Cardiac Surgery in Patients with End-Stage Liver Disease

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Background

- Cirrhotic patients with coronary artery disease (CAD) or valvular heart disease are a challenging population;
- Most liver transplant centers require treatment of cardiac disease before consideration for listing;
- Inability to proceed with cardiac surgery can prevent these patients from proceeding to a lifesaving liver transplantation;
- Increase in the elderly, obese , diabetic population in need of transplantation continues to incresse

Heart Surgery and End-Stage Liver Disease

Cardiac Operations in Patients With Cirrhosis

John D. Klemperer, MD, Wilson Ko, MD, Karl H. Krieger, MD, Michelle Connolly, MD, Todd K. Rosengart, MD, Nasser K. Altorki, MD, Samuel Lang, MD, and O. Wayne Isom, MD

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Background. A retrospective review was performed to determine the outcome after cardiac operations in patients with a documented history of noncardiac cirrhosis.

Methods. The charts of patients admitted to the cardiothoracic surgical service between 1990 and 1996 were reviewed, and 13 patients with a preoperative history of cirrhosis were identified. The severity of preoperative liver disease was graded according to the criteria of Child.

Results. Most of the cases of cirrhosis were alcohol-related. Eight patients were classified as having Child class A and 5 as having Child class B cirrhosis. One hundred percent of patients with Child class B and 25% of those with Child class A cirrhosis had major complications. The postoperative chest tube output and transfusion requirements of these patients were approximately three times higher than average. The overall perioperative mortality rate was 31%. In patients with Child class B cirrhosis, the mortality rate was 80%. No patient with Child class A cirrhosis died. Deaths were related to gastrointestinal and septic complications, and not to cardiovascular failure.

Conclusions. These findings suggest that patients with minimal clinical evidence of cirrhosis can tolerate cardiopulmonary bypass and cardiac surgical procedures, whereas those with more advanced liver disease should not be offered operation.

(Ann Thorac Surg 1998;65:85–7)

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Cardiac Surgery and Cirrhosis

13 patients with history of non cardiac cirrhosis (N10 Alcohol related)

Severity of disease graded according to Child Criteria; (N8 – Child A)

Table 1. Preoperative Patient Characteristics

Patient No.	Age (y)	Sex	Cause of Cirrhosis	Child's Class	Bilirubin[a] (mg/dL)	Ejection Fraction	Other Diseases
1	56	M	ETOH	A	2.1	. . .	DM, COPD, PVD
2	63	F	Viral	B	. . .	0.50	CRI
3	59	M	ETOH	B	3.2	0.50	DM
4	61	M	ETOH	A	1.5	0.40	. . .
5	71	M	ETOH	A	0.6	. . .	. . .
6	60	M	ETOH	A	1.6	0.50	. . .
7	68	M	ETOH	A	0.8	0.19	DM
8	79	M	ETOH	A	0.6	0.55	DM
9	64	F	Viral	A	1.0	0.30	. . .
10	76	M	PBC	A	0.4	0.74	DM, CRI, CVA
11	78	M	ETOH	B	2.6	0.20	CHF
12	62	M	ETOH	B	3.1	. . .	DM, COPD, CRI, PVD
13	53	M	ETOH	B	1.8	0.25	CRI, pacemaker

[a] Preoperative total serum bilirubin level (normal range, 0.2–1.3 mg/dL).

CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CRI = chronic renal insufficiency; CVA = cerebrovascular accident; DM = diabetes mellitus; ETOH = alcohol-related; F = female; M = male; PBC = primary biliary cirrhosis; PVD = peripheral vascular disease; viral = viral hepatic/postnecrotic.

(Ann Thorac Surg 1998;65:85–7)

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- 7 out of 13 patients experienced significant postoperative morbidity;
- The 5 patients with Child B cirrhosis had multiple post operative complications and high postoperative ICU and Hospital stays
- The 4 deaths occurred in patients with moderate impairment of liver reserve
- All patients with Child A survived the operation

Cardiac Surgery and Cirrhosis

Table 2. Operations and Postoperative Complications

Patient No.	Type of Operation	Urgency of Operation	Type of Complication	Intensive Care Unit Stay (h)	Hospital Stay (days)	Death
1	CABG	EL	. . .	46	9	No
2	AVR	U	I, P, G, N, RE	640	27	Yes
3	CABG, AVR	U	I, N, R, E	530	27	Yes
4	CABG	EL	. . .	42	11	No
5	CABG	U	. . .	32	10	No
6	AVR	U	. . .	24	7	No
7	CABG	U	I, RE	39	8	No
8	CABG	EL	. . .	46	10	No
9	AVR	EL	. . .	30	7	No
10	AVR	U	N	122	15	No
11	CABG, AVR	U	I, P, G, RE	408	31	No
12	CABG	EM	R, P	336	14	Yes
13	CABG, MVR, TR	U	I, R, P, G, RE	768	56	Yes

AVR = aortic valve replacement; CABG = coronary artery bypass grafting; EL = elective; EM = emergency; G = gastrointestinal; I = infectious; MVR = mitral valve replacement; N = neurologic; P = pulmonary; R = renal; RE = reexploration for mediastinal bleeding; TR = tricuspid valve repair; U = urgent.

Cardiac Surgery and Cirrhosis

Clinical Outcome After Cardiac Operations in Patients With Cirrhosis

Nobuhiko Hayashida, MD, Takahiro Shoujima, MD, Hideki Teshima, MD, Yoshinori Yokokura, MD, Kazuyoshi Takagi, MD, Hiroshi Tomoeda, MD, and Shigeaki Aoyagi, MD

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Cardiac Surgery and Cirrhosis

- 1989 to 2003 - 18 patients with non cardiac cirrhosis who needed cardiac surgery

10 patients with Child A

7 patients with Child B

1 patient with Child C

15 patients underwent surgery using cardiopulmonary bypass

60% with Child A and 100 % of class B and C had major postoperative complications , including infections , respiratory failure , bleeding and gastrointestinal disorder

Cardiac Surgery and Cirrhosis

Ann Thorac Surg
2004;77:500–5

Table 1. Preoperative Patient Characteristics

Patient No.	Age	Sex	Cardiac Disease	Other Diseases	NYHA	Urgency
1	54	F	MSR, ASR	. . .	2	N
2	62	M	ASD, MR	. . .	2	N
3	64	F	IHD, MR	DM	2	N
4	72	F	MS	Post OMC, CRF, PMI, DM	3	N
5	65	F	MS	HCC	2	N
6	45	M	IHD	CRF	3	Y
7	67	M	AS	Post HCC resection, DM	3	N
8	48	M	AR	Gastric cancer, HT	2	N
9	78	F	AS	SSS, hypothyroid	2	N
10	73	M	IHD	PVD, hypothyroid	2	N
11	76	F	DA	Post-MCT and RF for HCC	4	Y
12	73	F	MS	. . .	3	N
13	81	M	IHD	. . .	4	Y
14	44	M	CP	Post-PAPVD repair	3	N
15	49	M	PVL, TR	Post-AVR and MVR	4	N
16	73	M	IHD	PVD, RCC	2	N
17	58	M	IHD	DM	2	N
18	73	M	IHD	. . .	2	N

AR = aortic regurgitation; AS = aortic stenosis; ASD = atrial septal defect; ASR = aortic stenosis and regurgitation; CP = chronic constrictive pericarditis; CRF = chronic renal failure; DA = acute dissecting aneurysm; DM = diabetes mellitus; HCC = hepatocellular carcinoma; HT = hypertension; IHD = ischemic heart disease; MCT = microwave coagulation necrotic therapy; MR = mitral regurgitation; MS = mitral stenosis; MSR = mitral stenosis and regurgitation; NYHA = New York Heart Association functional class; OMC = open mitral commissurotomy; PAPVD = partial anomalous pulmonary venous drainage; PMI = pacemaker implantation; PVD = peripheral vascular disease; RCC = renal cell carcinoma; RF = radio frequency ablation; SSS = sick sinus syndrome.

