MELD-XI Score in Hospitalized Heart Failure Patients with Cardiac Electronic Devices

Kardiyak Elektronik Cihazları olan Hospitalize Edilmiş Kalp Yetersizliği Hastalarında MELD-XI Skoru

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ABSTRACT

Objective: MELD-XI (Model for End-Stage Liver Disease Excluding INR) score predicts mortality in patients with heart failure. Herein, we assessed the role of MELD-XI score in predicting in-hospital mortality among heart failure patients having intracardiac cardioverter defibrillator (ICD) or cardiac resynchronization therapy with defibrillator backup (CRT-D) who presented with appropriate device shock or acute decompensated heart failure.

Methods: We reviewed the medical records of patients with implantable cardioverter defibrillator or cardiac resynchronization therapy with defibrillator backup admitted to coronary care unit with acute decompensated heart failure or appropriate implantable device shocks between 01 January 2013 and 01 November 2018. MELD-XI score was compared between the deceased and surviving patients. The correlation of MELD-XI score with in-hospital mortality was sought.

Results: There were 106 coronary care unit admissions of 67 patients (52 (77.6%) males and 15 (22.4%) females), who had a mean age of 64.8 (range 19-93) years. Eighty-eight (83.0%) admissions were for acute decompensated heart failure and 18 (17.0%) for appropriate device shock and/or electrical storm. A total of 16 (15.1%) patients died at hospital. The median MELD-XI score of the patients who died at hospital was significantly greater than that of the survivors (11.80 (0.59-28.98) vs 15.24 (9.11-24.64); p<0.05). A binary logistic regression analysis showed that MELD-XI score was a significant independent predictor of in-hospital mortality (X²=1.229 (%95 CI 1.06-1.43); p<0.05).

Conclusion: MELD-XI score successfully predicts in-hospital mortality among patients with ICD or CRT-D admitted with acute decompensated heart failure or appropriate implantable electronic device shocks.

Key Words: MELD-XI, heart failure, electrical storm, shock, implantable cardioverter-defibrillator, cardiac resynchronization therapy

ÖZET

Amaç: MELD-XI (Model for End-Stage Liver Disease Excluding INR- INR'yi Dışlayan Son Dönem Karaciğer Hastalığı Modeli) kalp yetersizliği hastalarında mortaliteyi öngörmektedir. Bu çalışmada, implante edilir kardiyoverter defibrilatör (ICD) ya da defibrilatör destekli kardiyak resenkronizasyon tedavisi (CRT-D) olan ve uygun cihaz şoku ya da akut dekompanse kalp yetersizliği ile başvuran kalp yetersizliği hastalarında hastane içi mortaliteyi öngörmede MELD-XI skorunun rolünü değerlendirdik.

Yöntem: Bu çalışmada, implante edilir kardiyoverter defibrilatör ya da defibrilatör destekli kardiyak resenkronizasyon tedavisi olan ve 01 Ocak 2013 ile 01 Kasım 2018 tarihleri arasında koroner bakım ünitesine akut dekompanse kalp yetersizliği ya da uygun cihaz şoku ile başvuran hastaların tıbbi kayıtlarını gözden geçirdik. MELD-XI skoru ölen ve yaşayan hastalar arasında karşılaştırıldı. MELD-XI skoru ile hastane içi mortalite arasındaki korelasyon araştırıldı.

Bulgular: Ortalama yaşları 64,8 (aralık 19-93) yıl olan toplam 67 (52 (%77,6) erkek, 15 (22,4) kadın) hastanın toplam 106 koroner bakım ünitesi yatışı vardı. Seksen sekiz (%83,0) yatış akut dekompanse kalp yetersizliği ve 18 (%17,0) yatış uygun cihaz şoku ve/veya elektriksel fırtına nedeniyle yapılmıştı. Toplamda 16 (%15,1) hasta hastanede öldü. Hastanede ölen hastaların ortanca MELD-XI skoru yaşayanlardan anlamlı şekilde daha yüksekti (11,80 (0,59-28,98)'e karşılık 15,24 (9,11-24,64); p<0,05). İkili lojistik regresyon analizinde MELD-XI skorunun hastane içi mortalitenin bağımsız öngördürücüsü olduğu gösterildi (X²=1,229 (%95 CI 1,06-1,43); p<0,05).

Sonuç: MELD-XI skoru ICD ya da CRT-D'si olup akut dekompanse kalp yetersizliği ya da uygun implante edilir elektronik cihaz şoku ile başvuran hastalarda hastane içi mortaliteyi başarıyla öngörmektedir.

