Updates in Heart Failure Management

Jerry D. Estep, MD, FACC, FASE

Section Head, Heart Failure and Heart Transplantation
Medical Director, Kaufman Center for Heart Failure,
Department of Cardiovascular Medicine,
Heart and Vascular Institute,
Cleveland Clinic

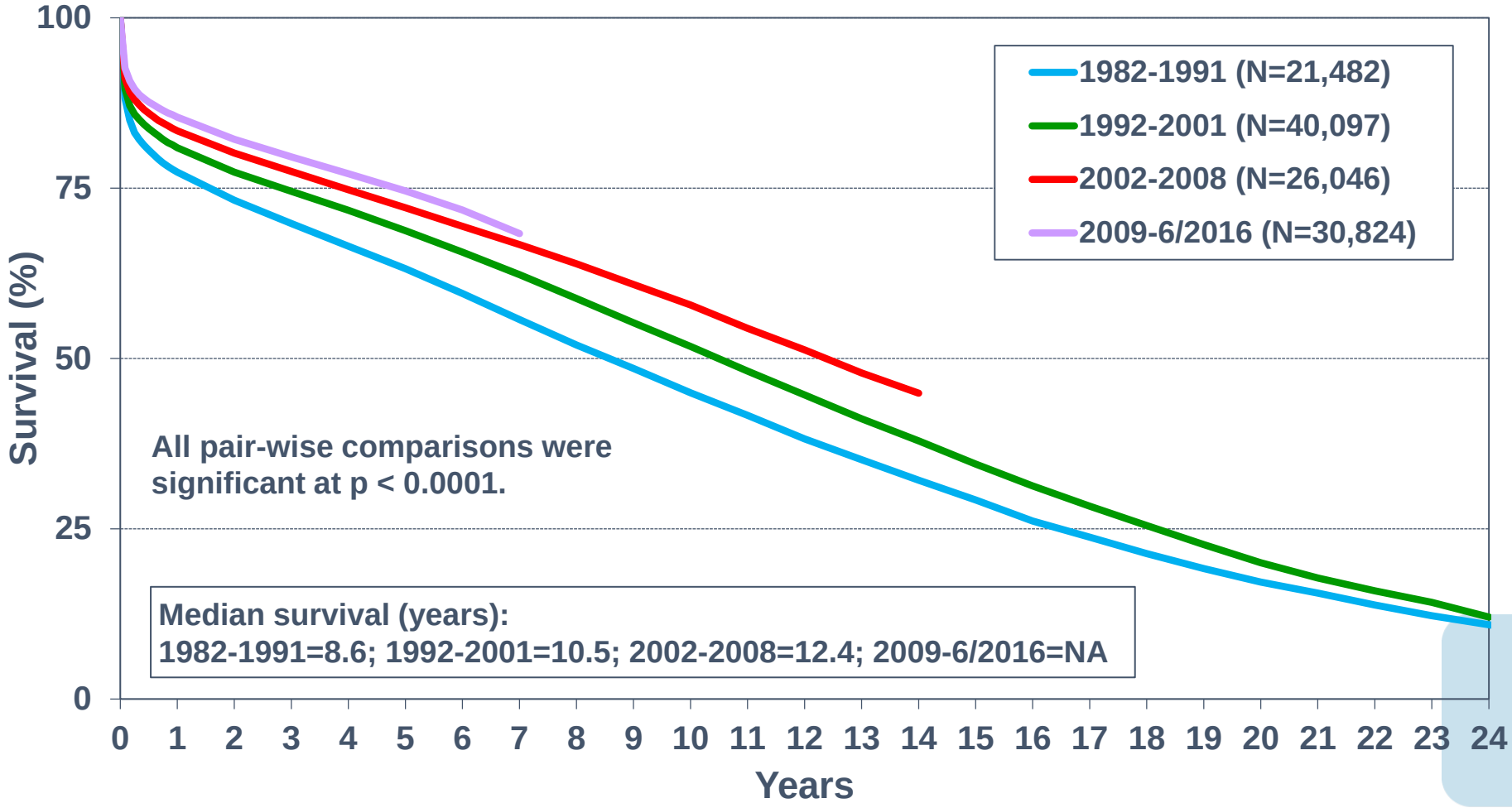
Disclosures

- Consultant for Abbott.
- Medical Advisor for Medtronic Inc.
- Consultant for Getinge.