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Table 2. Preoperative Liver Function

Patient No.	Cause of LC	Varices	Ascites	Encephal	TB (mg/dL)	Alb (g/dL)	PT (%)	A/G	ChE (U/L)	Child-Pugh class
1	Viral	–	–	–	1.8	3.1	71	0.8	95	A
2	Congest	–	–	–	1.9	3.6	71	1.2	99	A
3	Alcohol	–	–	–	0.8	3.8	66	1.3	107	A
4	Viral	+	+	–	1.9	4.0	54	1.1	65	A
5	Viral	+	–	–	1.1	4.0	82	1.1	101	A
6	Viral	+	–	–	1.0	2.1	90	0.6	127	A
7	Viral	–	–	–	0.9	3.9	49	1.1	75	A
8	Viral	–	–	–	0.6	3.9	67	1.2	132	A
9	PBC	+	–	–	0.7	3.5	73	1.0	116	A
10	Alcohol	–	–	–	0.8	4.3	96	1.2	92	A
11	Viral	+	–	–	1.9	2.6	72	0.8	115	B
12	Viral	+	–	–	0.8	3.1	92	0.7	65	B
13	Alcohol	+	–	–	1.9	3.5	63	1.1	58	B
14	Unknown	+	+	–	3.6	4.3	54	1.4	90	B
15	Viral	–	+	–	1.5	2.8	68	0.8	77	C
16	Viral	–	+	–	0.7	3.0	56	0.8	57	B
17	Viral	–	–	–	0.8	3.1	59	0.5	55	B
18	Viral	–	–	–	2.4	2.8	66	0.7	66	B

A/G = albumin to globulin ratio; Alb = albumin; Alcohol = alcohol-related; ChE = cholinesterase; Congest = congestive liver; Encephal = encephalopathy; LC = liver cirrhosis; PBC = primary biliary cirrhosis; PT = prothrombin time; TB = total bilirubin.

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Table 3. Operative Information and Postoperative Complications

Patient No.	Cardiac Operation	CPB Time (min)	ICU Stay (days)	Complications	Death
1	AVR, MVR, TAP	179	4	B	N
2	ASD repair, MAP, TAP	86	3	...	N
3	MVR, CABG	251	5	I	N
4	MVR, TAP	143	3	Asthma, PL	N
5	MVR, TAP	106	24	R, GI	N
6	CABG	175	2	ARF	N
7	AVR	141	3	...	N
8	AVR	125	2	...	N
9	AVR	109	3	...	N
10	CABG	123	4	I	N
11	Ascend Ao Rep	213	28	I, B	Y
12	MVR	150	3	I	N
13	CABG	97	30	ARF, R, I, GI	Y
14	Pericardiectomy	67	2	ARF, PL, HA	N
15	AVR, MVR, TVR	293	100	ARF, R, I, GI, B, HA	Y
16	OPCAB	...	6	...	N
17	OPCAB	...	3	...	N
18	OPCAB	...	2	ARF	N

ARF = renal failure; Ascend Ao Rep = ascending aortic replacement; B = bleeding; CABG = coronary artery bypass grafting; CPB = cardiopulmonary bypass; GI = gastrointestinal disorder; HA = hyperammonemia; I = infection; ICU = intensive cure unit; MAP = mitral annuloplasty; OPCAB = off-pump coronary artery bypass grafting; PL = pleural effusion; R = respiratory failure; TAP = tricuspid annuloplasty; TVR = tricuspid valve replacement. Other abbreviations as listed in Table 1.

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Table 4. Morbidity and Mortality According to Child-Pugh Classification

Classification	Morbidity	Mortality
Patients undergoing CPB		
Child-Pugh class A	40% (4/10)	0% (0/10)
Child-Pugh class B	100% (4/4)	50% (2/4)
Child-Pugh class C	100% (1/1)	100% (1/1)
Patients undergoing OPCAB		
Child-Pugh class B	33% (1/3)	0% (0/3)

CPB = cardiopulmonary bypass; OPCAB = off-pump coronary artery bypass grafting.

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Child Pugh Classification

Encephalopathy

- ○ None (1 point)
- ○ Grade 1: Altered mood/confusion (2 points)
- ○ Grade 2: Inappropriate behavior, impending stupor, somnolence (2 points)
- ○ Grade 3: Markedly confused, stuporous but arousable (3 points)
- ○ Grade 4: Comatose/unresponsive (3 points)

Ascites

- ○ Absent (1 point)
- ○ Slight (2 points)
- ○ Moderate (3 points)

Bilirubin

- ○ <2 mg/dL (1 point)
- ○ 2-3 mg/dL (2 points)
- ○ >3 mg/dL (3 points)

Albumin

- ○ >3.5 g/dL (1 point)
- ○ 2.8-3.5 g/dL (2 points)
- ○ <2.8 g/dL (3 points)

Prothrombin time prolongation

- ○ Less than 4 seconds above control/INR <1.7 (1 point)
- ○ 4-6 seconds above control/INR 1.7-2.3 (2 points)
- ○ More than 6 seconds above control/INR >2.3 (3 points)

5 to 6 points:	Child class A
7 to 9 points:	Child class B
10 to 15 points:	Child class C

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Cardiac Disease and Liver Transplantation

AASLD PRACTICE GUIDELINE

Evaluation for Liver Transplantation in Adults: 2013 Practice Guideline by the American Association for the Study of Liver Diseases and the American Society of Transplantation

Paul Martin,[1] Andrea DiMartini,[2] Sandy Feng,[3] Robert Brown, Jr.,[4] and Michael Fallon[5]

This practice guideline has been approved by the American Association for the Study of Liver Diseases and the American Society of Transplantation and represents the position of both Associations.

disciplinary approach to the evaluation of this complex group of patients who have the comorbidities typical of middle age, recommendations have been developed to assist in their cardiac management.[5] With an increasing number of long-term survivors of LT there has been a

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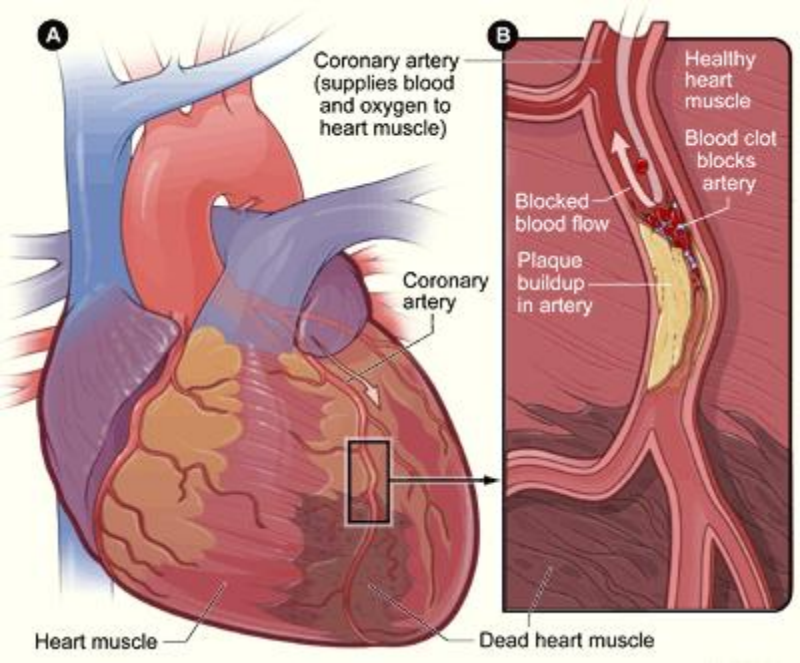
Prevalence of CAD in liver transplant

- Equal or higher than non cirrhotic population

  5-28%



Coronary Artery Disease

CAD is at least as frequent in LT candidates as in general population and is influenced by typical cardiovascular risk factors

Noninvasive Echocardiography is indicated in all adult LT candidates

Patients with advanced liver disease may be unable to achieve target heart rate during standard exercise test

Pharmacological stress tests (adenosine, dipyridamole, dobutamine) can be used

Cardiac catheterization if CAD cannot be excluded (bleeding , renal dysfunction)

LIVER TRANSPLANTATION 16:550-557, 2010

REVIEW

Coronary Artery Disease in Orthotopic Liver Transplantation: Pretransplant Assessment and Management

