

SUPPLEMENTAL MATERIAL

Supplemental Table I. INTERMACS Variables Included for Feature Selection

COMORBIDITIES		
CC_ALLOSENSITIZATION_M	CC_HIST_DRUG_USE_M	CC_OTH_CEREBROVASC_DISEASE_M
CC_CHRONIC_COAGULOPATHY	CC_HIST_HIV	CC_OTH_MAJOR_PSYCH_DIAG_M
CC_CHRONIC_INF_CONCERNS_M	CC_HIST_LYMPHOMA_LEUKEMIA_M	CC_PERIPH_VASC_DISEASE_M
CC_CHRONIC_RENAL_DISEASE_M	CC_HIST_SMOKING_M	CC_PULMONARY_DISEASE_M
CC_CONTRAIN_TO_IMMSUPPRES_M	CC_HIST_SOLID_ORGAN_CNCR_M	CC_PULMONARY_HYPERTENSION_M
CC_CURR_SMOKING_M	CC_LARGE_BMI_M	CC_PX_DOES_NOT_WANT_TX_M
CC_FRAILITY_M	CC_LIMITED_SOCIAL_SUPPORT_M	CC_RCNT_PULM_EMBOLUS_M
CC_FREQUENT_ICD_SHOCKS	CC_LIVER_DYSFUNCTION_M	CC_RPTD_NON_COMPLIANCE_M
CC_HEP_INDUCED_THROMBO_M	CC_LTD_COG_UNDERSTND_M	CC_SEVERE_DEPRESSION_M
CC_HISTORY_GI_ULCERS	CC_MAJOR_STROKE_M	CC_SEVERE_DIABETES_M
CC_HISTORY_HEPATITIS_M	CC_MALNUTRITION_CACHEXIA_M	CC_THORACIC_AORTIC_DIS_M
CC_HIST_ALCOHOL_ABUSE_M	CC_MUSCSKELETAL_LIMIT_M	CC_UNFAV_MEDIASTINAL_ANAT_M
CC_HIST_ATRIAL_ARRHYTHMIA	CC_NARCOTIC_DEPENDENCE	
CC_HIST_BONE_MARROW_TX	CC_OTHER_CO_MORBIDITY_M	
CLINICAL RISK FACTORS		
AGE_DEIDENT	BLOOD_TYPE	INTERVENTION_48_HRS_IABP
GENDER	PRIMARY_DGN	INTERVENTION_48_HRS_ECMO
ETHNICITY	TIME_CARD_DGN	INTERVENTION_48_HRS_VENTILAT
RACE_AF_AMER	PX_PROFILE_INTERMACS	INTERVENTION_48_HRS_ULTRAFILT
RACE_ASIAN	MODIFIER_A	INTERVENTION_48_HRS_DIALYSIS
RACE_AM_IND	CURRENT_ICD	PREV_CARDIAC_OPER_NONE
RACE_PAC_ISLAND	HR_RATE	CONCOM_SURG_AORTIC
RACE_WHITE	SYS_BP	CONCOM_SURG_MITRAL
BSA	DIA_BP	CONCOM_SURG_TRICUSPID
BMI	IV_INO_THERAPY	
MEDICAL THERAPY		
MED_PRE_IMP_AMIODARONE	MED_PRE_IMP_BETA_BLOCKERS	MED_PRE_IMP_WARFARIN
MED_PRE_IMP_ACE_INHIBITORS	MED_PRE_IMP_ALDOSTERONE	MED_PRE_IMP_ANTEPLATELET
MED_PRE_IMP_ANGIOSTENSIN	MED_PRE_IMP_LOOP_DIURETICS	MED_PRE_IMP_INOTROPE_INFUSION
LABORATORY & EKG & ECHO		
BUN_MG_DL	WBC_X10_3_UL	EKG_RHYTHM
CREAT_MG_DL	HEMOGLOBIN_G_DL	LVEF (pre-implant)
BILI_TOTAL_MG_DL	PLATELET_X10_3_UL	LVEDD (pre-implant)
SODIUM_MEQ_L	SGOT_AST	LVEF (post-implant)
POTASSIUM_MEQ_L	SGPT_ALT	LVEDD (post-implant)
ALBUMIN_G_L	INR	
LVAD VARIABLES		
DEVICE_TY	DEVICE_STRATEGY	LV_CENTRIFUGAL

Supplemental Table II. Training Dataset Model Performance (AUC) with or without Feature Selection

Classifier	With Feature Selection	Without Feature Selection
Bayesian LR	0.842	0.815
Linear SVM	0.834	0.773
GBDT	0.829	0.817
NN	0.833	0.803
RF	0.820	0.815

Bayesian LR, Bayesian logistic regression; SVM, support vector machine; GBDT, gradient-boosted decision trees; NN, neural networks; RF, random forest.

