

Chronotropic Incompetence on Dobutamine Stress Echocardiography in Candidates for a Liver Transplant

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Abstract

Objectives: We evaluated dobutamine stress echocardiography as an initial screening test for a cardiac evaluation before a liver transplant.

Materials and Methods: We retrospectively examined 111 liver transplant candidates who had undergone previous cardiac evaluation; 30 of whom had undergone a liver transplant.

Results: Eighty patients (72.1%) completed a dobutamine stress echocardiography (41 chronotropically competent, 39 incompetent), while 31 patients (27.9%) required us to terminate early. Overall, 68 patients (61%) were on β -blockers (21 required early dobutamine stress echocardiography termination, 30 chronotropically incompetent, and 17 competent). Patient results were normal. Thirty patients underwent a liver transplant. Among candidates requiring termination of early dobutamine stress echocardiography, posttransplant cardiac events included 1 fatal acute myocardial infarction, 1 nonfatal acute myocardial

infarction, and 1 idiopathic cardiomyopathy. Among chronotropically incompetent patients, 2 patients had transient bradycardia, and among those who were chronotropically competent, 1 had refractory atrial fibrillation, and 1 had transient bradycardia. **Conclusions:** Nearly 50% of patients with end-stage liver disease may not reach the target heart rate. Early termination of dobutamine stress echocardiography because of cardiac symptoms or significant echocardiographic changes have more effect in predicting postoperative cardiac events, but further evaluation is required even if their target heart rate is close to that desired. Lower target heart rate may be acceptable in chronotropically incompetent individuals provided they are asymptomatic, have no echocardiographic changes, or cardiovascular risk factors, especially if they are on β -blockers.

Key words: Cardiac, Stress, β -blocker, Cirrhosis

Introduction

Over the last decades, a liver transplant (LT) has emerged as a the treatment of choice for patients with end-stage liver disease (ESLD). Better surgical techniques, advances in immunosuppression, and donor organ management have significantly improved patient survival. However, while long-term patient survival has increased, cardiac complications have become a more common cause of early morbidity and mortality. Studies report a high incidence of posttransplant cardiovascular complications, with arrhythmias and overt congestive heart failure in as many as 25% and 56% of all transplant recipients.¹⁻³

Patients with ESLD are at increased risk of acute coronary occlusion, myocardial failure, arrhythmia, and complete cardiovascular collapse after a transplant compared with other major surgical

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Acknowledgements: This data was presented as an oral presentation and was awarded a travel grant at the 15th European Society of Organ Transplantation Congress, September 4-7, 2011, Glasgow, Scotland. Transplant Intl. 2011;24(s2):27,O # 097.

Ashish Singhal was responsible for the research design, performance of research, data analyses, and writing of paper; Andreas Karachristos and Athanasios Thomaidis performed the research; Amar Nath Mukerji was responsible for the data analyses and editing; Manoj Maloo, Benjamin Sanchez, Michael Keresztury, and Thomas A. Santora performed the research and edited the manuscript; and Ashokkumar Jain was responsible for the research design, editing of the manuscript, performing the research, and analyzing the data.

The authors thank Khushbo Majmundar for her technical support with the data analyses.

The authors have no conflicts of interest and received no funding for this study.

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Experimental and Clinical Transplantation (2013) 6: 546-553

procedures. This is partly because there has been an increase in the number of patients older than 60 years undergoing an LT, which shows that these patients have more cardiovascular risk factors, then do young persons.⁴ Secondly, despite improvements in surgical techniques, the heart must respond to major hemodynamic/metabolic stressors intraoperatively including major and rapid blood loss, massive fluid shifts, and caval cross-clamping. However, there is no effective way to detect cardiovascular disease in asymptomatic patients before an LT, or determining the risk an LT candidate with heart disease has of a perioperative adverse cardiac event.

The American College of Cardiology/American Heart Association has guidelines that suggest that routine angiography is not indicated in LT candidates, unless noninvasive testing reveals a high-risk of adverse outcomes.^{5,6} Exercise stress testing is the noninvasive method of choice. The inherent debilitated state of most ESLD patients presents them from undertaking the physical challenge required of an exercise stress test. This limitation has led dobutamine stress echocardiography (DSE) to become the screening technique of choice at many transplant centers. Although various studies have produced conflicting results about the predictive value of DSE in these patients.⁷⁻¹¹

This study sought to determine the prevalence and causes of chronotropic incompetence in patients with ESLD, and to examine the adequacy of our current DSE protocol in predicting cardiac events after an LT.

