment of normality, normally distributed continuous variables were compared using analysis of variance, and nonnormally distributed continuous variables were compared using the Kruskal-Wallis test. Categorical variables were compared using the χ^2 test. Univariate and multivariate logistic regression were applied to predict the risk of 30-day mortality in those who underwent cardiac surgery, stratified by severity of LD. Variables with a P value $< .2$ in the univariate analysis and clinically significant variables for this group of patients were included in the multivariate analysis. Statistical analysis was performed by using R version 4.4 (R Foundation for Statistical Computing).

RESULTS

The general and clinical demographics of the cohort are shown in Table 2. The cohort identified predominantly as male (68.1%) and White (67.0%). A cutoff value of the MELD score (ie, 12.7) was chosen as a result of the receiver-operating characteristic curve analysis on 30-day operative mortality and used to dichotomize CTP class B into early- and advanced-class B (Figure 1). The MELD value of 12.7 was found to be the optimal threshold of classification, maximizing the sum of sensitivity and specificity.

TABLE 2. Summary of baseline characteristics

Variable	Overall (N = 285)	CTP class A (n = 219)	CTP early- class B (n = 34)	CTP advanced-class B (n = 32)	*P* value*
Age (y)	60 (52-66)	61 (55-67)	43 (30-56)	60 (50-65)	<.001
Male	194 (68.1)	156 (71.2)	15 (44.1)	23 (71.9)	.006
Race					.448
White	191 (67.0)	147 (67.1)	27 (79.4)	17 (53.1)	
Black	51 (17.9)	39 (17.8)	3 (8.8)	9 (28.1)	
Hispanic	22 (7.7)	17 (7.8)	2 (5.9)	3 (9.4)	
Asian	5 (1.8)	5 (2.3)	0 (0.0)	0 (0.0)	
Other	16 (5.6)	11 (5.0)	2 (5.9)	3 (9.4)	
BMI	27 (23-31)	27 (24-32)	24 (21-27)	27 (22-33)	.002
Ejection fraction (%)	58 (50-63)	58 (50-63)	61 (57-64)	57 (50-63)	.149
Hypertension	217 (76.1)	179 (81.7)	13 (38.2)	25 (78.1)	<.001
Pulmonary hypertension	28 (9.8)	21 (9.6)	1 (2.9)	6 (18.8)	.095
Dyslipidemia	159 (55.8)	133 (60.7)	8 (23.5)	18 (56.3)	<.001
Diabetes	106 (37.2)	91 (41.6)	5 (14.7)	10 (31.3)	.002
Dialysis	20 (7.0)	11 (5.0)	0 (0.0)	9 (28.1)	<.001
Cirrhosis	95 (33.3)	73 (33.3)	8 (23.5)	14 (43.8)	.502
HF within 2 wk	150 (52.6)	107 (48.9)	18 (52.9)	25 (78.1)	.002
Previous MI	99 (34.7)	81 (37.0)	6 (17.6)	12 (37.5)	.083
Chronic lung disease	81 (28.4)	70 (32.0)	7 (20.6)	4 (12.5)	.015
Infective endocarditis	84 (29.5)	43 (19.6)	22 (75.9)	19 (51.4)	<.001
Intravenous drug use	106 (37.2)	70 (32.0)	25 (73.5)	11 (34.4)	<.001
Peripheral vascular disease	48 (16.8)	31 (14.2)	6 (17.6)	11 (34.4)	.020
Previous cardiac interventions	105 (36.8)	86 (39.3)	9 (26.5)	10 (31.3)	.076
Medical therapy					
ACE inhibitors	42 (14.7)	42 (19.2)	0 (0.0)	0 (0.0)	.002
Anticoagulant	116 (40.7)	86 (39.3)	16 (47.1)	14 (43.8)	.645
Beta blocker	158 (55.4)	135 (61.6)	10 (29.4)	13 (40.6)	<.001
Diuretics	125 (43.9)	86 (39.3)	20 (58.8)	19 (59.4)	.614
Etiology of liver disease					.129
Viral	150 (52.7)	109 (49.8)	22 (64.7)	19 (59.4)	
Unknown	56 (19.6)	50 (22.8)	4 (11.8)	2 (6.3)	
Alcoholic	24 (8.4)	21 (9.6)	1 (2.9)	2 (6.3)	
>2 etiologies†	19 (6.8)	16 (7.4)	2 (5.8)	1 (3.1)	
Cardiogenic	16 (5.6)	9 (4.1)	3 (8.8)	4 (12.5)	
Other‡	20 (7.2)	13 (6.5)	2 (5.8)	4 (12.5)	
Ascites					<.001
None	247 (86.7)	209 (95.4)	18 (52.9)	20 (62.5)	
Mild/moderate	37 (13.0)	10 (4.69)	15 (44.1)	12 (37.5)	
Severe	1 (0.4)	0 (0.0)	1 (2.9)	0 (0.0)	
Encephalopathy					<.001
None	277 (97.2)	218 (99.5)	32 (94.1)	27 (84.4)	
Grade 1-2	8 (2.8)	1 (0.5)	2 (5.9)	5 (15.6)	
Grade 3-4	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Laboratory values					
Creatinine (mg/dL)	1.0 (0.8-1.4)	1.0 (0.8-1.3)	1.0 (0.7-1.3)	1.9 (1.2-3.8)	<.001
Albumin (g/dL)	3.6 (3.1-4.0)	3.8 (3.5-4.1)	2.4 (2.2-3.0)	3.0 (2.4-3.4)	<.001
Bilirubin (mg/dL)	0.5 (0.3-0.9)	0.5 (0.3-0.8)	0.5 (0.3-0.8)	1.4 (0.5-2.2)	<.001