Anahtar Sözcükler: MELD-XI, kalp yetersizliği, elektriksel fırtına, şok, implante edilir kardiyoverter-defibrilatör, kardiyak resenkronizasyon tedavisi

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INTRODUCTION

It has been recently postulated that hepatic and/or renal affection by acute cardiac conditions such as heart failure and low cardiac output may predict survival among critically ill patients and risk stratify them, mainly occurring due to hypoperfusion, venous congestion, or both (1-5). As such, increased serum total bilirubin is known to be linked with hepatocellular hypoxia originating from low cardiac output and/or increased hepatic venous pressure (1,6). This link between poor cardiac function, mainly in the form of lowered cardiac output with venous cengestion and hepatic and renal derangements, has led to a search for hepatic and renal surrogate markers of cardiac dysfunction and its prognosis. So, the original Model for End-Stage Liver Disease (MELD) score has been developed as a tool to predict clinical outcomes in patients with liver disease. It involves the logarithmic conversions of serum creatinine, total serum bilirubin, and International Normalized Ratio (INR) and calculated as (0.957 x ln(Serum Cr) + 0.378 x ln(Serum Bil) +1.120 x ln(INR) + 0.643) x 10 (if hemodialysis, value for creatinine is automatically set to 4.0) (7). It was considered a good indicator of the severity of hepatic disorders in patients on liver transplant waiting list (8) and those with multi-organ failure (9). Additionally, it was shown to offer prognostic implications for patients with heart failure (10) and patients who were implanted left ventricular assist devices (LVADs) (11,12). The MELD score's ability for prediction of prognosis in heart failure stems from its capacity to reflect hepatic and renal disturbances in low-output and/or venous congestive conditions (13) .

The use of MELD, however, can be problematic in a significant proportion of patients with congestive heart failure or LVADs who are on systemic anticoagulants that cause INR elevation beyond that observed in hepatic congestion/dysfunction, and also among those who are on warfarin or phenprocoumon. For this purpose, MELD-XI score excluding INR has been developed (14) as a modification of the original MELD score, and was shown to be as accurate as its predecessor for estimating mortality in liver cirrhosis (14).

To date, MELD-XI score has been shown to predict survival in a number of cardiac conditions including heart failure and after cardiac transplantation (14-17) but it has not been used for patients with cardiac impantable electrical devices hospitalized for decompensated heart failure and implantable electronic cardiac device shock/electrical storm. In this study we aimed to investigate the role of MELD-XI score in predicting in-hospital mortality among patients with implantable cardioverter-defibrillator (ICD) or cardiac resynchronization therapy with defibrillator backup (CRT-D) who presented with device shock/electrical storm or acute decompensated heart failure.

MATERIALS and METHOD

This study was approved by Başkent University Institutional Review Board (Project no:KA 19/57) and supported by Başkent University Research Fund. We reviewed the medical records of all heart failure patients with implantable cardioverter-defibrillators (ICD) or cardiac resynchronization therapy with defibrillator (CRT-D) who presented to Başkent University Faculty of Medicine Department of Cardiology, Coronary Care Unit with decompensated heart failure or ICD/CRT-D shock or electrical storm between 01 January 2013 and 01 November 2018. All patient data were accessed through the hospital's electronic data management system and written patient medical records. All patients were examined for their demographic properties including age, gender, comorbidities, device type, indication for device implantation and heart failure type (ischemic vs non-ischemic cardiomyopathy; primary or secondary arrhythmic protection or progressive heart failure requiring frequent hospitalization), duration of coronary care unit stay, biochemical parameters, full blood count, and in-hospital mortality rate.

Decompensated heart failure was defined as either of the following:
1.Rapid-onset or worsening of symptoms and/or sign of congestive heart failure requiring hospitalization and intravenous diuretic administration, namely recent-onset or worsening dyspnea, ortophnea, paroxysmal nocturnal dyspnea, fatigue, volume retention and peripheral edema and/or ascites leading to weight gain of >2-2.5 kg in less than a week or >1-1.5 kg in a day, and increased liver enzymes such as ALT, AST, ALP, and GGT.
2.Low-output acute decompensated heart failure as evidenced as low peripheral and/or central perfusion due to reduced cardiac output, indicated by poor mental state (including mental obduntation, somnolence, stupor, or coma), poor urine output (oliguria as defined by a urine output of less than 400 cc/day or anuria as defined by a urine output of less than 100 cc/day), cold, clammy extremities, and tachycardia (>100 bpm).

True ICD/CRT-D shocks were defined as any internal shock delivered by the electronic intracardiac device as a response to a true sustained ventricular arrhythmia, namely ventricular tachycardia or ventricular fibrillation, as verified by device interrogation at the time of hospitalization. Electrical storm was defined as 2 or more appropriate ICD/CRT-D shocks in a 24-hour period.

The exclusion criteria of the study included age younger than 18 years, patients with heart faiure and CRT-D/ICD who were hospitalized for reasons other than decompensated heart failure or true shock/electrical storm, inappropriate shocks due to atrial fibrillation or other supraventricular tachyarrhythmias, lead failure, electromagnetic interference, or device malfunction, and missing laboratory data including total bilirubin and serum creatinine level.