Materials and Methods

This study retrospectively evaluated 111 patients with decompensated ESLD who had undergone a DSE at our institution as part of their pre-LT cardiac evaluation between March 2009 and September 2010. The study was approved by the institutional review board. All protocols conformed with the ethical guidelines of the 1975 Helsinki Declaration.

All patients underwent a complete cardiac evaluation including a detailed clinical history and physical examination to identify symptoms and risk factors associated with coronary artery disease. These included age, sex, diabetes mellitus and its management (diet-controlled, oral hypoglycemic, or insulin-dependent), hypertension (defined as *systolic blood pressure of >140 mm Hg and/or diastolic blood pressure of > 90 mm Hg*) requiring antihypertensive

medications, hypercholesterolemia (defined as *total cholesterol of > 5.18 mmol/L*), obesity (defined as *body mass index of > 30*), and smoking (including ex-smokers if smoking was discontinued in the 10 years before the study). A family history was considered positive if a first-generation relative had been diagnosed with coronary artery disease before the age of 60. Medication history was noted including the use of β -blockers for treatment of portal hypertension. A standard 12-lead electrocardiogram (ECG) and a 2-dimensional echocardiography preceded the DSE in all patients.

Dobutamine stress test and additional cardiac testing

Dobutamine stress testing was performed according to a standard protocol using increasing dosages of dobutamine given at 3-minute intervals. Intravenous dobutamine was infused incrementally from a starting dose of 5 $\mu\text{g}/\text{kg}/\text{min}$ to a maximum dosage of 40 $\mu\text{g}/\text{kg}/\text{min}$, or by the time the study endpoint had been achieved. The endpoints terminating dobutamine infusion included developing a new wall motion or ECG abnormalities, containing 85% of the age-predicted maximal heart rate (HR), or developing significant adverse effects related to the dobutamine. Patients not achieving 85% of age-predicted maximal HR at the maximum dobutamine dose were given atropine (up to 2 mg) as per the cardiologist.

Continuous cardiac monitoring was done throughout the test, while blood pressures were measured at rest, every 3 minutes during the study, and at maximal stress. The results were reviewed and interpreted by senior cardiologists. Similar to the definition of exercise-induced cardiac stress testing, chronotropic incompetence was defined as *the inability to reach 85% of the predicted maximal HR for age and sex at the maximum dosage of dobutamine (40 $\mu\text{g}/\text{kg}/\text{min}$)*.⁸ Ischemic endpoints including chest pain, segment depression > 2 mm, new or worsened wall-motion abnormalities, dysrhythmias, significant blood pressure changes (blood pressure > 240/120 mm Hg or decline in systolic blood pressure > 40 mm Hg), or any intolerable symptoms led to early termination of the stress test. We did not compare the clinical and hemodynamic characteristics among patients who achieved their target heart rate (THR) with those who did not.

At our institution, additional cardiac testing includes a dipyridamole-thallium scan¹² and cardiac

catheterization in patients who failed to achieve their THR, failed to complete a DSE, or were considered a high risk for coronary artery disease (eg, [i] age \geq 55 y for men and \geq 65 y for women, [ii] \geq 2 cardiovascular risk factors, [iii] echocardiographic evidence of ventricular enlargement or dysfunction, [iv] symptoms suggestive of coronary artery disease including dyspnea or angina) despite the results of a DSE being negative for ischemia.

Follow-up

Follow-up data were obtained regarding additional testing done after chronotropic incompetence on a DSE, or early termination of protocol, and cardiac events immediately after surgery.

Statistical analyses

Statistical analyses were performed with SPSS software (SPSS: An IBM Company, version 18.0, IBM Corporation, Armonk, NY, USA). Results are expressed as means \pm standard deviation (SD) for normal distributions and median (first and third quartiles) for nonnormal distributions. Comparisons were made using chi-square tests for categorical variables. The unpaired *t* test was used to compare the means of continuous variables with a normal distribution. The nonparametric Mann-Whitney *U* test was used to compare means of continuous variables with nonnormal distributions. Differences were considered statistically significant when the value for *P* was $<$.05.