Javed Ehtisham,[1] Mario Altieri,[2] Ephrem Salamé,[2] Eric Saloux,[1] Isabelle Ollivier,[3] and Martial Hamon[1,4]

[1]Departments of [1]Cardiology, [2]Surgery, [3]Hepato-Gastroenterology, University Hospital of Caen, Normandy, France, and [4]Unit 744, National Institute of Health and Medical Research, Lille, France

TABLE 1. Prevalence of Coronary Artery Disease in Patients Considered for Orthotopic Liver Transplantation

Study	Number of Patients	Prevalence of Coronary Artery Disease*	Definition of Significant Coronary Artery Disease
Carey et al.[8] (1995)	37	28% (15.2-43.1)	>70% stenosis
Morris et al.[9] (1995)	608	5.7% (4.0-7.7)	Criteria not described
Donovan et al.[10] (1996)	165	2.9% (0.7-6.3)	>50% stenosis
Plotkin et al.[11] (1998)	40	7.1% (0.5-17.4)	>70% stenosis
Tiukinhoy-Laing et al.[12] (2006)	161	20.3% (14.4-26.8)	>70% stenosis
Blei et al.[3] (2007)	161	24.5% (18.2-31.4)	>70% stenosis
Fili et al.[13] (2009)	627	3.0% (1.8-4.5)	>50% stenosis

*Midpoint of the adjusted Wald interval with the 95% confidence interval.

Clinical burden of screening asymptomatic patients for coronary artery disease prior to liver transplantation.

Filì D, Vizzini G, Biondo D, Pietrosi G et al

Am J Transplant. 2009 May;9(5):1151-7

- 627 liver transplant candidates over ~ 8 years period.
- 16 patients had a previous diagnosis of CAD or symptoms suggestive (2.5%).
- The remaining 611 underwent further tests according to a predefined protocol, including EKG, echocardiogram and, on the basis of CAD risk factors: stress tests.
- Selective coronary angiography (SCA) was performed in the 30 patients with positive heart stress test: in only 2 did SCA show any CAD, and in both it was subcritical disease requiring neither intervention nor contraindicating LT.

- Prevalence ~3 % of advanced CAD

Liver transplantation outcome in patients with angiographically proven coronary artery disease: a multi-institutional study.
Wray C, Scovotti JC, Tobis J et al
Am J Transplant. 2013 Jan;13(1):184-91

- Retrospective study of 630 patients who underwent coronary angiography prior to transplantation at 7 institutions over a 12-year period.
- Obstructive CAD (defined as > 50% stenosis of 1 or more vessels).
- Obstructive CAD was present in 151 (55 moderate, 96 severe) of 630 patients

Prevalence was 24 %, significant differences between centers

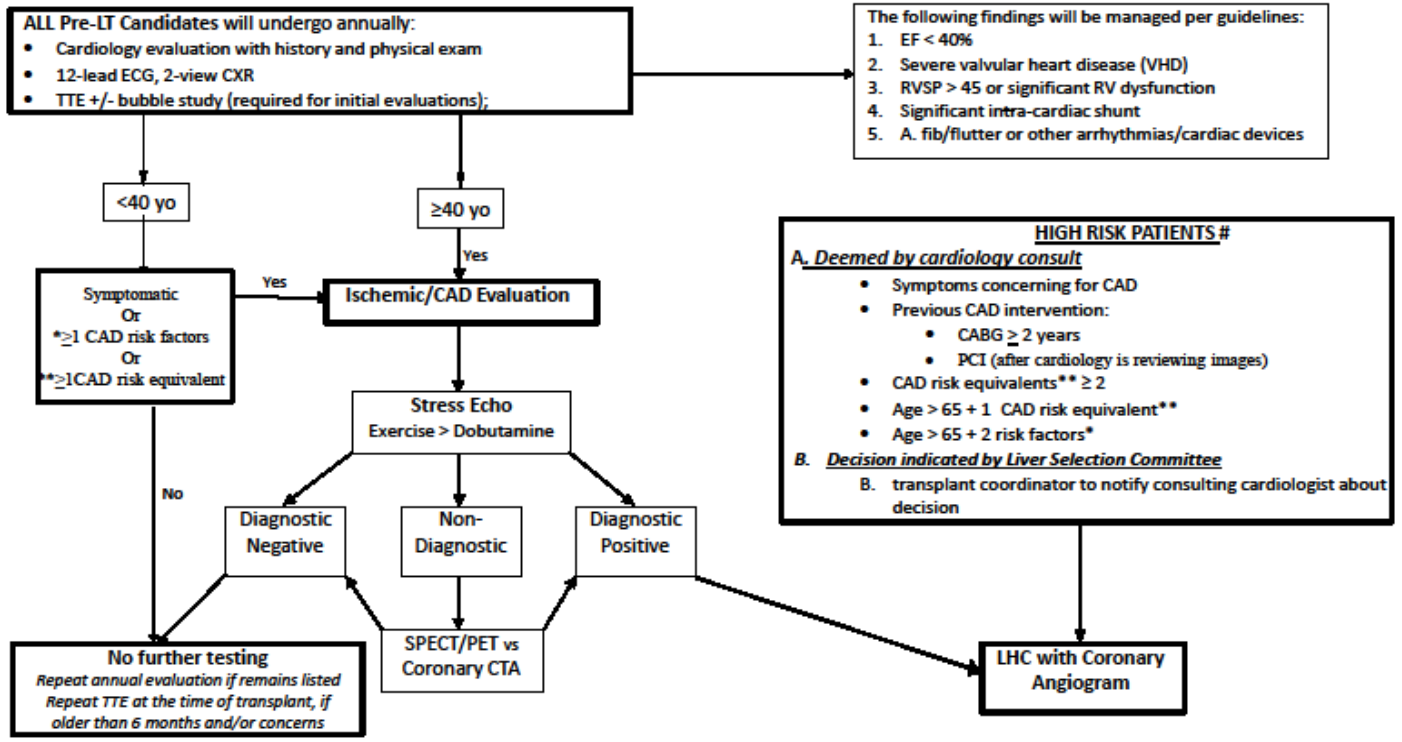
Prevalence of CAD in liver transplant

- 3- 28 % varies and depends on many factors:
  - testing method
  - transplant center
  - patient demographic
- Reasons:
  - candidate age, diabetes, obesity, and NASH contribute to an observed incidence of CAD that exceeds in the US population

Cardiovascular risk assessment of the liver transplant candidate

- In addition to advanced age and the presence of comorbidities, there are specific cardiovascular responses in cirrhosis that can be detrimental to the LT candidate.
  - Patients with cirrhosis demonstrate **increased cardiac output** and a **compromised ventricular response to stress**, a condition termed **cirrhotic cardiomyopathy**.
    - decreased beta-agonist transduction,
    - increased circulating inflammatory mediators with cardio-depressant properties
    - repolarization changes
  - **Low systemic vascular resistance** and **bradycardia** are also commonly seen in cirrhosis and can be aggravated by beta-blocker use
- **Non-obstructive lesions (< 50 % stenosis)** can be responsible for acute coronary syndromes (unstable angina, myocardial infarction, or sudden cardiac death) often as a result from rupture of coronary plaques.