Discussion Aims

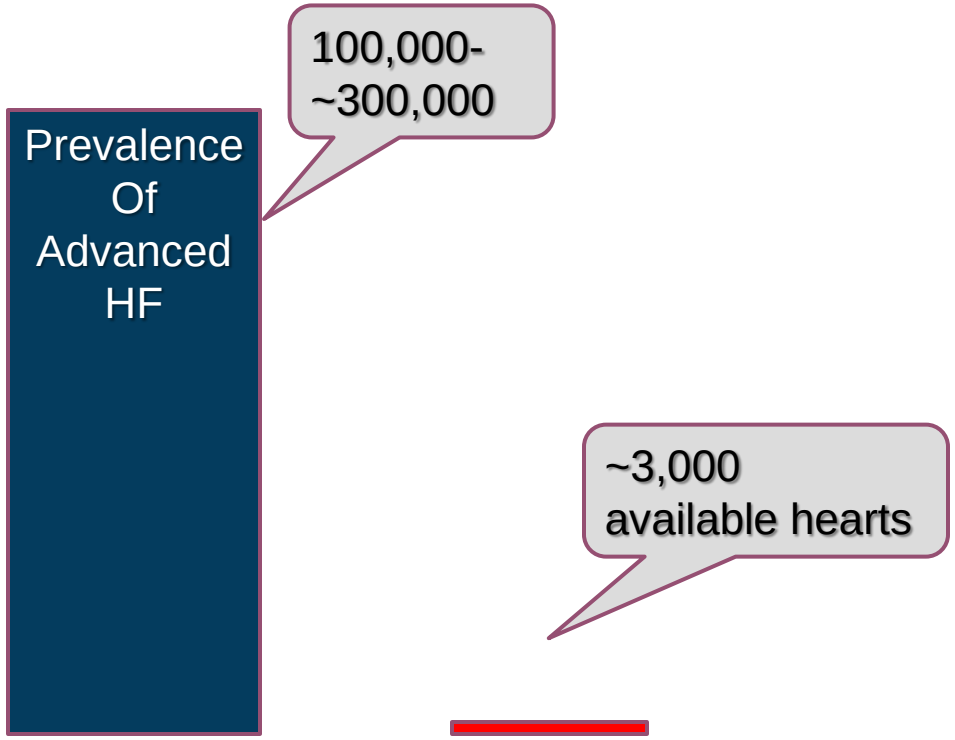
- Discuss innovations in LVADs
  - Utilization trends
  - Current outcome
  - New device technology and treatment strategies
  - Importance of team approach and shared decision making in this patient population
- Highlight the new allocation policy for heart transplant and clinical implications

Adult Heart Transplants
Kaplan-Meier Survival by Era
(Transplants: January 1982 – June 2016)



ISHLT • INTERNATIONAL SOCIETY FOR HEART AND LUNG TRANSPLANTATION
2018
JHLT. 2018 Oct; 37(10): 1155-1206

Conceptual Model: Epidemiological Mismatch



*Rich M. *J Am Geriatric Soc*. 1997;45:968–974.
American Heart Association. 2001 *Heart and Stroke Statistical Update*. 2000.