Results

Baseline characteristics

Table 1 shows the patients' baseline characteristics. The mean age of the patients was 55.1 ± 8.4 years (median, 54; range, 22-77 y); 77 of whom were men (69.3%). The mean body mass index was 28.6 ± 6.7 kg/m² (mean, 27.2; range, 17-61 kg/m²). Viral hepatitis was the most common cause of ESLD involving 70 patients (63.1%), followed by alcoholic cirrhosis in 25 patients (22.5%). Seventy-five patients (67.5%) had a MELD score $<$ 15, and 9 patients (8.2%) had a MELD score $>$ 25 at evaluation.

Dobutamine stress echocardiography

Dobutamine stress echocardiography was terminated early in 31 patients (27.9%), and 21 of them were on β -blockers. Dysrhythmias (n=10) were the most

common reason for early termination of DSE. Others reasons included hypotension (n=6), hypertension (n=6), chest pain (n=4), palpitations (n=2), headache (n=2), dyspnea (n=2), nonspecific sinus tachycardia abnormality (n=4), and sinus tachycardia depression (n=2). Seven patients had multiple symptoms and/or ECG changes. Based on their cardiac history and/or symptoms during the DSE, 4 patients underwent a conventional coronary angiography and were found to have normal coronary arteries and 9 underwent dipyridamole-thallium scanning; all results were normal.

Table 1. Baseline Patient Characteristics (All Patients)

Characteristic/Variable	n=111
Age, mean (SD), y	55.1 (8.4)
Men, n (%)	77 (69.3)
Ethnicity, n (%)	
White	58 (52.2)
African-American	20 (18.1)
Hispanic	32 (28.8)
Other	1 (0.9)
Body mass index, kg/m ² , mean (SD)	28.6 (6.7)
Cardiovascular risk factors, n (%)	
Hypertension	39 (35.1)
Hyperlipidemia*	26 (23.4)
Diabetes mellitus	36 (32.4)
Tobacco history*	51 (45.9)
Family history of coronary artery disease	22 (19.8)
Cause of end-stage liver disease, n (%)	
Viral hepatitis	70 (63.1)
Alcoholic	25 (22.5)
NASH	3 (2.7)
Cryptogenic	5 (4.5)
Other	8 (7.2)
MELD, mean (SD)	14.3 (7.8)
$<$ 15, n (%)	75 (67.5)
16-25, n (%)	27 (24.3)
$>$ 25, n (%)	9 (8.2)

Abbreviations: MELD, model for end-stage liver disease; NASH, non-alcoholic steatohepatitis; SD, standard deviation

*Whenever the data were available.

Forty-one patients (51.2%) achieved the age-predicted THR (mean dobutamine dosage, 34.4 ± 8.1 μ g). Thirty-nine patients (48.8%) failed to achieve the THR (mean dobutamine dosage, 39.7 ± 6.3 μ g) including 12 patients who received atropine (mean atropine dosage, 0.44 ± 0.12 μ g; 8 on β -blockers). Table 2 shows that the mean resting HR was not significantly different between chronotropically competent and incompetent individuals. As expected, at maximum dobutamine dosage, the chronotropically incompetent individuals had a statistically significant lower peak HR ($P <$.05), lower average HR increment, and lower rate-pressure product (Table 2). The blood pressures at rest and at maximal stress were comparable. There was no difference in resting left ventricular ejection

fractions and right ventricular systolic pressures. The left ventricular (LV) mass was calculated using the American Society of Echocardiography formula.¹³ The LV mass index also was not statistically different.

Symptoms in patients who completed a DSE were deemed to be tolerable and comparable between the 2 groups, except for chest pain (Table 3). The most common symptom in both groups was palpitation, followed by chest pain, headache, hypertension, and dyspnea. Premature ventricular contraction was the most-common dysrhythmia in both groups. Some patients had multiple symptoms. Nonspecific sinus tachycardia changes were noted in 9 patients chronotropically incompetent (23.4%) and 2 chronotropically competent patients (4.8%; $P < .05$).