MELD-XI score was calculated as follows: MELD-XI = 5.11 × ln (serum bilirubin in mg/dL) + 11.76 × ln (serum creatinine in mg/ dL) + 9.44. Serum creatinine and bilirubin values utilized were those reported on day of admission.

After determining the patients with heart failure and ICD/CRT-D who were hospitalized during the study period, we determined the indications of patient admission, and selected the ones who were admitted for decompensated heart failure and device shock/electrical storm. There were a total of 156 admissions in this category. After excluding patients and admissions meeting the exclusion criteria, a total of 67 patients admitted in a total of 106 admissions remained for the final analysis (Figure 1-study flow chart). Among these, in-hosptial mortality was determined. The MELD-XI score was then compared between patients who died at hospital (i.e having in-hospital mortality) versus who survived. The patients were then subgrouped based upon their implanted device type (CRT-D vs ICD subgroups) and their indication for coronary care unit admission (decompensated heart failure vs device shock/electrical storm), and the MELD-XI score was compared between the deceased and survived patients in each subgroup.
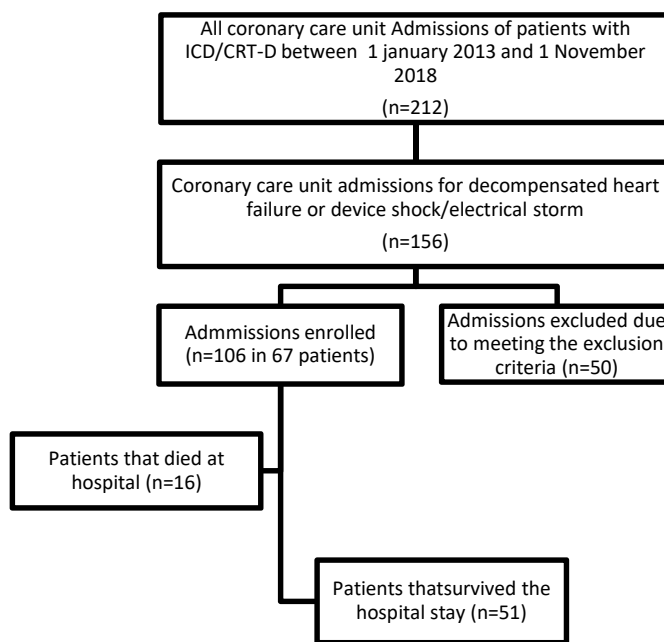

Figure 1- Study flow chart

Statistical analysis

All statistical analyses were performed using SPSS v.20 (SPSS Inc., Chicago, IL, USA) statistical software package. Normality of the distribution of quantitative variables was tested using Kolmogorov-Smirnov test. Descriptive statistics included mean±standard deviation for normally distributed quantitative variables, median (minimum-maximum for non-normally distributed quantitative variables, and number and percentage (%) for qualitative variables. The significance between the means of the quantitative variables was tested using independent samples' t test for the normally distributed quantitative variables and Mann Whitney-U test for the non-normally distributed quantitative variables. Qualitative variables were compared using the Pearson Chi-square test or Fisher's exact test. The significant predictors of in-hospital mortality were initially tested with a univariate analysis using all available demographic, clinical, biochemical, and echocardiographic variables.

All univariate predictors of in-hospital mortality with p value < 0.25 were then used in a binary logistic regression model determine the independent predictors in-hospital mortality. Receiver Operating Characteristics (ROC) analysis was performed to determine the predictive ability of MELD-XI score for prediction of in-hospital mortality.

Table 1. Clinical, demographic, and biochemical characteristics of the study population