Supplemental Table III. Training Dataset Model Performance (AUC) Using Various Class Balancing Methods

Classifier	Raw	Class-weighting	Down-sampling	Smote
Bayesian LR	0.842	0.833	0.817	0.832
Linear SVM	0.710	0.710	0.710	0.834
GBDT	0.808	0.821	0.814	0.829
NN	0.829	0.833	0.819	0.830
RF	0.785	0.785	0.820	0.816

Bayesian LR, Bayesian logistic regression; SVM, support vector machine; GBDT, gradient-boosted decision trees; NN, neural networks; RF, random forest.

Supplemental Table IV. Calculation of regression-based I-CARS and simplified Topkara Recovery Score (I-TOPS) from INTERMACS Registry

I-CARS Recovery Score

<u>Variables</u>	<u>Score:</u>
Age < 50 years	1
Non- Ischemic HF	3
Time from cardiac diagnosis <2 yrs	1
Implanted ICD	2
Creatinine < 1.2 mg/dL	1
<u>LVEDD < 6.5 cm</u>	<u>1</u>
Total Maximum I-CARS Score:	9

I-TOPS Recovery Score

<u>Variables</u>	<u>Score:</u>
Age < 50 years	1
Non- Ischemic HF	1
Time from cardiac diagnosis <2 yrs	1
Suboptimal HF therapy*	1
LVEDD < 6.5 cm	1
PASP < 50 mmHg	1
BUN < 30 mgdL	1
<u>Axial-flow device</u>	<u>1</u>
Total Maximum I-TOPS Score:	8

* Optimal HF defined as prior or current use of at least 2 neurohormonal blocking agents from 3 major drug classes (β -blockers, ACE inhibitors/ARB, and aldosterone antagonists) and in combination with ICD and/or CRT device.

I-CARS Score: Wever-Pinzon O, et al. J Am Coll Cardiol. 2016 Oct 4;68(14):1540-53.

I-TOPS Score: Topkara, VK et al. Circ Heart Fail. 2016 Jul;9(7):10.1161.

Supplemental Table V. Machine Learning Model Parameter Tuning in the Training Dataset

Classifier	Tuning parameters	AUC
Linear SVM	cost = 1	0.834
GBDT	interaction depth=1, n of trees=50	0.805
	interaction depth=1, n of trees=100	0.824
	interaction depth=1, n of trees=150	0.829
	interaction depth=2, n of trees=50	0.816
	interaction depth=2, n of trees=100	0.824
	interaction depth=2, n of trees=150	0.825
	interaction depth=3, n of trees=50	0.827
	interaction depth=3, n of trees=100	0.819
	interaction depth=3, n of trees=150	0.818
NN	size=1, decay=0	0.833
	size=1, decay=0.0001	0.832
	size=1, decay=0.1	0.794
	size=3, decay=0	0.817
	size=3, decay=0.0001	0.825
	size=3, decay=0.1	0.803
	size=5, decay=0	0.808
	size=5, decay=0.0001	0.826
	size=5, decay=0.1	0.803
RF	mtry=2	0.820
	mtry=15	0.792
	mtry=28	0.777

Linear SVM, linear support vector machine; GBDT, gradient-boosted decision trees; NN, neural networks; RF, random forest.

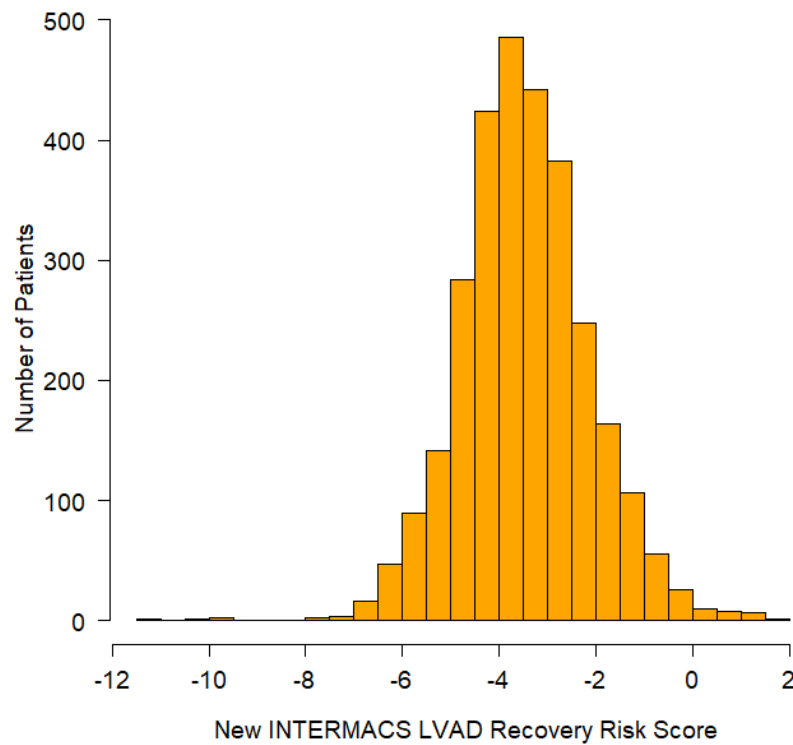
Supplemental Table VI. Predictors of LVAD Explant for Recovery by Multivariable Logistic Regression with Backward Stepwise Selection in the Training Dataset