(Continued)

TABLE 2. Continued

Variable	Overall (N = 285)	CTP class A (n = 219)	CTP early- class B (n = 34)	CTP advanced-class B (n = 32)	*P* value*
INR	1.1 (1.0-1.2)	1.0 (1.0-1.1)	1.1 (1.0-1.2)	1.3 (1.2-1.6)	<.001
Hemoglobin (g/dL)	12 (9.4-13)	12 (10-14)	9.0 (8.4-10)	9.2 (8.3-10)	<.001
Platelets (10^9/L)	195 (150-270)	199 (150-260)	208 (110-380)	150 (110-230)	.041
CTP score	6 (5-6)	5 (5-6)	7 (7-7)	7 (7-8)	<.001
MELD score	8.7 (7-12)	7.9 (6.5-11)	9.0 (7.8-11)	18 (15-22)	<.001

Values are presented as median (interquartile range) or n (%). *CTP*, Child-Turcotte-Pugh; *BMI*, body mass index; *HF*, heart failure; *MI*, myocardial infarct; *ACE*, angiotensin-converting enzyme; *INR*, international normalized ratio; *MELD*, model for end-stage liver disease. *Pearson χ^2 test; Kruskal-Wallis test. †Includes the following combinations: alcoholic and cardiogenic, cardiogenic and viral, viral and alcoholic, viral and metabolic, viral and malignancy, and malignancy and autoimmune. ‡Includes the following etiologies, each with an absolute frequency of <4%: autoimmune, drug-induced hepatitis, malignancy, and metabolic.

A MELD score of 12.7 had a sensitivity of 79.9% and a specificity of 52.4% for 30-day mortality and an area under the curve of 0.6546. Patients in CTP class B had MELD scores ranging from 6.43 to 31.78, and a mean MELD score of 10.45. No patients were classified as CTP class C. Proportionately more patients in CTP class A had hypertension, dyslipidemia, diabetes, and chronic lung disease. Heart failure within 2 weeks as well as dialysis were most prevalent in CTP advanced-class B. CTP early-class B had the highest rate of infective endocarditis. Mild/moderate ascites was most common in CTP early-class B (44.1%) and encephalopathy was most common in CTP advanced-class B (15.6%). No patients developed hepatorenal syndrome. Approximately 52.7% of the cohort had liver disease that can be attributed to viral disease (Table 2).

The most common operations were isolated CABG (30.2%) and isolated valvular surgery (22.8%). Off-pump CABG was performed for 10.5% of CTP class A, 0% of CTP early-class B, and 3.1% of CTP late-class B. Cardiopulmonary bypass time and crossclamp time was shortest in CTP early-class B (Table 3).