Heart Transplantation is Not the Answer for Many

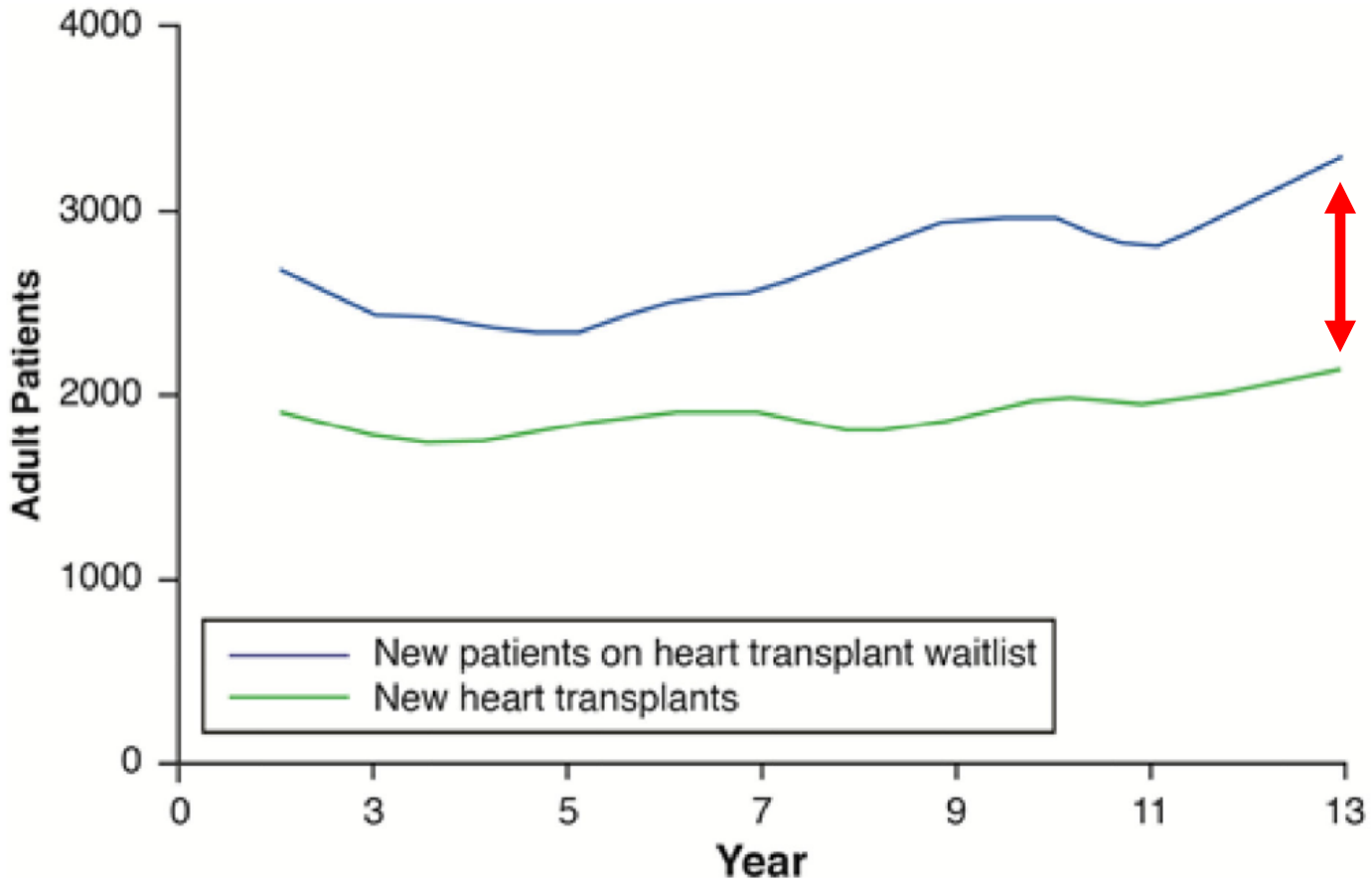