Beta-blocker use

At our institution, withholding β -blockers for any length of time before the DSE is not practiced because most patients received β -blockers for a history of gastrointestinal bleeding. Of the 80 patients who completed the stress protocol, 47 patients (58.7%)

Table 3. Symptoms/Arrhythmias During Stress Test (Completed DSE, n=80)

Symptoms/Arrhythmias*	Chronotropic Incompetence	
	Yes, n=39 (%)	No, n=41 (%)
Dyspnea	1 (2.6)	1 (2.4)
Palpitations	4 (10.4)	5 (12)
Chest Pain	5 (13)	1 (2.4)
Headache	2 (5.2)	0 (0)
Hypertension	2 (5.2)	0 (2.4)
Symptomatic hypotension	0 (0)	1 (2.4)
Premature atrial contractions	11 (28.6)	14 (34.1)
Premature ventricular contractions	14 (36.4)	20 (48)
Supraventricular tachycardia	1 (2.6)	2 (4.8)
Nonsustained ventricular tachycardia	1 (2.6)	0 (0)
Nonspecific ST abnormality**	9 (23.4)	2 (4.8)

Abbreviations: DSE, dobutamine stress echocardiography

*Some patients had more than 1 symptom.

** $P < .05$.

were on β -blockers. Among these 47 patients, 30 patients (63.9%) could not achieve the THR, compared with 9 out of 33 patients (27.3%) who were not on β -blockers (chi-square test; $P < .05$) (Table 4). In addition, 21 patients (67.7%) were using β -blockers out of the 31 in whom DSE was terminated early. Mean percentages of maximal HR achieved among those with and without β -blocker were 73.8 ± 14.6 and 84.5 ± 5.7 .

Table 2. Laboratory Data and Cardiac Characteristics (Completed Dobutamine Stress Echocardiography, n=80)

Parameters	Chronotropic incompetence		U	P Value
	Yes, n=39	No, n=41		
Hematologic/Biochemical*				
S. creatinine ($\mu\text{mol/L}$)	70.7 (53.0, 79.6)	70.7 (61.9, 88.4)	696	.42
eGFR	99 (76, 112.5)	95 (76.8, 107)	852	.48
S. sodium (mmol/L)	137 (133.5, 139)	136.5 (134.8, 139)	812	.76
S. bilirubin ($\mu\text{mol/L}$)	34.2 (23.9, 77.0)	29.1 (12.0, 54.7)	929.5	.14
AST ($\mu\text{kat/L}$)	1.2 (0.8, 1.8)	1.1 (0.7, 1.8)	874	.36
ALT ($\mu\text{kat/L}$)	0.6 (0.5, 1.3)	0.7 (0.4, 1.1)	791	.92
S. albumin (g/L)	29 (24, 35)	30 (24, 37)	701.5	.44
Platelet count $\times 10^9/\text{L}$	85 (56, 109)	96.5 (68.5, 164.5)	648.5	.2
INR	1.3 (1.2, 1.5)	1.2 (1.2, 1.4)	847	.52
Baseline ECG findings				
Average HR at rest (beats/min)	70.4 \pm 11.5	76 \pm 10.6		.2
Average systolic BP at rest (mm Hg)	124.9 \pm 16.3	126.8 \pm 15.4		.59
SA node dysfunction	-	-	-	-
AV node dysfunction	-	-	-	-
Atrial fibrillation	-	-	-	-
Paced rhythm	1	-	-	-
RBBB	-	3	-	-
Baseline ECHO findings				
LVEF, %	60 (60, 60)	60 (60, 60)	689.5	.38
RVSP, mm Hg	33.5 (25, 36.8)	32 (26.25, 35.75)	407.5	.78
LV mass index, gm/m ²	105.9 (88.1, 122.7)	108 (97.8, 128)		
Stress				
Median dobutamine dose (μg)	40 (40, 40)	40 (30, 40)	1088.5	.005
Median peak HR (beats/min)	120 (100.5, 132)	142 (139, 146)	140.5	< .0001
Median peak systolic BP (mm Hg)	150 (140, 158)	147 (131, 163)	783.5	.88
Median rate-pressure product (beats/min \times mm Hg)	17760 (13800.5, 20178.5)	20874 (19028, 23472)	354	< .0001
Atropine, (n)	12	2	-	-
Average atropine dose (mg)	0.44 \pm 0.12	0.3 \pm 0.14	-	-