Pre-Operative Cardiovascular Evaluation of Liver Transplant (LT) Patients



*CAD risk factors: HTN, HLD, tobacco, NASH, Significant coronary calcification reported on CT scan or known CCS > 400

**CAD risk equivalents: DM, PVD, AAA, CVA, ESRD (on dialysis)

Functional capacity to be taken into account

CV Contraindications for LT

- EF < 40% or significant RV dysfunction
- Severe VHD
- Unrevascularized high risk CAD
- Severe pulmonary arterial HTN (WHO Group 1)

Initiate management per ACC/AHA Guidelines & re-evaluate

CAD and Liver transplantation

If significant coronary stenosis unsuitable to stenting (> 70% stenosis) is detected revascularization may be attempted prior to LT (low meld scores – child A)

Cardiac surgery carries a signicant risk especially in decompnsated cirrhosis

Coronary Stenting

- Is increasingly performed prior to LT;
- Bare metal stents are preferred in order to avoid dual antiplatelet therapy;
- Recent outcomes have demonstrated superior outcomes in patients who have undergone single stenting with single vessels disease compared to outcomes for patients with prior CABG for multivessel disease; (con – anticoagulation)
- High Meld patients (>30) may not have the luxury to wait due to increase mortality and risk for bleeding

Combined Cardiac Surgery and LT

CASE REPORTS

Combined Cardiac Surgery and Liver Transplantation

Devin E. Eckhoff,[*] Luc Frenette,[†] Marty T. Sellers,[*] Brendan M. McGuire,[‡] Juan L. Contreras,[*] John S. Bynon,[*] and David C. McGiffin[§]

During evaluation for liver transplantation, a 63-year-old man with cirrhosis secondary to hepatitis C was diagnosed with severe aortic stenosis (aortic valve area, 0.87 cm^2) and coronary artery disease. A combined procedure involving aortic valve replacement (pericardial xenograft), coronary artery bypass surgery, and orthotopic liver transplantation was performed. Convalescence was uneventful, and at 2 years after the procedure, the patient has normal cardiac function, good prosthetic valve function, and biochemically normal liver function. (*Liver Transpl 2001;7: 60-61.*)

tion greater than 0.55, aortic valve velocity of 4.35 m/s (peak instantaneous gradient, 76 mm Hg), aortic valve area of 0.87 cm^2, and minimal left ventricular hypertrophy. Left heart catheterization showed obstructive disease in the proximal left anterior descending coronary artery and an aortic valve area of 0.92 cm^2 (peak-to-peak gradient, 62 mm Hg). Pulmonary artery pressures measured 40/14 mm Hg, with a mean of 22 mm Hg and cardiac index of 2.87 L/min/m^2).

The cardiac and liver transplant teams' assessment was that the severity of cardiac disease precluded liver transplantation before aortic valve replacement, and the severity of liver

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Cardiac Surgery and LT

Original Paper

Perfusion

Concomitant cardiac surgery and liver transplantation: an alternative approach in patients with end stage liver failure?

Sanjay Chaubey,[1] Azhar Hussain,[2] Saad Badar Zakai,[3] Salman Butt,[2] Prakash Punjabi[1] and Jatin Desai[2]

Perfusion
1–8

DOI: 10.1177/0267659120966549
journals.sagepub.com/home/prf
SAGE

Perfusion - 2020

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Cardiac surgery only

Table 2. Demographic data, post-operative morbidity and mortality in patients with ESLD undergoing isolated cardiac surgery.

Age	Year of operation	Sex	Comorbidity	Cardiac pathology	Cardiac operation	Logistic EuroSCORE (%)	Cause ESLD	MELD score	Child Pugh score (grade)	Post-operative complications	Current status	Cause of death
60	2008	M	NYHA3; smoker; hypertension; poor LV	SBE	AVR/MVR	19.4	Alcoholic cirrhosis	17	9 (B)	Arrhythmias; renal dysfunction; septicemia	Dead (in hospital)	MOF
83	2009	M	CCS4; NYHA4; smoker; hypertension; poor LV; diabetic	CAD	CABG	27.5	Hepatitis B	9	5 (A)	Pleural effusion; chest infection; AF; renal impairment; delirium	Alive	NA
64	2010	F	NYHA4; renal dysfunction; jaundice; ascites	SBE	AVR	14.6	Primary biliary cirrhosis	27	11 (C)	Chest infection; VRE bacteremia; clostridium difficile diarrhoea; sacral sore, pulmonary odeama; pleural effusion; PV bleeding; VT; AF; dialysis	Dead (in hospital)	MOF
57	2012	F	CCS2; NYHA2; ex-smoker; hypertension; ascites	AS	AVR	3.37	Cryptogenic cirrhosis	15	9 (B)	Pleural effusion; AF; renal impairment	Alive	NA
65	2015	F	CCS1; NYHA3; smoker; hypertension	AS	AVR	4.9	Alcoholic cirrhosis	7	5 (A)	Bleeding; resternotomy for tamponade; AF; pulmonary odema	Dead (in hospital)	liver failure
57	2015	M	CCS2; smoker; asthma; diabetic; hypertension	Atrial myxoma	Excision of atrial myxoma	5.12	Hepatocellular carcinoma	8	6 (A)	Chest infection; bleeding; hemiplegia, AF	Dead (in hospital)	MOF
50	2017	M	CCS4; NYHA4; smoker; hypertension; poor LV; jaundice; ascites	CAD	CABG	7.12	Hepatitis C	13	8 (B)	Bleeding; resternotomy; renal impairment	Dead (in hospital)	MOF

AF: atrial fibrillation; ARF: acute renal failure; AS: Aortic Stenosis; AVR: Aortic Valve Replacement; CABG: Coronary Artery Bypass Grafting; CAD: Coronary Artery Disease; CCS: Canadian Cardiovascular Society score; CMV: cytomegalovirus; LV: left ventricle; MOF: Multi-organ failure; MVR: Mitral Valve Replacement; NYHA: New York Heart Association classification; PV: per vaginal; SBE: Subacute Bacterial Endocarditis; TV Reg: Tricuspid Valve Regurgitation; VT: ventricular tachycardia.

Concomitant surgery and LT

Table I. Demographic data, post-operative mortality and morbidity in patients undergoing concomitant OLT and cardiac surgery.

Age	Year of operation	Sex	Comorbidity	Cardiac pathology	Cardiac operation	Logistic Euro SCORE (%)	Cause ESLD	MELD score	Child Pugh score (grade)	Post operative complications	Total FU	Current status	Cause of death
21	2004	F	NYHA2; renal dysfunction; poor LV; jaundice; encephalopathy; ascites	TV Reg	TV repair	41.2	Ischemic	22	10 (C)	Brain injury; chest infection; AF; ARF; septicemia	3 months	Dead (in hospital)	Anoxic brain injury post CPR in theater
55	2006	F	CCS2;reral dysfunction; smoker; mod LV; jaundice; ascites	CAD	CABG	20.1	Primary biliary cirrhosis	11	9 (B)	Chest infection; pleural effusion; AF; ARF; laparoscopic abdominal washout; CMV viremia	1 year 11 months	Dead	Liver failure
60	2009	M	NYHA3; smoker; hypertension; ascites	AS	AVR	11.3	Alcoholic cirrhosis	21	12 (C)	Respiratory failure; ARF; pericardial drainage; septicemia	20 days	Dead (in hospital)	Fungal infection of the aorta resulting in tamponade
64	2010	F	Jaundice	AS	AVR	6.8	Cryptogenic cirrhosis	17	9 (B)	None	8 years 4 months	Alive	NA
50	2012	M	NYHA2; Diabetic; hypertension; Moderate LV	AS	AVR	6.8	Hepatitis B & C	10	8 (B)	None	6 years 6 months	Alive	NA
73	2012	M	Pulmonary fibrosis; renal dysfunction; smoker; jaundice; ascites; encephalopathy	SBE	AVR	36.8	Cryptogenic cirrhosis	12	11 (C)	Pulmonary effusion; tachycardia; worsening renal impairment;	6 years 5 months	Alive	NA
61	2015	M	Hypertension; jaundice; ascites; encephalopathy; obese	AS	AVR	7.7	Alcoholic cirrhosis	7	9 (B)	Pulmonary effusion; renal impairment; septicemia	3 years 11 months	Alive	NA
54	2018	M	NYHA2; diabetic; jaundice; ascites	AS	AVR	6.8	Hepatitis C	16	11 (C)	Sternal osteomyelitis; sternal rewiring; pulmonary oedema; pleural effusion; ARF; duodenal ulcer; septicemia	3 months	Alive	NA

AF: atrial fibrillation; ARF: acute renal failure; AS: Aortic Stenosis; AVR: Aortic Valve Replacement; CABG: Coronary Artery Bypass Grafting; CAD: Coronary Artery Disease; CCS: Canadian Cardiovascular Society score; CMV: cytomegalovirus; LV: left ventricle; MVR: Mitral Valve Replacement; NYHA: New York Heart Association classification; SBE: Subacute Bacterial Endocarditis; TV Reg: Tricuspid Valve Regurgitation.