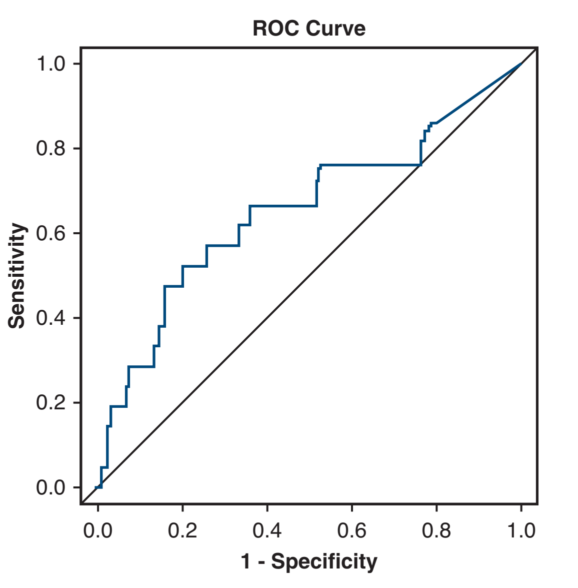


FIGURE 1. Receiver operator characteristic curve for the ability of the model for end-stage liver disease score to predict 30-day mortality. *ROC*, Receiver operating characteristics.

In regard to postoperative outcomes, there was a significant difference noted in the 3 groups with respect to the length of stay (LOS), the incidence of surgical site infection, prolonged ventilation, renal failure, and readmission rates. No significant difference was noted for stroke, sepsis, and reoperation for bleeding. There were 115 patients (40.4%) who had at least 1 postoperative complication. Further stratification of this composite outcome shows that patients in CTP class A (37.9%) and CTP early-class B (38.2%) had a similar incidence rate of complications, whereas patients in CTP advanced-class B (59.4%) had a higher incidence rate of any complications (Table 4). In total, 21 patients died within 30 days of surgery (Table 4). We found 18.8% of patients in CTP advanced-class B died compared with 5.9% of patients in both CTP class A and CTP early-class B ($P = .033$). Analysis of 30-day mortality using linear regression revealed that for every unit increase in MELD score, the odds ratio (OR) of death increased by a factor of 1.1107 (95% CI, 1.033-1.19; $P = .029$).

Univariate analysis of the whole cohort identified the following variables with significant association with 30-day mortality: sex, heart failure within 2 weeks, infective endocarditis, CTP score, MELD score, peripheral vascular disease, and cerebrovascular disease (Table 5). Upon examining the independent effect of those variables on 30-day mortality using multivariate analysis, independent predictors for 30-day mortality were found to be female sex (OR, 3.01; 95% CI, 1.07-8.77; $P = .037$), and peripheral vascular disease (OR, 4.01; 95% CI, 1.33-12.2; $P = .013$) (Table 6). Neither the CTP score (OR, 0.98; 95% CI, 0.56-1.64; $P = .927$) nor the MELD score (OR, 1.08; CI, 0.98-1.18; $P = .126$) were independent predictors for 30-day mortality.

DISCUSSION

This study aimed to assess whether the presence of advanced LD was associated with inferior surgical

TABLE 3. Summary of operative characteristics

Variable	Overall (n = 285)	CTP class A (n = 219)	CTP early- class B (n = 34)	CTP advanced- class B (n = 32)	*P* value*
Type of surgery					<.001
Isolated valvular	65 (22.8)	47 (21.5)	4 (11.8)	14 (43.8)	
Isolated CABG	86 (30.2)	78 (35.6)	3 (8.8)	5 (15.6)	
Concomitant valvular	10 (3.5)	6 (2.7)	2 (5.9)	2 (6.3)	
CABG and valvular	17 (6.0)	15 (6.8)	2 (5.9)	0 (0.0)	
Other	107 (37.5)	73 (33.3)	23 (67.6)	11 (34.4)	
Clinical status					<.001
Elective	110 (38.6)	101 (46.1)	5 (14.7)	4 (12.5)	
Urgent	160 (56.1)	109 (49.8)	27 (79.4)	24 (75.0)	
CPB use	261 (91.6)	196 (89.5)	34 (100)	31 (96.9)	.006
Perfusion time (min)	110 (79-150)	110 (83-150)	98 (62-130)	130 (100-180)	.279
Crossclamp time (min)	80 (59-110)	81 (59-110)	67 (53-110)	87 (62-120)	.635

Values are presented as median (interquartile range) or n (%). *CTP*, Child-Turcotte-Pugh; *CABG*, coronary artery bypass graft; *CPB*, cardiopulmonary bypass. *Pearson χ^2 test; Kruskal-Wallis test.

outcomes after cardiac surgery. The results demonstrated that increased severity of LD was significantly associated with an increase in death at 30-days, death at discharge, LOS, prolonged pulmonary ventilation, and renal failure.