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; AV node, atrio-ventricular node; BP, blood pressure; ECG, electrocardiogram; eGFR, estimated glomerular filtration rate; HR, heart rate; INR, international normalized ratio; LV, left ventricular; LVEF, left ventricular ejection fraction; RBBB, right bundle branch block; RVSP, right ventricular systolic pressures; S, serum; SA node, sino-atrial node

*Values are represented as a means \pm SD for normal distributions or as median (1st quartile, 3rd quartile) for those that are not. P values were calculated by 2-way Mann-Whitney U test for nonnormal distributions and the t test was used for normal distributions

Table 4. Percentage of Predicted Maximal Heart Rate Versus β -blocker. (Completed Dobutamine Stress Echocardiography, n=80)

Percentage of Predicted Maximal HR	β -Blocker (n=47) n (%)	No β -Blocker (n=33) n (%)	Overall (n=80) n (%)
Achieved standard target HR in $\geq 85\%$	17 (36.1)*	24 (72.7)*	41 (51.2)
Not achieved standard target HR in $< 85\%$	30 (63.9)*	9 (27.3)*	39 (48.8)
Achieved lower HR			
$\geq 80\%$	22 (46.8)	27 (81.8)	49 (61.3)
$\geq 75\%$	28 (59.6)	30 (90.9)	58 (73)
$> 70\%$	33 (70.2)	32 (97)	65 (81.3)
$\geq 65\%$	36 (76.6)	33 (100)	69 (86.3)

Abbreviations: HR, heart rate

*Chi-square test results, $P < .05$.

Effect of model of end-stage liver disease score

Fifty-six patients (70%) with MELD score < 15 and 24 patients (30%) with MELD score > 15 completed the stress protocol. There was no significant difference for not achieving the THR based on MELD score (< 15 , 26/56 vs > 15 , 13/24). Further, a comparable number of patients who did not achieve the THR were on β -blockers (MELD score < 15 , 22/26 vs MELD score > 15 , 11/13). A subanalysis of patients with a MELD score > 15 showed that 8 of 14 patients (57.1%) who were taking β -blockers did not achieve the THR compared with 3 of 10 patients (30%) who were not taking β -blockers ($P < .05$).

Additional testing

In patients with early termination of DSE, 4 underwent coronary angiography, and all were found to have normal coronary arteries. Nine patients undertook dipyridamole-thallium scanning, and all the test results were normal. In the

chronotropically incompetent group, 5 patients underwent right and left heart catheterization, and in 2 of them, significant pulmonary hypertension was noted (pulmonary arterial pressure of 80/30 mm Hg and 72/14 mm Hg). Six patients underwent dipyridamole-thallium scanning, and none showed any evidence of heart disease.