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ADULT CARDIAC

Safety and Outcomes of Combined Liver Transplantation and Cardiac Surgery in Cirrhosis

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Background. Decompensation of liver function after cardiac surgery in patients with cirrhosis has resulted in high morbidity and mortality. A treatment strategy, for which there is a scarcity of data in the literature, encompasses combined liver transplantation and cardiac surgery.

Methods. We performed a retrospective analysis of prospectively collected data on 15 patients who underwent combined liver transplantation and cardiac surgery between 2005 to 2017 at our institution.

Results. Between 2005 and 2017, 15 patients with cirrhosis and coronary artery disease or valve disease were identified who underwent combined liver transplantation and cardiac surgery. The cardiac disease was considered severe enough to preclude liver transplantation alone. Likewise, the advanced cirrhosis precluded cardiac surgery alone. Eighty percent of the patients were male and average age was 60 years. Six patients had coronary artery disease, 2 patients had severe aortic stenosis and coronary artery disease, 1 patient had severe mitral regurgitation and coronary artery disease, 2 patients had severe aortic stenosis, 1 patient had mitral valve prolapse, and 3 patients had severe aortic insufficiency. The mean model for end-stage liver disease score was 24. Four subjects were Child-Pugh class B, and 11 were class C. One-year survival was 73.3%.

Conclusions. Combined liver transplant and cardiac surgery is feasible in this selected, otherwise inoperable, patient population with an acceptable early and midterm survival when performed in high volume centers with a cohesive multidisciplinary team.

(Ann Thorac Surg 2021;111:62-8)

Pathway

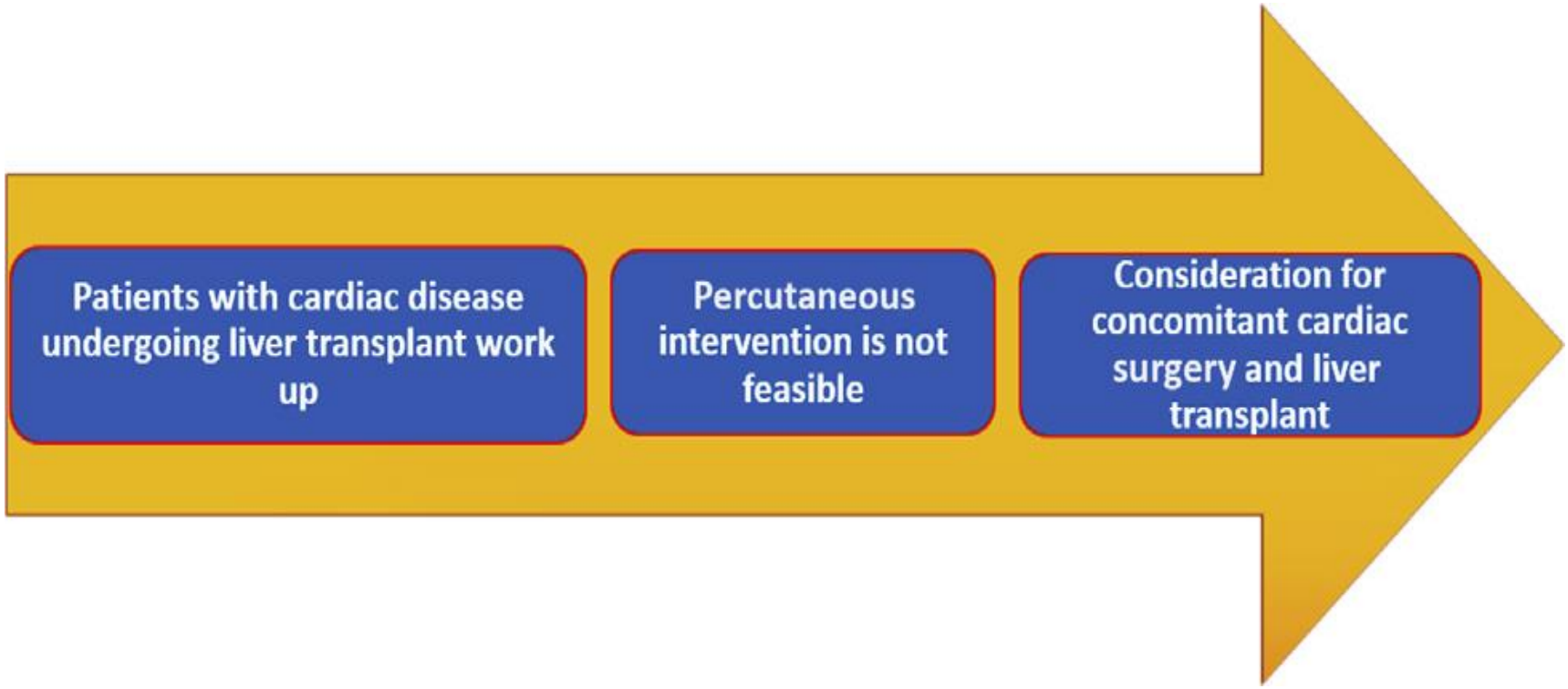

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Table 1. Patient Characteristics

Pt. No.	Age (y)	Sex	Etiology of Liver Cirrhosis	Cardiac Diagnosis	Chem. MELD Score	Chem. MELD-Na Score	Child-Pugh Class
1	64	M	NASH	CAD	20	25	C
2	65	F	Hepatitis C	AI	20	20	B
3	72	M	NASH	CAD	27	27	C
4	69	M	Hepatitis C	AS	20	20	C
5	66	M	Cryptogenic	AS, CAD	22	22	B
6	63	M	NASH	AS, CAD	25	27	C
7	41	M	Alcohol	AI	22	24	C
8	50	M	HH	CAD	18	18	C
9	55	M	Hepatitis C	CAD, MR	22	22	B
10	66	M	Alcohol	CAD	37	37	C
11	61	F	Hepatitis C	CAD	22	22	C
12	58	F	NASH	CAD	25	25	C
13	59	M	NASH	HOCM, AI, MVP	27	27	B
14	51	M	Alcohol	AI	27	27	C
15	62	M	Hepatitis C	AS	22	22	C

AI, aortic insufficiency; AS, aortic stenosis; CAD, coronary artery disease; Chem, chemical; F, female; HH, hereditary hemochromatosis; HOCM, hypertrophic cardiomyopathy; M, male; MR, mitral regurgitation; MVP, mitral valve prolapse; Na, sodium; NASH, nonalcoholic steatohepatitis.

Table 2. Cardiac Assessment

Pt. No.	EF(%)	Operation Performed	No. of Grafts
1	62	LT+CABGx2	2
2	55	LT+AVR	NA
3	61	LT+CABGx3	1
4	65	LT+AVR	NA
5	60	LT+AVR+CABGx1	2
6	65	LT+AVR+CABGx1	1
7	55	LT+AVR	NA
8	55	LT+CABGx2	1
9	55	LT+CABGx2+MVr	2
10	67	LT+CABGx1	3
11	60	LT+CABGx1	1
12	69	LT+CABGx2	2
13	67	LT+AVR+MVR+SM	NA
14	60	LT+AVR	NA
15	65	LT+AVR	NA

AVR, aortic valve replacement; CABG, coronary artery bypass graft surgery; LT, liver transplantation; MVr, mitral valve repair; MVR, mitral valve replacement; NA, not applicable; No., number; Pt, patient; SM, septal myectomy.

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Table 3. Postoperative Complications During Hospitalization

Child-Pugh Class	Stroke	RF Requiring CRRT	Sepsis	Hemorrhage Requiring Operative Reexploration	Postoperative PEA Arrest	ISB Requiring Resection	HRF Requiring Reintubation
B	0 (0)	1 (6.7)	0 (0)	0 (0)	0 (0)	0 (0)	1 (6.7)
C	1 (6.7)	3 (20)	2 (13.3)	2 (13.3)	1 (6.7)	1 (6.7)	3 (20)
Total	1 (6.7)	4 (26.7)	2 (13.3)	2 (13.3)	1 (6.7)	1 (6.7)	4 (26.7)

Values are n (%). Some patients had more than one complication.