Baseline characteristics of the 3 groups differed significantly. CTP early-class B had a significantly lower median age of 43, compared with a median age of 61years and 60 years for CTP class A, and CTP advanced-class B, respectively. A possible explanation for this age difference is that the majority of CTP early-class B consisted primarily of young patients with a history of intravenous drug use (73.5%) with infective endocarditis (75.9%), rather than other pathologies with risk that increases with age. The CTP early-class B group also had the lowest prevalence and incidence of all comorbidities except for heart failure within 2 weeks, infective endocarditis, peripheral vascular disease, and previous cardiac interventions. Although there were no patients in CTP class C in this study, those patients are not categorically declined for surgery, they rarely undergo operation.[15]

TABLE 4. Postoperative outcomes

Variable	Overall (N = 285)	CTP class A (n = 219)	CTP early- class B (n = 34)	CTP advanced- class B (n = 32)	*P* value*
Hospital LOS (d)	8 (5-13)	7 (5-11)	11 (7-15)	14 (9-28)	<.001
Surgical site infection	10 (3.5)	9 (4.1)	1 (2.9)	0 (0.0)	.029
Stroke	7 (2.5)	5 (2.3)	2 (5.9)	0 (0.0)	.286
Sepsis	9 (3.2)	7 (3.2)	1 (2.9)	1 (3.1)	.997
Prolonged ventilation	59 (20.7)	37 (16.9)	7 (20.6)	15 (46.9)	<.001
Renal failure	18 (6.3)	11 (5.0)	0 (0.0)	7 (21.9)	<.001
Reoperation for bleeding	8 (2.8)	5 (2.3)	1 (2.9)	2 (6.3)	.646
Readmission	51 (17.9)	41 (18.7)	7 (20.6)	3 (9.4)	.007
Composite outcome					.066
Yes	115 (40.4)	83 (37.9)	13 (38.2)	19 (59.4)	
No	170 (59.6)	136 (62.1)	21 (61.8)	13 (40.6)	
Discharge status					.033
Alive	264 (92.6)	206 (94.1)	32 (94.1)	26 (81.3)	
Dead	21 (7.4)	13 (5.9)	2 (5.9)	6 (18.8)	
30-d status					.033
Alive	264 (92.6)	206 (94.1)	32 (94.1)	26 (81.3)	
Dead	21 (7.4)	13 (5.9)	2 (5.9)	6 (18.8)	

Values are presented as median (interquartile range) or n (%). *CTP*, Child-Turcotte-Pugh; *LOS*, length of stay. *Pearson χ^2 test; Kruskal-Wallis test.

TABLE 5. Univariate logistic regression analysis for 30-day mortality status

Variable	Odds ratio	95% CI	*P* value
Age	0.99	0.96-1.02	.516
Female	2.05	0.83-5.06	.115
BMI	0.98	0.91-1.04	.555
Dyslipidemia	1.13	0.45-3.11	.799
Diabetes	1.13	0.43-2.83	.798
Dialysis	0.64	0.03-3.37	.677
Hypertension	0.60	0.24-1.65	.294
Cirrhosis	1.54	0.61-3.79	.345
Heart failure within 2 weeks	3.08	1.17-9.64	.033
Infective endocarditis	2.33	0.94-5.76	.064
Sleep apnea	0.29	0.02-1.46	.235
CTP score	1.73	1.17-2.53	.004
MELD score	1.11	1.03-1.20	.003
Immunosuppressive	0.64	0.10-2.34	.561
Peripheral vascular disease	4.70	1.79-12.1	.001
Cerebrovascular disease	3.59	1.38-9.15	.007

BMI, Body mass index; *CTP*, Child-Turcotte Pugh; *MELD*, model for end-stage liver disease.