Clinical Variable	B	SE	p-value	Odds Ratio (95% CI)
Current Smoking	1.15	0.232	8.1 x 10⁻⁷	3.15 (1.97 – 4.91)
Current ICD	-0.87	0.188	3.4 x 10⁻⁶	0.42 (0.29 – 0.61)
LVEF 0 – 20 % (post)	-0.78	0.178	1.1 x 10⁻⁵	0.46 (0.32 – 0.65)
Hemoglobin	0.16	0.040	4.8 x 10⁻⁵	1.18 (1.09 – 1.27)
BUN (mg/dL)	-0.03	0.008	4.6 x 10⁻⁴	0.97 (0.96 – 0.99)
LVEDD (post)	-0.25	0.072	5.2 x 10⁻⁴	0.78 (0.68 – 0.90)
Age	-0.02	0.007	0.001	0.98 (0.96 – 0.99)
Dilated Ischemic Cardiomyopathy	-0.63	0.216	0.003	0.53 (0.34 – 0.80)
Centrifugal LVAD	-0.70	0.242	0.004	0.50 (0.30 – 0.79)
BTR Indication	0.53	0.564	0.007	4.62 (1.44 – 13.5)
IABP Intervention 48 hours	-0.56	0.243	0.019	0.57 (0.35 – 0.90)
Preimplant Warfarin use	-0.46	0.198	0.029	0.63 (0.42 – 0.92)
History of ETOH abuse	0.53	0.238	0.026	1.70 (1.05 – 2.67)
Postpartum Cardiomyopathy	0.73	0.338	0.032	2.07 (1.04 – 3.95)
Frailty	-1.30	0.610	0.033	0.27 (0.07 – 0.77)
Time cardiac diagnosis (1M-1Y)	0.41	0.200	0.042	1.50 (1.01 – 2.21)