CRRT, continuous renal replacement therapy; HRF, hypoxic respiratory failure; ISB, ischemic small bowel; PEA, pulseless electrical activity; RF, renal failure.

Table 4. Postoperative Course

Pt. No.	Days on Ventilator	Days ICU Stay	Days Hospital Stay	Outcome
1	2	5	19	Alive
2	4	6	18	Alive
3	3	15	40	Dead[a]
4	3	7	15	Alive
5	1	3	19	Alive
6	11	11	11	Dead[b]
7	1	3	12	Alive
8	4	8	11	Alive
9	3	6	15	Alive
10	1	17	38	Alive
11	1	5	12	Alive
12	2	4	35	Dead[c]
13	3	6	26	Alive
14	67	72	84	Dead[d]
15	7	21	30	Alive

[a]Septic shock; [b]Hemorrhagic stroke; [c]Ischemic stroke, pneumonia; [d]Myocardial infarction.

ICU, intensive care unit; Pt. No., patient number.

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Cardiac Surgery and LT

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CASE REPORT

JOURNAL OF CARDIAC SURGERY WILEY

Combined off-pump coronary bypass grafting without heparin and liver transplantation: A novel approach to a complex dilemma

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Abstract

Cardiac disease is a leading cause of early mortality for patients undergoing liver transplantation (LT), and severe coronary artery disease (CAD) is usually considered a contraindication for LT in patients with cirrhosis. Incidence of CAD in LT candidates has increased in recent years. While stable patients might be candidates for percutaneous interventions, patients with decompensated liver failure, or critical coronary lesions present a therapeutic challenge, and are often not considered candidates for LT. We present the case of a 60 year old male patient with decompensated liver failure, and critical CAD, who received successful combined off-pump coronary bypass grafting without heparin and LT using ex vivo normothermic liver perfusion machine. This approach represents a novel strategy to offer LT to this very selective group of patients.

KEYWORDS
coronary artery disease, liver transplant, OPCABG

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Normothermic Liver Perfusion and CABG

FIGURE 1 Intraoperative image of median sternotomy extended with right subcostal incision. Note the two coronary bypass grafts (blue circle), including LIMA-LAD (*) and SVG-Ramus (**), and the transplanted liver (arrow). LAD, left anterior descending; LIMA, left internal mammary artery; SVG, saphenous vein grafts

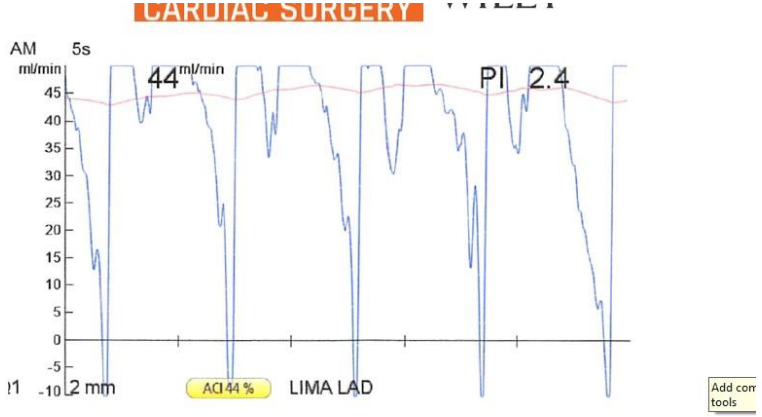

FIGURE 2 Intraoperative measurements of LIMA-LAD coronary bypass graft flows with Doppler ultrasound. LAD, left anterior descending; LIMA, left internal mammary artery

Patient remained with chest open and gently packed to facilitate exposure with extension of median sternotomy with a supraumbilical midline incision with extension to the right. The liver graft remained in the normothermic preservation machine for 10 hours. The donor liver was removed from the perfusion machine after the recipient hepatectomy was concluded, and flushed with preservation solution immediately before the implantation. The liver transplant was performed using the standard piggy-back technique, with anastomosis of the vena cava of the graft with the common ostium of the three hepatic veins, usual portal vein and hepatic artery anastomosis,

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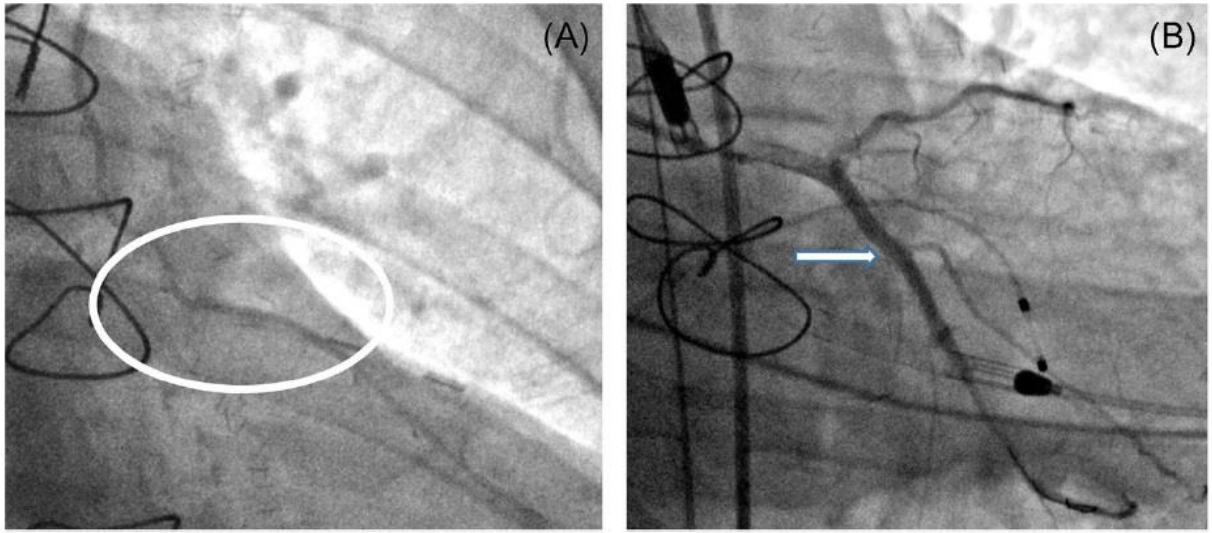
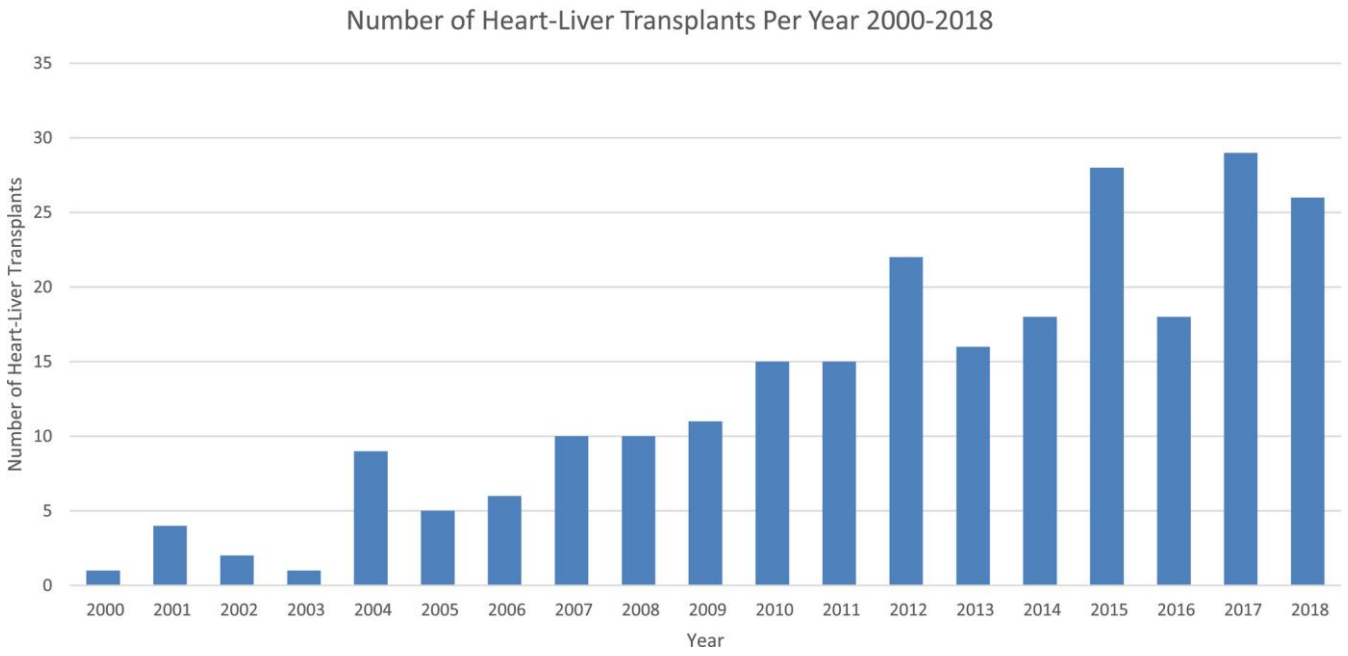