Characteristics	Patients that died at hospital (n=16)	Patients that survived hospital stay (n=51)	p	
Age (years)	65.8±16.7	63.6±13.9	>0.05*	
Male, n (%)	13 (81.3%)	40 (78.4%)	>0.05**	
Hypertension, n (%)	10 (62.5%)	38 (74.5%)	>0.05**	
Diabetes mellitus, n (%)	7 (43.8%)	20 (39.2%)	>0.05**	
Smoking (active), n (%)	2 (12.5%)	6 (11.8%)	>0.05**	
CAD (all severities), n (%)	13 (81.3%)	37 (72.5%)	>0.05**	
Cardiomyopathy type				
Ischemic, n (%)	10 (62.5%)	33 (64.7%)	>0.05**	
Non-ischemic, n (%)	5 (31.3%)	19 (37.3%)	>0.05**	
Implantable device subtype				
CRT-D, n (%)	5 (31.3%)	20 (39.2%)	>0.05**	
ICD, n (%)	7 (43.8%)	35 (68.6%)	>0.05**	
Primary prevention, n (%)	9 (56.3%)	22 (43.1%)	>0.05**	*
Secondary prevention, n (%)	3 (18.8%)	8 (15.7%)	>0.05**	
Presentation type (all admissions, n=106)				
Decompensated heart failure, n (%)	12 (75.0 %)	75 (83.3%)	>0.05**	
Congestive symptoms, n (%)	10 (62.5%)	61 (67.7%)	>0.05**	
Low output symptoms, n (%)	2 (12.5%)	18 (20.0%)	>0.05**	
Device shock/electrical storm, n (%)	3 (18.6%)	14 (15.5%)	>0.05**	
Device shock, n (%)	3 (18.6%)	11 (12.2%)	>0.05**	
Electrical storm, n (%)	0 (0%)	3 (3.3%)	>0.05**	
Duration of stay at coronary care unit (days)	4 (2-72)	6 (8-118)	>0.05**	
MELD-XI score	15.24 (9.11-24.64)	11.80 (0.59-28.98)	<0.05***	
Laboratory parameters				
Hb (g/dL)	11.7±4.8	12.8±5.6	<0.05*	
White blood cell (µL)	8.1±2.9	7.6±1.9	>0.05*	
Platelet (10^3 /µL)	236.4±55.7	255.6±32.2	>0.05³	
Creatinine (mg/dL)	1.46±0.5	1.33±0.9	>0.05*	
Blood urea nitrogen (BUN) (mg/dL)	25.8±12.3	22.4±10.8	>0.05*	
Na (mmol/L)	134.7±16.4	132.9±12.5	>0.05*	
K (mmol/L)	5.3±0.6	4.9±1.1	>0.05*	
Total bilirubin (mg/dL)	2.32±2.0	1.58±1.8	>0.05*	
ALT (U/L)	28.3±12.6	21±8.8	<0.05*	
AST (U/L)	30.4±11.8	34.4±9.7	>0.05*	
CRP (mg/dL)	23.6±10.7	10.8±8.9	<0.01*	
Medications				
Beta blocker, n (%)	13 (81.3%)	40 (78.4%)	>0.05**	
ACEI/ARB, n (%)	12 (75.0 %)	42 (82.4%)	>0.05**	
Statin, n (%)	10 (62.5%)	41 (80.4%)	<0.05**	
Amiodarone, n (%)	5 (31.3%)	13 (25.5%)	<0.05**	
Loop diuretic, n (%)	14 (87.5%)	40 (78.4%)	>0.05**	
Aldosterone antagosit, n (%)	10 (62.5%)	24(47.1%)	>0.05**	
Antiplatelet agents, n (%)	12 (75.0%)	42 (82.4%)	>0.05**	
Anticoagulant (warfarin, heparin, NOACs)	7 (43.8%)	20 (39.2%)	>0.05**	
Echocardiographic and electrocardiographic parameters				
Left ventricular ejection fraction (%)				
Left ventricular end-systolic diameter (mm)	27.3±13.6	24.3±10.9	>0.05*	
Left ventricular end-diastolic diameter (mm)	45.5±18.6	46.5±16.6	>0.05*	
Left ventricular hypertrophy (any wall thickness >11 mm), n (%)	66.8±16.7	64.8±13.0	>0.05*	
Left ventricular diastolic dysfunction (any degreee), n (%)				
Rhythm	10 (62.5%)	40 (78.4%)	<0.05**	
Sinus				
Atrial fibrillation	14 (87.5%)	60 (89.6%)	>0.05**	
Paced (biventricular or right ventricular)				
Native QRS width	10 (62.5%)	30 (58.8%)	>0.05**	
	3 (18.8%)	11(21.6%)	>0.05**	
	3 (18.8%)	6 (11.8%)	<0.05**	
	116±24.8	113±18.8	>0.05*	

Independent samples t test, ** Chi-Square test, *** Mann Whitney-U test
CAD: Coronary artery disease, CRT-D: Cardiac resynchorinization therapy with defibrillator backup; ICD: implantable cardioverter defibrillator, MELD-XI: Model for end stage liver disease excluding international noralized ratio; ALT: alanine aminotransferase, AST: Aspartate aminotransferase, CRP: Carbon monoxide-reactive protein, ACEI: Angiotensin converting enzyme inhibitor, ARB: angiotensin receptor blocker, NOAC: Novel oral anticoagulant; QRS: QRS complex on 12-lead electrocardiogram

RESULTS

There were a total of 106 coronary care unit admissions of a total of 67 patients. Fifty-two (77.6%) patients were male and 15 (22.4%) were female, and their mean age was 64.8±17.9 years. The heart failure etiology was ischemic cardiomyopathy in 43 (64.2%) patients, and nonischemic cardiomyopathy in 24 (35.8%) patients. The mean ejection fraction was 27.3%±13.6%.