Due to the increase in severity of systematic implications as LD progressed, the urgency and complexity of operations increased as well. The rate of urgent operations increased, and elective operations become less frequent. Additionally, both perfusion time and crossclamp time were on average the shortest for CTP early-class B, which could be explained by the predominance of infective tricuspid endocarditis. An increase in hospital LOS was also observed, as well as prolonged pulmonary ventilation (>24 hours) with increasing severity of LD. Renal failure was most prominent in CTP advanced-class B (21.9%), which is consistent with incidence reports in other studies.[16] Patients with more advanced LD were readmitted less frequently in comparison to CTP class A patients, which could be due to the higher mortality rate in CTP advanced-class B group. For both 30-day and in-hospital mortality, the observed overall mortality rate was surprisingly low (7.4%). Both CTP class A and CTP early-class B had a 5.9% 30-day and in-hospital mortality rate, whereas the rate increased to an 18.8% 30-day and in-hospital mortality rate in CTP advanced-class B. The results of this study suggest an overall 30-day mortality rate 2- to 4-fold lower than previous reports in the literature.[17-19] The most common causes of mortality in the overall cohort were cardiogenic shock (3.2%) and sepsis (2.5%), both of which are frequently associated with poor prognosis in patients with liver disease.[20,21] Other causes of mortality included cardiac tamponade, heart failure, multiorgan failure, RVAD failure, and hemorrhage (0.4% each).

TABLE 6. Multivariate logistic regression analysis for 30-day mortality status

Variable	Odds ratio	95% CI	*P* value
Female	3.01	1.07-8.77	.037
Hypertension	0.51	0.16-1.70	.265
Cirrhosis	1.43	0.47-4.24	.517
Heart failure within 2 wk	2.47	0.82-8.55	.124
Infective endocarditis	1.80	0.61-5.35	.286
CTP score	0.98	0.56-1.64	.927
MELD score	1.08	0.98-1.18	.126
Peripheral vascular disease	4.01	1.33-12.2	.013
Cerebrovascular disease	2.49	0.83-7.25	.094

CTP, Child-Turcotte Pugh; *MELD*, model for end-stage liver disease.

Similarities in the incidence of postoperative complications in CTP class A and CTP early-class B, along with the aforementioned mortality rate suggest that patients in CTP class A and CTP early-class B should be able to safely undergo cardiac surgery (Figure 2). The contrasting baseline characteristics of the CTP early-class B patient group in comparison to the other 2 groups requires further investigation. This included mostly young patients with drug-use infective endocarditis, which by itself is associated with unfavorable short-term outcomes.[22]

Multivariate logistic regression showed that female sex (OR, 3.01; 95% CI, 1.07-8.77; $P = .037$), and peripheral vascular disease (OR, 4.01; 95% CI, 1.33-12.2; $P = .013$) were independent predictors for 30-day mortality. Previous literature has shown that men are twice as likely to die from LD and cirrhosis in comparison to women.[23] In contrast, Johnston and colleagues[24] reported that in patients without liver disease, women had a higher 30-day mortality rate after cardiac surgery. Sex-related differences in outcomes for cardiovascular and valvular pathologies are extensively studied and may be attributed to various factors such as a greater burden of comorbidities, delay in diagnosis, and treatment biases.[24,25] Advanced LD is associated with the transformation of both intra- and extrahepatic vasculature.[26] Additionally, abnormality of vascular endothelium contributes to multiple cardiovascular morbidities,[27] which may explain the fact that peripheral vascular disease was an independent predictor of 30-day mortality in this study. In the univariate analysis, the CTP score ($P = .004$) and MELD score ($P = .003$) were significantly associated with 30-day mortality. However, neither variable was found to be an independent predictor of 30-day mortality in the multivariate analysis, presumably as a result of both varying baseline characteristics and cohort size.