FIGURE 3 Coronary angiogram 3 month after index operation showing patency of LIMA-LAD bypass graft (white circle), and PCI with stent to left circumflex artery (white arrow). LAD, left anterior descending; LIMA, left internal mammary artery; PCI, percutaneous coronary interventions

Combined Heart and Liver Transplant:



Clinical Liver Disease, Volume: 13, Issue: 6, Pages: 170-175, First published: 02 July 2019, DOI: (10.1002/cld.812)

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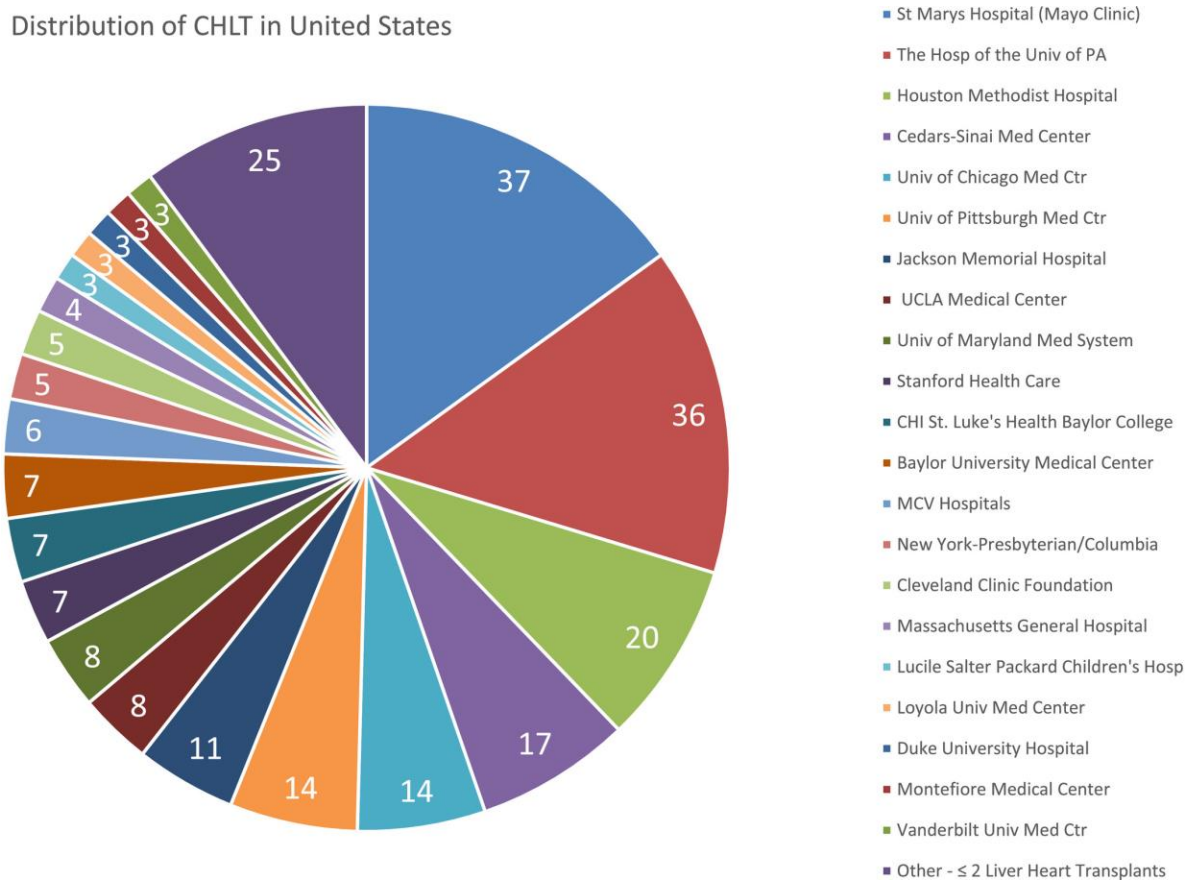

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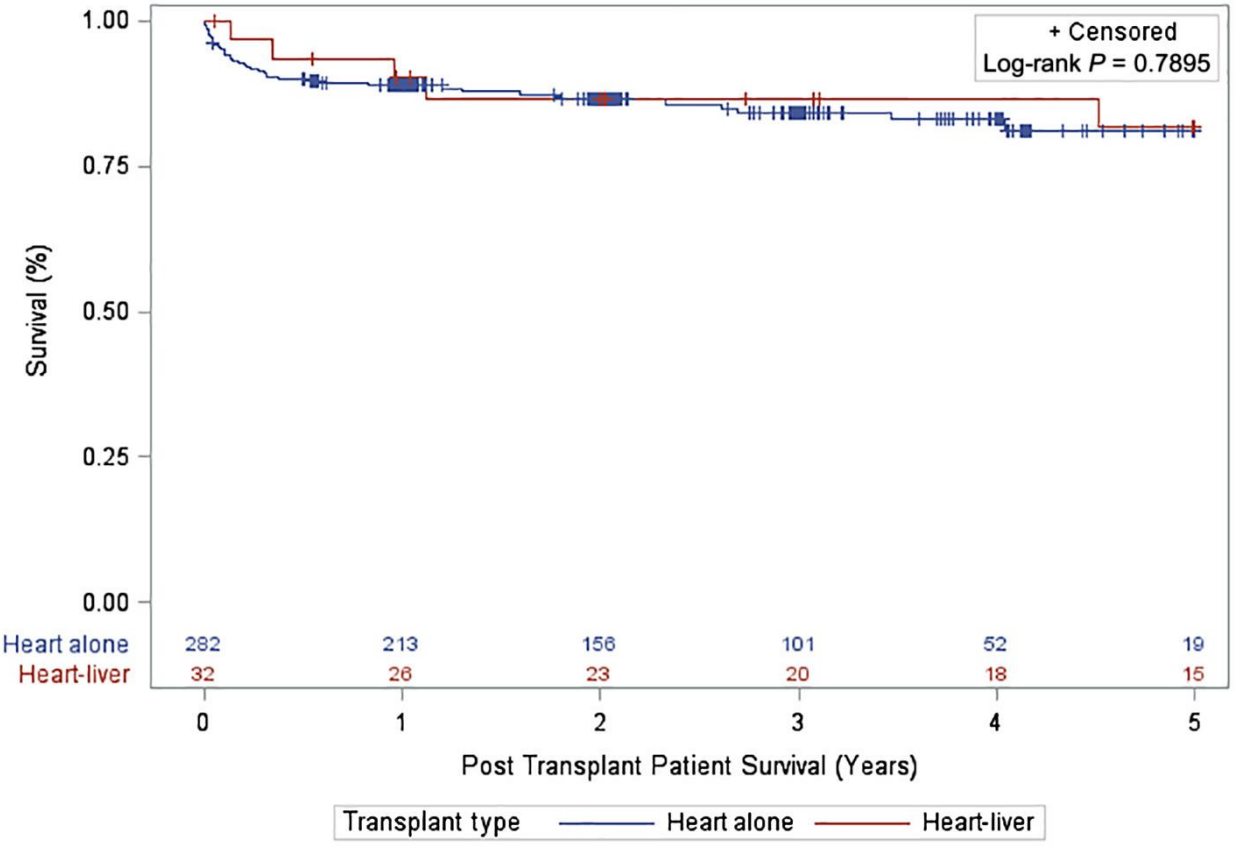