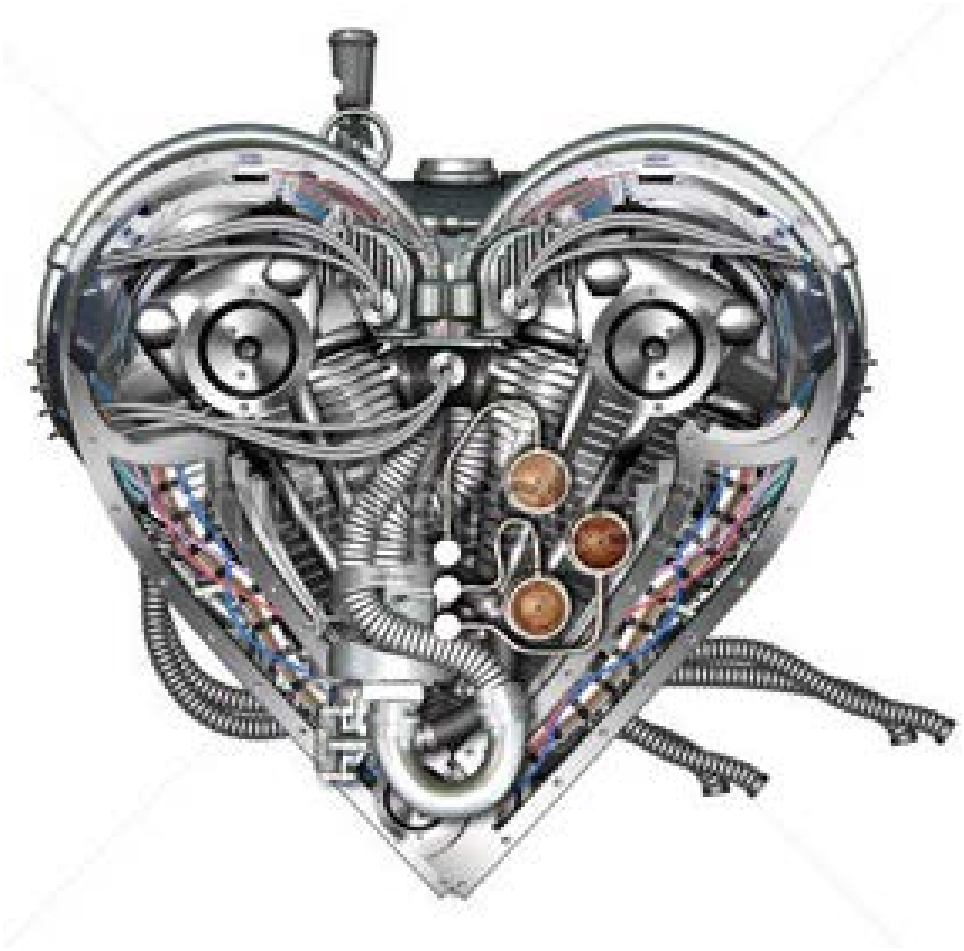
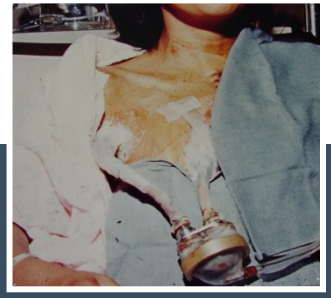