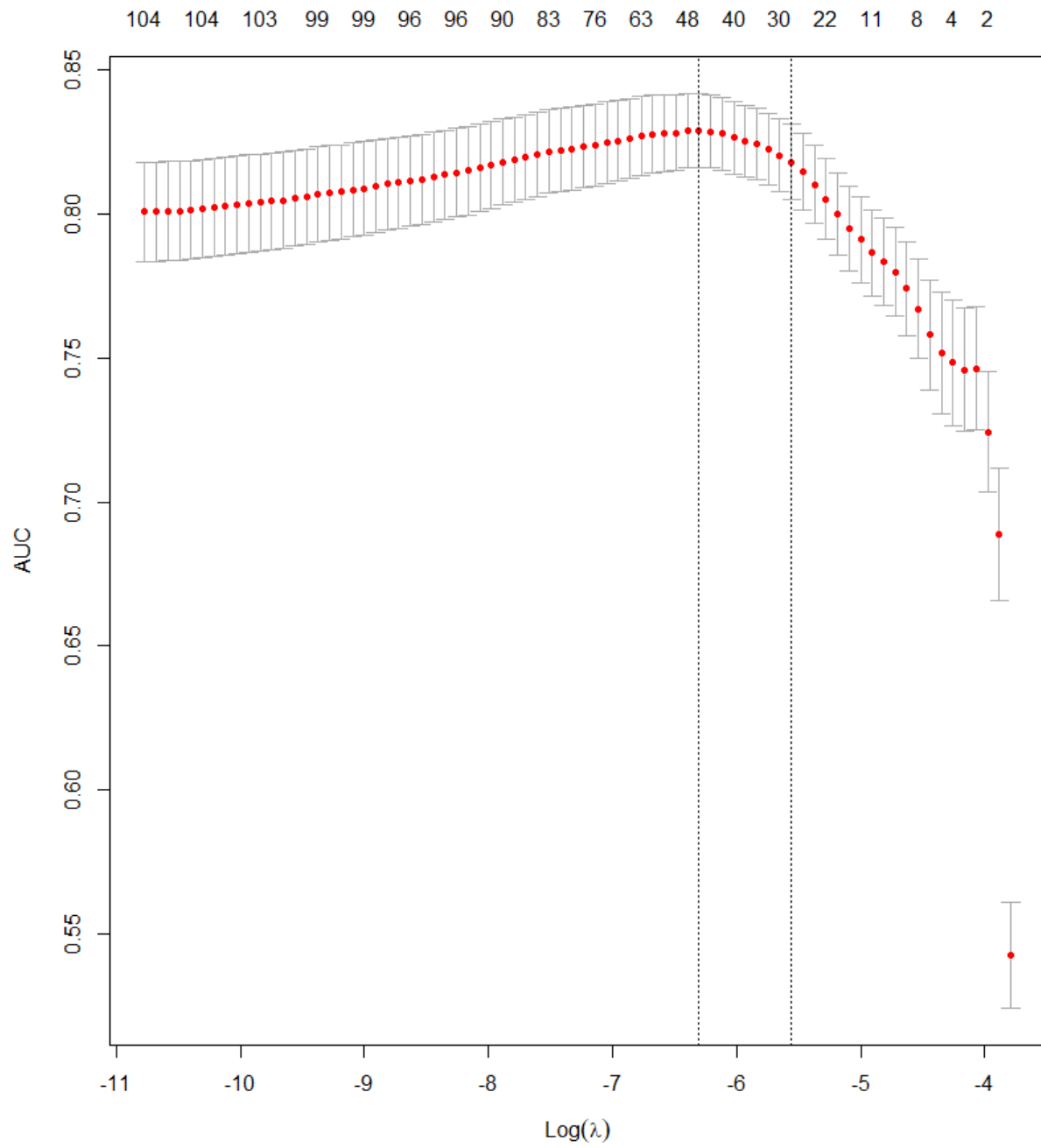
Calculation of New INTERMACS LVAD Recovery Risk Score

$$\text{Risk score} = (\beta_1 \times \text{variable}_1) + (\beta_2 \times \text{variable}_2) + \dots + (\beta_{16} \times \text{variable}_{16})$$

**New INTERMACS LVAD Recovery Risk Score
Distribution In the Validation Dataset**



Supplemental Figure II. LASSO feature selection. Cross-validation curve (red dotted line) with upper and lower standard deviation curves along the λ sequence



Supplemental Figure III. Concordance of Recovery Predictors from LASSO model (Machine Learning), conventional logistic regression-based model (New INTERMACS Score), and original simplified I-CARS and I-TOPS models shown on the heat map (green: risk factors positively associated with recovery, red: risk factors negatively associated with recovery)

	LASSO	New INTERMACS Score	I-CARS Score	I-TOPS Score
Age	Red	Red	Red	Red
BTR Indication	Green	Green		
BTT Indication	Red			
BUN (mg/dL)	Red	Red		Red
Centrifugal LVAD	Red	Red		Red
Concomitant Tricuspid Surgery	Red			
Creatinine			Red	Red
Current ICD	Red	Red	Red	Red
Current Smoking	Green	Green		
Dilated Ischemic	Red	Red	Red	Red
ECG Sinus Rhythm	Green			
Frailty		Red		
Heart Rate	Green			
Hemoglobin	Green	Green		
History of ETOH abuse	Green	Green		
IABP Intervention 48 hours	Red	Red		
INTERMACS Profile 3	Green			
Limited Social Support	Green			
LVEDD (post-LVAD)	Red	Red		
LVEDD (pre-LVAD)			Red	
LVEF 0 – 20 % (post)	Red	Red		
LVEF 20 – 29 % (post)	Red	Red		
Non-compliance	Green			
Other Psychiatric Disease	Green			
PA systolic pressure				Red
Postpartum Cardiomyopathy	Green	Green		
Preimplant Amiodarone use	Red			
Preimplant Warfarin use	Red	Red		
RVAD	Red	Red		
Serum Sodium	Green			
Time cardiac diagnosis (1M-1Y)	Green	Green	Green	Green
Time cardiac diagnosis (<1M)	Green		Green	Green

Supplemental Figure IV. Comparison of Traditional Logistic Regression Based (New INTERMACS LVAD Recovery Risk Score) versus Machine Learning (Bayesian LR) Based LVAD Recovery Prediction Risk Model