Limitations

Despite a sizeable cohort, this was a single-center, retrospective observational study. This consisted of patients with LD deemed suitable to undergo cardiac surgery, therefore

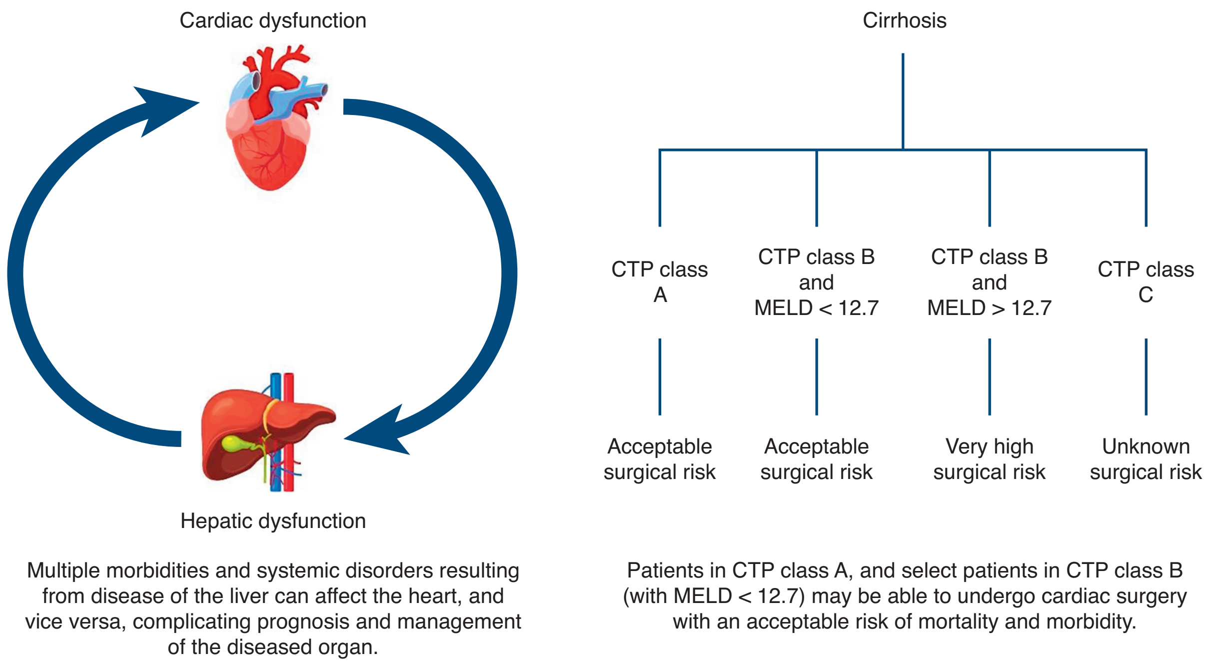


FIGURE 2. Coexistence of cardiac and liver dysfunction. *CTP*, Child-Turcotte Pugh; *MELD*, model for end-stage liver disease.

excluding patients with a more severe liver dysfunction deemed too high risk for operation. This introduces a selection bias including a lack of CTP class C, potentially underestimating the risk of perioperative complications and death. There was no control group, therefore limiting comparisons of overall mortality to patients without LD.