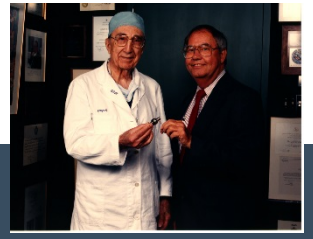
Figure 4.
Scientific Registry of Transplant Recipients: Total Patients Awaiting and Receiving Heart Transplantation from 2002-2013. Adapted from Colvin-Adams et al[39]

What about LVADs ?





Pulsatile LVAD 1966



First US implant 2000 axial
Flow pump DeBakey Micromed

HeartMate XVE

Pulsatile Technology

FDA Approved 2001

HeartMate II

Continuous Flow Technology: Axial Design

FDA Approved 2008

HeartMate 3

Continuous Flow Technology: Full MagLev Technology

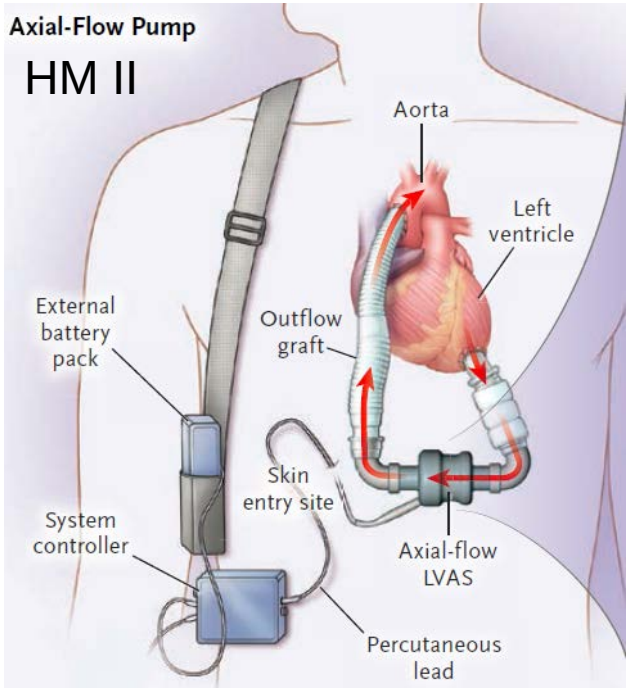
FDA Approved 2017

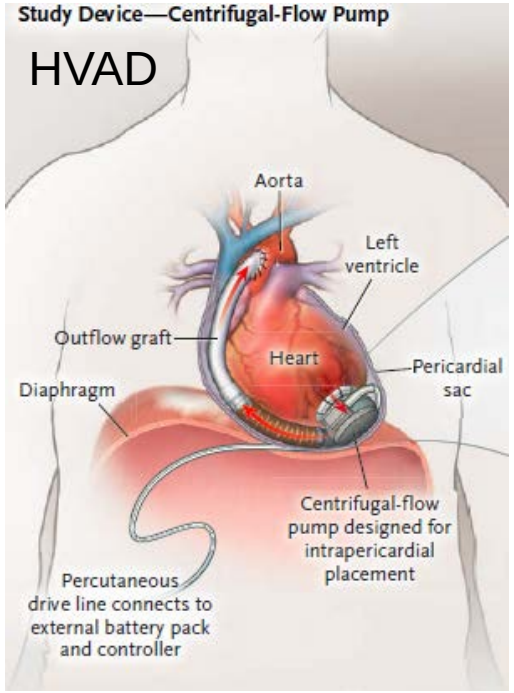
Heartware HVAD

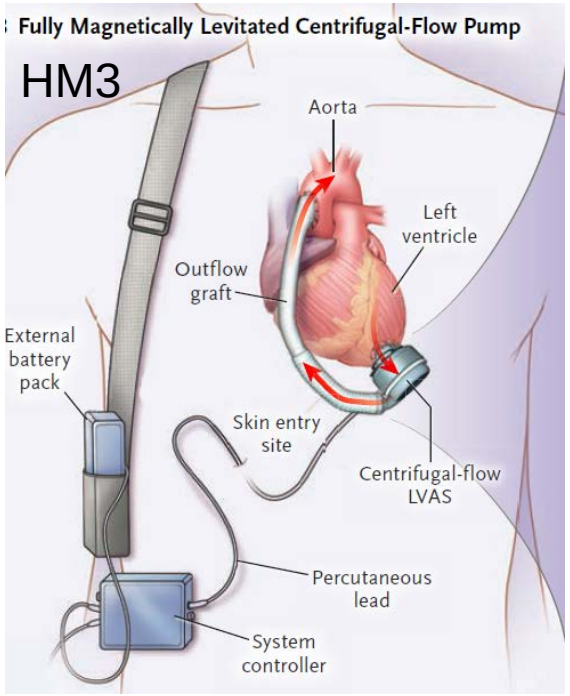
Continuous Flow Technology: Centrifugal Design