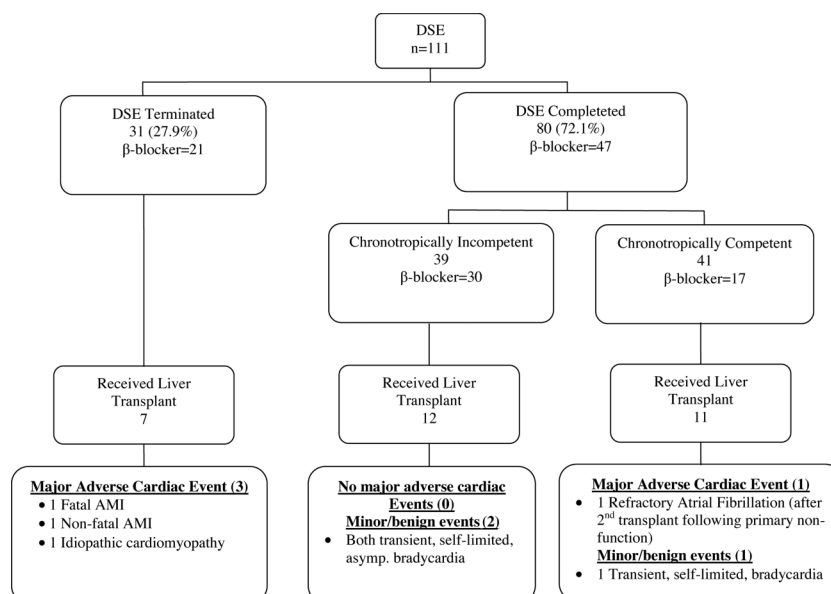
Posttransplant outcomes

During the study, 30 patients underwent an LT including 7 patients with early termination of the DSE, 12 chronotropically incompetent, and 11 chronotropically competent. Overall, 4 major postoperative cardiac events were noted as described below, although 1 was after a retransplant for primary graft nonfunction.

Dobutamine stress echocardiography terminated

Three of the 7 patients in this group experienced cardiac events.

Figure 1. Patient Outcomes



Abbreviations: AMI, acute myocardial infarction; β -blocker, beta-blocker; DSE, dobutamine stress echocardiography

Case No. 103: A 53-year-old nondiabetic hypertensive hyperlipidemic white man experienced atypical chest pain on postoperative day 6. Two-dimensional echocardiography showed global hypokinesia, which was suggestive of idiopathic cardiomyopathy. Pretransplant DSE was terminated in this patient because of hypotension.

Case No. 108: A 56-year-old diabetic, hyperlipidemic African-American woman developed hypotension 2 days after surgery. A 2-dimensional echocardiography showed global hypokinesia, troponin I was raised (1.2 ng/mL). The patient died 6 days after surgery, and an autopsy showed a myocardial infarction and critical stenosis in the left anterior descending and right coronary arteries. Dobutamine stress echocardiography was terminated in this patient because of left ventricular cavity obliteration at maximal dosage of dobutamine, although she was asymptomatic. Eighty-three percent of the THR was achieved by this patient.

Case No. 111: A 47-year-old diabetic and hypertensive white woman had hypotension and chest pain on postoperative day 2. Regional wall motion abnormality with a decrease in ejection fraction to 30% (60% preoperatively) on 2-dimensional echocardiography and raised troponin I (1.4 ng/mL) was demonstrated. However, the patient recovered from this event with β -blocker and nitrates. Dobutamine stress echocardiography was terminated in this case because of palpitations leading to a panic attack. The patient achieved 82% of her THR.

In all 3 of the above cases, additional testing was not done because they achieved > 80% of the predicted THR.

Of the remaining 4 patients who received a transplant and did not have posttransplant cardiac events, in 2 cases, the achieved HR was 60% of their THR. They underwent dipyridamole-thallium scans, the results of which were normal. Two patients had achieved a HR of 70% and 75% of predicted maximum and did not require any additional testing.

Chronotropically incompetent

Among the chronotropically incompetent patients, 2 of 12 (case Nos. 50 and 81) who underwent an LT experienced self-limited, transient, asymptomatic bradycardia on postoperative days 1 and 2. Case No. 81 was taking β -blockers before the transplant, but No. 50 was not. Considering the benign and self-limited nature of these events, we did not consider them in the final analyses.

Among the remaining 10 chronotropically incompetent patients who received a transplant but did not have posttransplant cardiac events, 3 patients had achieved a HR of 50%, 60%, and 64% of maximum. They underwent dipyridamole-thallium scans, and all the results were normal. The remaining 7 had achieved HR of 71% to 80% (mean, 75 ± 3.3), and therefore did not undergo any additional testing.

Chronotropically competent

One of the 11 cases in this group experienced a cardiac event after the LT.

Case No. 28: A 64-year-old white man with diabetes, hypertension, hyperlipidemia, and ischemic heart disease, had primary nonfunction and received a second transplant, and had a complicated postoperative course. On postoperative day 2, after the second transplant, refractory atrial fibrillation with recurrent supraventricular tachycardia presented as hypotension and was treated with antiarrhythmic medications and ablation.

Case No. 39: A 59-year-old white woman with diabetes and hyperlipidemia, experienced self-limiting, transient, asymptomatic bradycardia on postoperative day 2. She was taking β -blockers before the transplant and because the condition was benign and self-limiting, it was not considered a significant cardiac event.