The indication for device implantation was progressive heart failure symptoms in 25 (37.3%) patients (the CRT-D implanted patients); primary prevention of malignant ventricular arrhythmias in 31 (46.3%) patients (the patients with ICD implanted for primary prevention); and secondary prevention of malignant ventricular arrhythmias in 11 (16.4%) patients (the patients with ICD implanted for secondary prevention). Eighty-eight (83.0%) hospital admissions were for decompensated acute heart failure and 18 (17.0%) for appropriate device shock and/or electrical storm.

The appropriate device shocks and/or electrical storms occurred due to stable monomorphic VT in 8 patients, polymorphic VT due to magnesium depletion in 1 patient, pulmonary, urinary or other infections in 2 patients, ischemia in 1 patient, acute COPD exacerbation in 1 patient, and decompensated heart failure in 5 patients. The comparison of demographic, biochemical, echocardiographic, and electrocardiographic characteristics between deceased and surviving patients were presented on Table 1.

The median hospital stay was 6 (min 2-max 118) days. The patients with CRT-D significantly more commonly presented with decompensated heart failure than those with ICD (94.3% vs 77.5%, p<0.05). In contrast, patients with ICDs more commonly presented with device shock/electrical storm than those with CRT-D (22.5% vs 5.7%, p<0.05). A total of 16 (23.8%) patients died at hospital.

The mean MELD-XI score was 12.78±5.80. The median MELD-XI score of patients that died at hospital was significantly greater that those who survived (15.24 (9.11-24.64) vs 11.80 (0.59-28.98); p<0.05). When the patients were subgrouped into CRT-D and ICD subgroups based on the implanted device type, there was a significant difference between the MELD-XI scores of those that died at hospital and those that survived within the CRT-D subgroup (20.05 (13.92-20.69) vs 13.05 (2.71-27.17); p<0.05) but not within the ICD subgroup (14.58±5.20 vs 11.46±5.84; p>0.05). A similar subgroup analysis was performed on the basis of the indication for hospital admission among the subgroup of patients hospitalized for decompansated heart failure, showing that MELD-XI score was significantly greater in those who died at hospital compared to those who survived (15.68±4.75 vs 12.21±6.13). Among patients with appropriate device shocks or electrical storm, the MELD-XI score could not be compared as there was only one patient who died in the device shock/electrical storm subgroup (Table 2).

Table 2. Inter-group and intra-group comparisons of the MELD-XI score between patients with and without in-hospital mortality

	MELD-XI score		
	Deceased	Survived	p
In-hospital mortality in the general patient population	15.24 (9.11-24.64)	11.80 (0.59-28.98)	<0.05*
In-hospital mortality among patients with CRT-D	20.05 (13.92-20.69)	13.05 (2.71-27.17)	<0.05*
In-hospital mortality among patients with ICD	13.73 (9.11-24.64)	10.71(0.49-28.98)	>0.05*
In hospital mortality among patients with decompensated heart failure	15.22(9.11-24.64)	11.99 (0.59-28.98)	<0.05*

* Mann Whitney-U test, CRT-D: Cardiac resynchorinization therapy with defibrillator backup; ICD: implantable cardioverter defibrillator

Univariate analysis of in-hospital mortality showed that MELD-XI score was a significant univariate predictor of in-hospital mortality (p<0.05) along with age (p<0.05), serum creatinine (p<0.05), admission CRP (p<0.05), and admission systolic blood pressure (p<0.05) . A binary logistic regression analysis showed that MELD-XI score was a significant independent predictor of in-hospital mortality (X^2=1.23 (95% CI 1.06-1.43); p<0.05). A ROC analysis performed to determine the predictive ability of the MELD-XI score for in-hospital mortality revealed that a MELD-XI score of ≥13.88 significantly predicted in-hospital mortality with a sensitivity 68.8%, a specificity of 65.6%, a positive predictive value of 92.2% and a negative predictive value of 26.2% (AUC= 0.695 (95% CI 0.57-0.82); p<0.05) (Figure 2). A categorization according to the MELD-XI score was also performed, in which patients with a MELD-XI score of <13.88 were categorized as the low MELD-XI score group and the ones with a MELD-XI score of ≥13.88 as the high MELD-XI score group. There was a significantly worse in-hospital survival among patients with a high MELD-XI score (Log Rank (Mantel-Cox) test; p<0.05) (Figure 3).