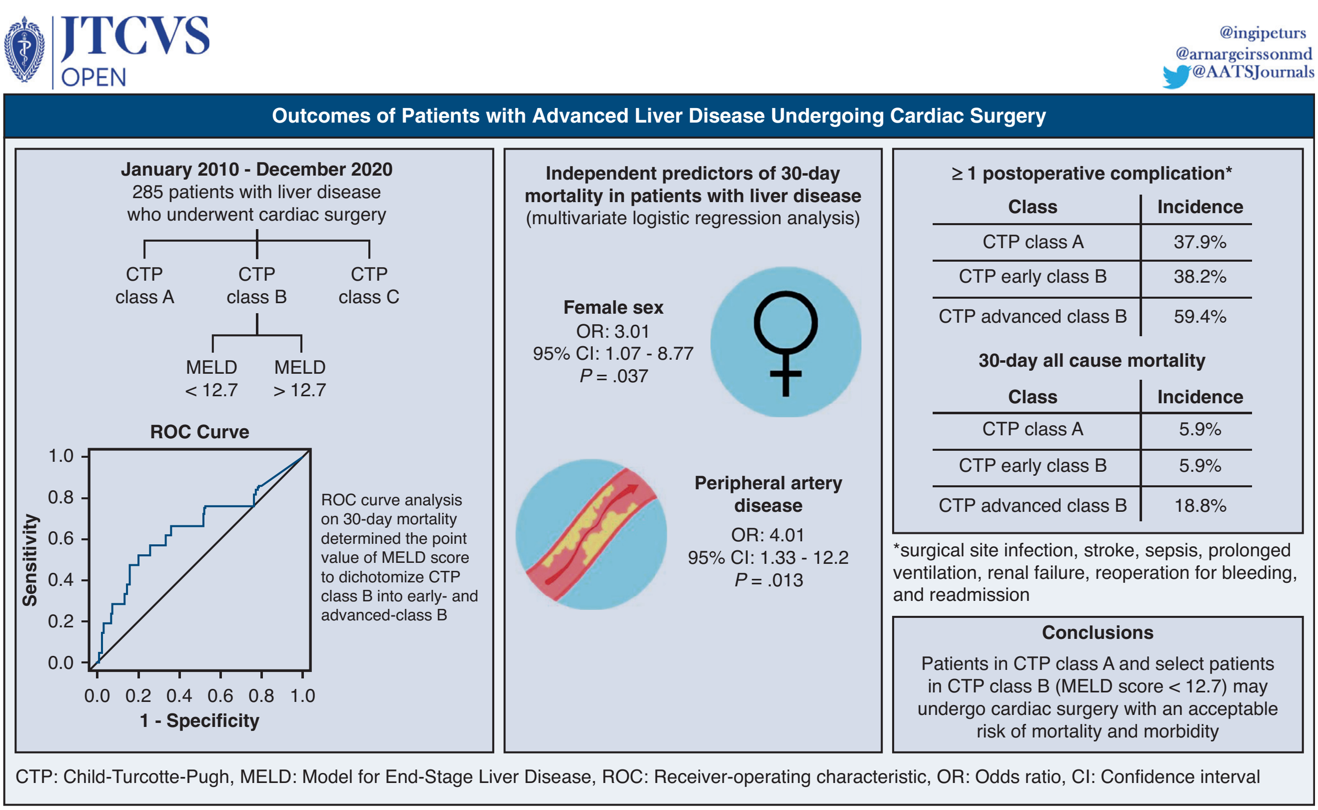
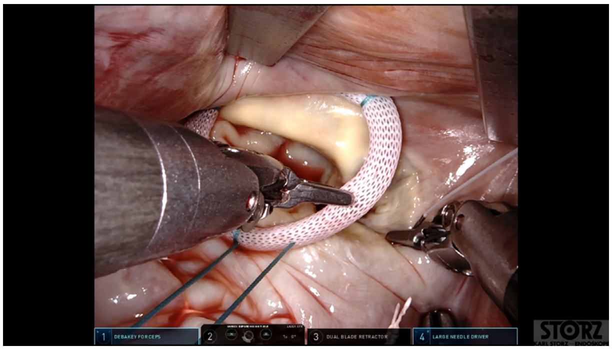


FIGURE 3. Graphical abstract. *CTP*, Child-Turcotte Pugh; *MELD*, model for end-stage liver disease; *OR*, odds ratio; *CI*, confidence interval; *ROC*, receiver operating characteristics.



VIDEO 1. Totally endoscopic, robotic-assisted mitral and tricuspid valve repair in a patient with liver disease. Video available at: https://www.jtcvs.org/article/S2666-2736(23)00180-8/fulltext.

CONCLUSIONS

Postoperative outcomes in cardiac surgery are influenced by increasing severity of preexisting LD (Figure 3). Our data suggest that select patients in CTP class A, as well as patients in CTP class B with a MELD score <12.7, may be able to undergo cardiac surgery with acceptable risks of postoperative morbidity and mortality (Video 1).

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/outcomes-in-cardiac-surgery-patients-with-advanced-liver-disease.

Conflict of Interest Statement

Dr Amabile receives consulting fees from JOMDD. Dr Krane is a physician proctor and a member of the medical advisory board for JOMDD, a physician proctor for Peter Duschek, a medical consultant for EVOTEC and Moderna, and has received speakers' honoraria from Medtronic and Terumo. Dr Geirsson receives consulting fees for being a member of the Medtronic Strategic Surgical Advisory Board and from Edwards Lifesciences. All other authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they have a conflict of interest. The editors and reviewers of this manuscript have no conflicts of interest.

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Key Words: cardiac surgery, liver disease, cirrhosis, CTP, MELD, outcomes