Clinical Liver Disease, Volume: 13, Issue: 6, Pages: 170-175, First published: 02 July 2019, DOI: (10.1002/cld.812)

SURGICAL TECHNIQUE

En-Bloc Simultaneous Heart–Liver Transplantation in Adult Patients

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TABLE 1. Preoperative Recipient Characteristics

Recipient Characteristics	Patient # 1	Patient # 2	Patient # 3	Patient # 4	Patient # 5
Age, y	63	46	26	51	30
Sex	Male	Male	Female	Male	Female
Race	White	Hispanic	AfroAmerican	White	AfroAmerican
Recipient ABO	A+	O+	AB+	0+	A+
BMI	21	28	21	25	32
Ideal body weight (%)	89	108	98	110	140
Pre-albumin, mg/dL	9	3	6	11	10
Etiology of cardiac disease	ATTR amyloidosis (hereditary-Thr60A1a)	NICM * liver/heart pathology: Hemochroma-tosis (Negative genes H63D, C282Y)	Postpartum	Idiopathic NICM	Postpartum
NYHA class	IV	IV	IV	III	IV
LVEF (%)	30	10–15	5	10–15	10–15
Preoperative inotropes	Milrinone	Norepinephrine	Milrinone Dobutamine	Milrinone Dobutamine	Dobutamine
MCS	No	IABP	No	No	No
Etiology of liver disease	Amyloidosis/cardiac cirrhosis	NASH*	Cardiac cirrhosis	Cryptogenic cirrhosis	Cardiac cirrhosis
Na MELD	8	28	21	18	13
INR	1.13	3.24	1.27	1.1	1.37
Creatinine, mg/dL	0.66	0.46	0.56	0.66	0.87
Warfarin	No	No	No	Yes	Yes
Pacemaker/ICD	Life vest	No	ICD	ICD	ICD
Pretransplant hospitalization, days	52	89	61	51	0

BMI, body mass index; ICD, Implantable cardioverter defibrillator; INR, International normalized ratio; MCS, mechanical circulatory support; NICM, non-ischemic cardiomyopathy.
*nonalcoholic steatohepatitis,

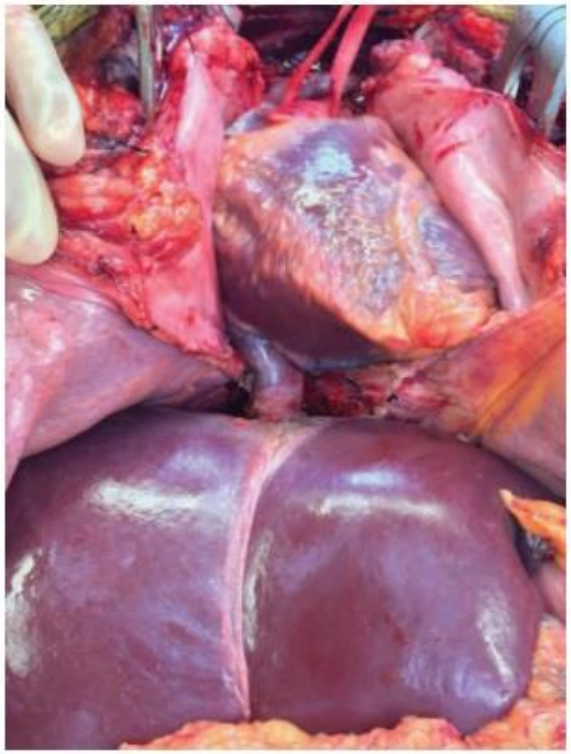

FIGURE 1. Final aspect of transplanted "en-bloc" heart and liver. Note continuity of IVC, and ligated diaphragmatic veins. Reconstruction of the diaphragm is performed with nonabsorbable suture, leaving space of 2 finger width around IVC to prevent any compression.

Case Presentation

- 63 year old Hispanic Male under evaluation for OLT
- Past Medical History:
  - Liver Failure secondary to ETOH (last drink in 2019) and/or NASH diagnosed two years ago – complicated by esophageal variceal bleeding – s/p banding, hepatic encephalopathy (taking Rfaximin and Lactulose), recurrent ascites (requiring large volume paracentesis yet no SBP), anasarca, anemia, atered mental status, and fatigue
  - DMII
  - Hyperlipidemia
  - Hypertension
  - Obesity (83 kilos)
  - Chronic Kidney Disease (baseline creatinine between 1.5-2.0)
  - Colonic Tubular Adenomas (CLS: 9/11/20)

- Past Surgical History: None
- Social History:
  - Family Medicine Practitioner in NaSples
  - Last ETOH drink in 2019 prior to that had 3 glasses of wine per day for greater than 10 years; never smoked and no drug use
- MELD Score: 35

Case Presentation

- Meds from Home prior to Transplant:

Aquaphor topical ointment, See Instructions, 6 refills
Crestor 10 mg oral tablet, 10 mg= 1 tab, ORAL, BEDTIME, 6 refills
furosemide 40 mg oral tablet, 40 mg= 1 tab, ORAL, BID, 6 refills
lactulose 10 g/15 mL oral syrup, 30 g= 45 mL, ORAL, BID, 6 refills, **Still taking, not as prescribed**: pt stated that he takes TID
metFORMIN 500 mg oral tablet, 500 mg= 1 tab, ORAL, BID, 6 refills
midodrine 5 mg oral tablet, 5 mg= 1 tab, ORAL, TID, 6 refills, **Still taking, not as prescribed**: pt stated that he takes BID
pantoprazole 40 mg oral enteric coated tablet, 40 mg= 1 tab, ORAL, DAILY, 6 refills
rifaXIMin 550 mg oral tablet, 550 mg= 1 tab, ORAL, BID, 6 refills
triamcinolone topical 0.1% cream, 1 app, TOPICAL, BID, 6 refills

Case Presentation – Cardiac Work Up

- 9/4/2020 Stress Echo:
  - EF=60-65%
  - No valvular abnormality
  - Patient unable to walk and achieved 83% of the patient's maximum predicted heart rate with normal BP response.
  - NSVT noted during test with abnormal stress echo report
- 9/8/2020 Cardiac Cath:
  - RCA 100% Ostial Lesion
  - LAD 50-60% Proximal Lesion and 90% Lesi9on after Diagonal 1
  - Diagonal 1 has 20% Ostial and 90% mid diease
  - Type 2 Pulmonary HTN
  - Increased Cardiac Output/Cardiac Index with low SVR consistent with cirrhosis

Case Presentation

- Dilemma: Stent Possibility versus Bleeding Risk
- Decision: 1 week trial of DAPT therapy – no signs of bleeding proceed with left heart cath and PCI
- Outcome: Patient bled with trial therapy

Case Presentation

- What possibilities exist at this time?
  - Not a candidate for liver transplant since unable to proceed with PCI and CABG is too risky pre transplant
  - Attempt to stent knowing bleeding risks anyways versus clotting
  - Plan on CABG simultaneous to liver transplant

- What would be your decision?

Case Presentation

- CABG x 2 – vein graft to LAD and vein graft to OM2 – total cardiopulmonary bypass time was 64 min and 53 min clamp time
- Liver Transplant was 3 hours and 9 min
- Chest remained open while liver transplant going in
- S/P transplant and CABG – developed wound infection to left lower extremity with culture positive for Klebsiella ESBL requiring debridement and wound vac placement.
- Working allograft noted and improved renal function upon discharge – after 45 days and continues to do well without any further complication

Conclusion

Cardiac surgery can be attempted in patients with Child A in selected patients

Cardiac surgery in cirrhotic patients remains a challenge in patients with advanced disease (Child B and C)

Cardiac surgery can be performed concomitantly with good results in patients undergoing liver transplantation

Severity of disease can have an impact on survival rates and complications with high meld score patients having worse outcomes

Simultaneous Heart/ liver transplant is performed by very few centers in the US . En bloc technique seems to reduce operative times with initial excellent outcomes

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Thank you

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