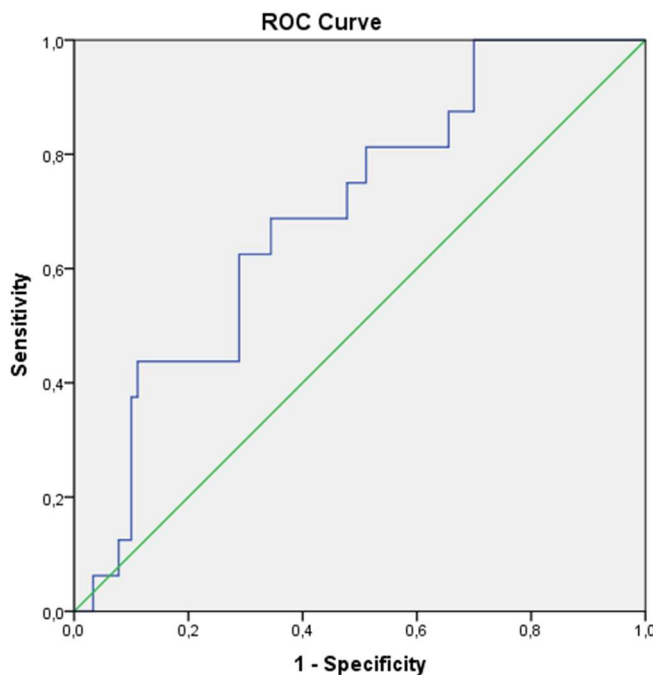**Figure 2.** ROC curve of the MELD-XI score for the prediction of in-hospital mortality
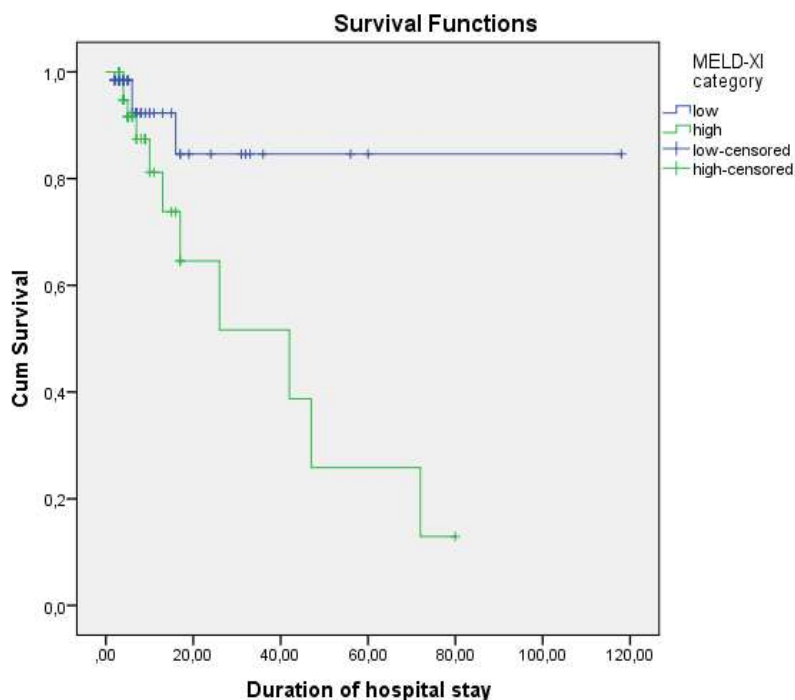
Survival Functions

Figure 3. Survival status by the MELD-XI category (low (<13.88) vs high (≥13.88) MELD-XI score)

DISCUSSION

Hepatic and/or renal functional impairment mainly secondary to hypoperfusion, venous congestion, or both as a result of acute or chronic cardiac dysfunction such as heart failure and low cardiac output may predict survival among critically ill patients (1-5). Increased serum total bilirubin and creatinine are known to be linked with hepatocellular and renal hypoxia and venous congestion originating from low cardiac output and/or increased venous pressure (1,6,18) Therefore, it is plausible that changes in serum levels of both parameters reflect worsening cardiac function. This link between poor cardiac function and hepatic and renal derangement prompted a search for hepatic and renal surrogate markers of cardiac dysfunction and its prognosis. As a result, the original MELD score and its modification MELD-XI score have been developed, both of which have been validated for use to predict mortality risk in heart failure and other cardiac conditions as well as patients undergoing cardiac surgery including cardiac transplantation and left ventricular assist device implantation (19-24). However, neither score has been used for patients with cardiac impantable electrical devices hospitalized for decompensated heart failure and implantable electronic cardiac device shock/ electrical storm. To our best knowledge, our study demonstrated to the first time in the medical literature that MELD-XI score can be used as a predictor of in-hospital mortality among patients with CRT-D or ICD that presented with either decompensated heart failure or device shock or electrical storm. While previous studies have reported that MELD-XI score may predict both short and long-term prognosis in various patient populations (13-15,22,23,25,26), we demonstrated that it significantly predicted in-hospital mortality. We demonstrated that a cut-off value of ≥ 13.88 for MELD-XI score was associated with a significant risk of in-hospital mortality with a relatively fair sensitivity and specificity. Moreover, a high-MELD-XI category significantly worsened in-hospital survival. Critsinelis et al (16) reported an almost identical cut-off point (>14) for MELD-XI for predicting potoperative mortality among patients with heart failure undergoing left ventricular assist device (LVAD) implantation, and Yang et al (20) reported that a MELD-XI score of ≥17,which was close to our best cut-off value of 13.88, predicted long-term mortality after LVAD placement.