Discussion

Significance of chronotropic incompetence

In our study, chronotropically incompetent patients had significantly lower resting HRs and demonstrated smaller rise in their HRs with dobutamine. These observations were attributed to a systemic hyperdynamic state, resulting from an accumulation of endogenous vasodilators like nitric oxide leading to vascular hyporesponsiveness,¹⁴⁻¹⁶ reduced HR variability because of developing an autonomic neuropathy,^{6,17,18} and using β -blockers.¹⁹

Cirrhotic patients exhibit a blunted response to physiologic and pharmacologic β -receptor stimulation because of a reduction in the number of cell membrane β -receptors and multiple downstream defects in β -receptor signaling pathways.²⁰⁻²² Chronotropic incompetence predicts a poor prognosis and mortality in patients with liver disease.²³

Daly and associates showed that in patients who lack an adequate HR during the early stages of

DSE (eg, an infusion up to 20 $\mu\text{g}/\text{kg}/\text{min}$); the administration of atropine rather than progressively higher amounts of dobutamine might provide a more effective strategy to achieve the THR.²⁴ However, in our study, only 2 of 14 patients (14.2%) who received atropine during the DSE achieved the THR and notably, both were not taking β -blockers. While studies have reported improved DSE sensitivity by increasing the HR response by adding atropine,²⁴ it must be kept in mind that these studies were performed in the non-ESLD cardiac population, excluding patients taking β -blockers, which is in contrast to most of our patients.

Model of end-stage liver disease score and chronotropic incompetence

In our study, 73% of the patients who achieved the THR had MELD score < 15. One may argue that as liver disease progresses, systemic circulation become increasingly hyperdynamic and/or these patients are more likely to be taking β -blockers. However, this was not the case because a comparable number of patients with MELD score < 15 (22/26, 84.6%) and > 15 (11/13, 84.6%) were taking β -blockers, and did not achieve their THR. These findings suggest that the hyperdynamic state is significant, even when the MELD score is low and becomes more pronounced, proportionally, with the severity of the liver disease.

In our study, cardiac symptoms and ECG changes appearing during the DSE may be more important for directing additional testing in the DSE-terminated category, even if high percentages of THRs are achieved.

Interpretation of dobutamine stress echocardiography in preliver transplant cardiac evaluation

With the objective of selecting appropriate patients for further testing, we proposed using lower cutoffs for percentages of predicted maximal heart rate achieved (Table 4), and wanted to focus on cardiac symptoms or significant ECG changes during the DSE. For example, Table 4 shows with 80% of the predicted maximal heart rate being the cutoff, overall, 49 patients (61.3%) were chronotropically competent. Among them, 22 patients (46.8%) were taking β -blockers, and 27 patients (81.8%) were not taking β -blockers. Hypothetically, if progressively decreasing the THRs is accepted, then the proportion of chronotropic competency will increase (at cutoff of

70% predicted maximal heart rate), 81.3% (70.2% were taking β -blockers and 97% were not taking β -blockers) would be chronotropically competent; thus, avoiding the requirement of additionally testing these patients without any cardiac symptoms or ECG changes.²⁰⁻²²

Earlier studies evaluating the DSE as a screening technique for obstructive coronary artery disease in ESLD patients have yielded conflicting results.⁷⁻¹¹ Plotkin and associates concluded that the DSE has sensitivity, specificity, and positive and negative predictive values of 100%⁹; however, Harinstein and associates reported that the DSE has a poor sensitivity as a screening test for obstructive coronary artery disease in LT candidates and recommend alternate or additional methods for adequate cardiac risk stratification.^{2,8}

Limitations

This is a retrospective study based on chart reviews and has a low event rate; therefore, drawing statistical conclusions may be difficult.

Conclusions

Overall, nearly 50% patients with ESLD may not reach the THR and even more if they are taking β -blockers. Early termination of any DSE because of cardiac symptoms or significant changes in an ECG have more effect in predicting postoperative cardiac events and should be further evaluated if close to the THR. Lower THR may be acceptable in chronotropically incompetent, provided they are asymptomatic, have no ECG changes, or cardiovascular risk factors, especially if they are taking β -blockers, although this should be further substantiated in larger, preferably prospective, studies.

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