Our subgroup analyses also showed that the MELD-XI score was significantly higher among the deceased patients than the survived ones in the subgroup of patients presented with decompensated heart failure. This suggest that, as previous stuides pointed (10,16,19,20,22,24), MELD-XI score is more related to decompansation of heart failure and thus venous congestion and resulting hepatic and renal dysfunction.

This finding was also corroborated by a higher MELD-XI score in the deceased patients withinin the CRT-D subgroup, which more commonly presented with decompensated heart failure than the ICD subgroup, which more commonly presented with device shock/electrical storm. These findings may suggest that MELD-XI score is a surrogate marker for renal and hepatic derangement, principally due to congestion, venous hypertension, and possibly low cardiac output. To the contrary, device shocks and electrical storm, when not accompanied/caused by congestion or low cardiac output, may not disturb hepatic hepatic and renal functions as severely as decompensated heart failure. As such, in patients with implanted devices device shocks and electrical storm may occur due to causes other than decompensated heart failure such as electrolyte imbalance, cardiac ischemia, infections, or drug proarrhtyhmia, although a notable proportion of patients may also present with decompensated heart failure causing device shocks. However, as the majority of device shock/electrical storm cases (72.2%; 13 out of 18 cases) in our study were not secondary to decompensated heart failure but other conditions such as stable monomorphic ventricular tachycardia, ischemia, infections, electrolyte disorders, and COPD exacerbations, and as there occurred only one death in the appropriate shock/electrical storm subgroup, we could not assess whether MELD-XI score affected mortality rate in the appropriate shock/electrical storm subgroup.

Our study has several limitations. First, it had a retrospective design. Second, only patients with ICD or CRT-D were included and patients with conventional pacemakers were excluded. This was because patients with a history of heart failure and low left ventricular ejection fraction requiring device therapy were included, who also frequently admit with decompensated heart failure and/or device shocks. Third, MELD-XI score only incorporates serum total bilirubin and creatinine, and does not include other confounding factors that affect mortality rate in decompensated heart failure and/or device therapy. Fourth, there occurred only one death in the appropriate shock/electrical storm subgroup, which prevented any assessment of the role of MELD-XI on survival in this patient subgroup.

CONCLUSION

MELD-XI score predicted in-hospital mortality among patients with ICD or CRT-D admitted to coronary care unit with decompensated heart failure or device shock/electrical storm. MELD-XI score appears especially useful among patients presenting with decompensated heart failure as well as those carrying a CRT-D who also more commonly presented with decompensated heart failure. These data suggest that MELD-XI score successfully predicts in-hospital mortality by reflecting heart failure decompensation through impaired renal and hepatic function.

Future randomized controlled studies should follow our study for determining the potential role of MELD-XI score for predicting in-hospital mortality among patients with CRT-Ds or ICDs, especially those presenting with decompensated heart failure.

Conflict of interest
No conflict of interest was declared by the authors.

REFERENCES

1. Roth C, Schrutka L, Binder C, Kriechbaumer L, Heinz G, Lang IM, et al. Liver function predicts survival in patients undergoing extracorporeal membrane oxygenation following cardiovascular surgery. Crit Care. 2016;20:57
2. Jung C, Kelm M, Westenfeld R. Liver function during mechanical circulatory support: from witness to prognostic determinant. Crit Care. 2016;20:134
3. Jung C, Lauten A, Ferrari M. Microcirculation in cardiogenic shock: from scientific bystander to therapy target. Crit Care. 2010;14:193
4. Cruz DN. Cardiorenal Syndrome in Critical Care: The Acute Cardiorenal and Renocardiac Syndromes. Advances in Chronic Kidney Disease. Adv Chronic Kidney Dis. 2013;20:56-66.
5. Samsky MD, Patel CB, DeWald TA, Smith AD, Felker GM, Rogers JG, Hernandez AF. Cardiohepatic interactions in heart failure: an overview and clinical implications. J Am Coll Cardiol. 2013 18;61:2397-2405..
6. Giallourakis CC, Rosenberg PM, Friedman LS. The liver in heart failure. Clin Liver Dis. 2002;6:947–67, viii–ix.
7. Cholongitas E, Marelli L, Shusang V, Senzolo M, Rolles K, Patch D, et al. A systematic review of the performance of the model for end-stage liver disease (MELD) in the setting of liver transplantation. Liver Transpl. 2006;12:1049–61.
8. McCaughan GW, Crawford M, Sandroussi C, Koorey DJ, Bowen DG, Shackel NA, et al. Assessment of adult patients with chronic liver failure for liver transplantation in 2015: who and when? Intern Med J. 2016;46:404–12.
9. Kamath PS, Kim WR, Advanced Liver Disease Study G. The model for end-stage liver disease (MELD). Hepatology. 2007;45:797–805.
10. Kim MS, Kato TS, Farr M, et al. Hepatic dysfunction in ambulatory patients with heart failure: application of the MELD scoring system for outcome prediction. J Am Coll Cardiol 2013;61:2253–61.
11. Dichtl W, Vogel W, Dunst KM, et al. Cardiac hepatopathy before and after heart transplantation. Transpl Int 2005;18: 697–702.
12. Matthews JC, Pagani FD, Haft JW, et al. Model for end-stage liver disease score predicts left ventricular assist device operative transfusion requirements, morbidity, and mortality. Circulation 2010;121:214–20.

13. Wernly B, Lichtenauer M, Franz M, et al. Model for End-stage Liver Disease excluding INR (MELD-XI) score in critically ill patients: Easily available and of prognostic relevance. PLoS One. 2017;12:e0170987.
14. Heuman DM, Mihas AA, Habib A, et al. MELD-XI: a rational approach to "sickest first" liver transplantation in cirrhotic patients requiring anticoagulant therapy. Liver Transpl 2007;13:30–7.
15. Spieker M, Hellhammer K, Wiora J, Klose S, Zeus T, Jung C, Saeed D, Horn P, Kelm M, Westenfeld R. Prognostic value of impaired hepato-renal function assessed by the MELD-XI score in patientsundergoing percutaneous mitral valve repair. Catheter Cardiovasc Interv. 2019;93:699-706.
16. Critsinelis A, Kurihara C, Volkovicher N, Kawabori M, Sugiura T, Manon M 2nd, Wang S, Civitello AB, Morgan JA. Model of End-Stage Liver Disease-eXcluding International Normalized Ratio (MELD-XI) Scoring System to Predict Outcomes in Patients Who Undergo Left Ventricular Assist Device Implantation. Ann Thorac Surg. 2018;106:513-9.
17. He PC, Wei XB, Luo SN, Chen XL, Ke ZH, Yu DQ, Chen JY, Liu YH, Tan N.Risk prediction in infective endocarditis by modified MELD-XI score. Eur J Clin Microbiol Infect Dis. 2018;37:1243-50.
18. Metra M., Davison B., Bettari L., et al: Is worsening renal function an ominous prognostic sign in patients with acute heart failure? The role of congestion and its interaction with renal function. Circ Heart Fail 2012; 5: 54-62.
19. Chokshi A, Cheema FH, Schaefle KJ, Jiang J, Collado E, Shahzad K, Khawaja T, Farr M, Takayama H, Naka Y, Mancini DM, Schulze PC J. Hepatic dysfunction and survival after orthotopic heart transplantation: application of the MELD scoring system for outcome prediction. Heart Lung Transplant. 2012; 31:591-600.
20. Yang JA, Kato TS, Shulman BP, Takayama H, Farr M, Jorde UP. Liver dysfunction as a predictor of outcomes in patients with advanced heart failure requiring ventricular assist device support Use of the Model of End-stage Liver Disease (MELD) and MELD eXcluding INR (MELD-XI) scoring system. J Heart Lung Transplant. 2012;31:601–10.
21. Murata M, Kato TS, Kuwaki K, Yamamoto T, Dohi S, Amano A. Preoperative hepatic dysfunction could predict postoperative mortality and morbidity in patients undergoing cardiac surgery: Utilization of the MELD scoring system. Int J Cardiol. 2016 Jan 15; 203:682-9.
22. Abe S, Yoshihisa A, Takiguchi M, Shimizu T, Nakamura Y, Yamauchi H. Liver Dysfunction Assessed by Model for End-Stage Liver Disease Excluding INR (MELD-XI) Scoring System Predicts Adverse Prognosis in Heart Failure. PLoS One Jun. 2014;9:e100618
23. Assenza GE, Graham DA, Landzberg MJ, Valente AM, Singh MN, Bashir A. MELD-XI score and cardiac mortality or transplantation in patients after Fontan surgery. Heart Apr. 2013;99:491–6.
24. Kim MS, Kato TS, Farr M, et al. Hepatic dysfunction in ambulatory patients with heart failure: application of the MELD scoring system for outcome prediction. J Am Coll Cardiol 2013;61:2253–61.
25. Grimm, Joshua C. et al. Modified Model for End-Stage Liver Disease eXcluding INR (MELD-XI) Score Predicts Early Death After Pediatric Heart Transplantation. Ann Thorac Sur;2016:101: 730 –5.
26. Wernly B, Lichtenauer M, Vellinga N, Boerma C, Ince C, Kelm M, Jung C. Model for End-Stage Liver Disease Excluding INR (MELD-XI) score is associated with hemodynamic impairment and predicts mortality in critically ill patients. Eur J Intern Med. 2018;51:80-4.