FDA Approved 2012

FDA Approved Durable LVADs

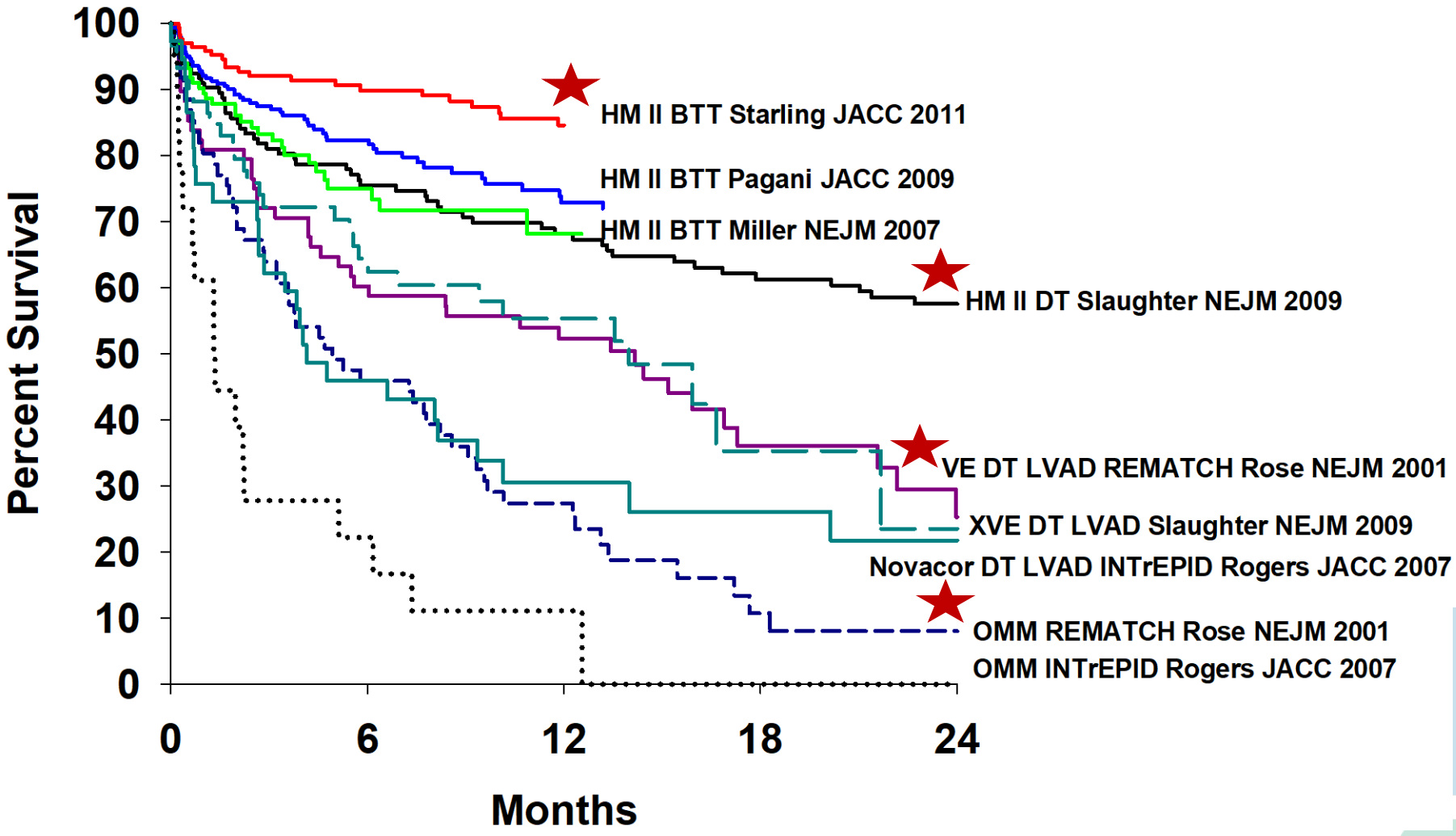






1. Larose JA et a. Design Concepts and principle of the operation of the Heartware system ASAIO 2015
2. Mandeep R. Mehra et al. A Fully Mangetically Levitated Circulatory Pump for Advanced HF. NEJM 2017 (Figures adopted)

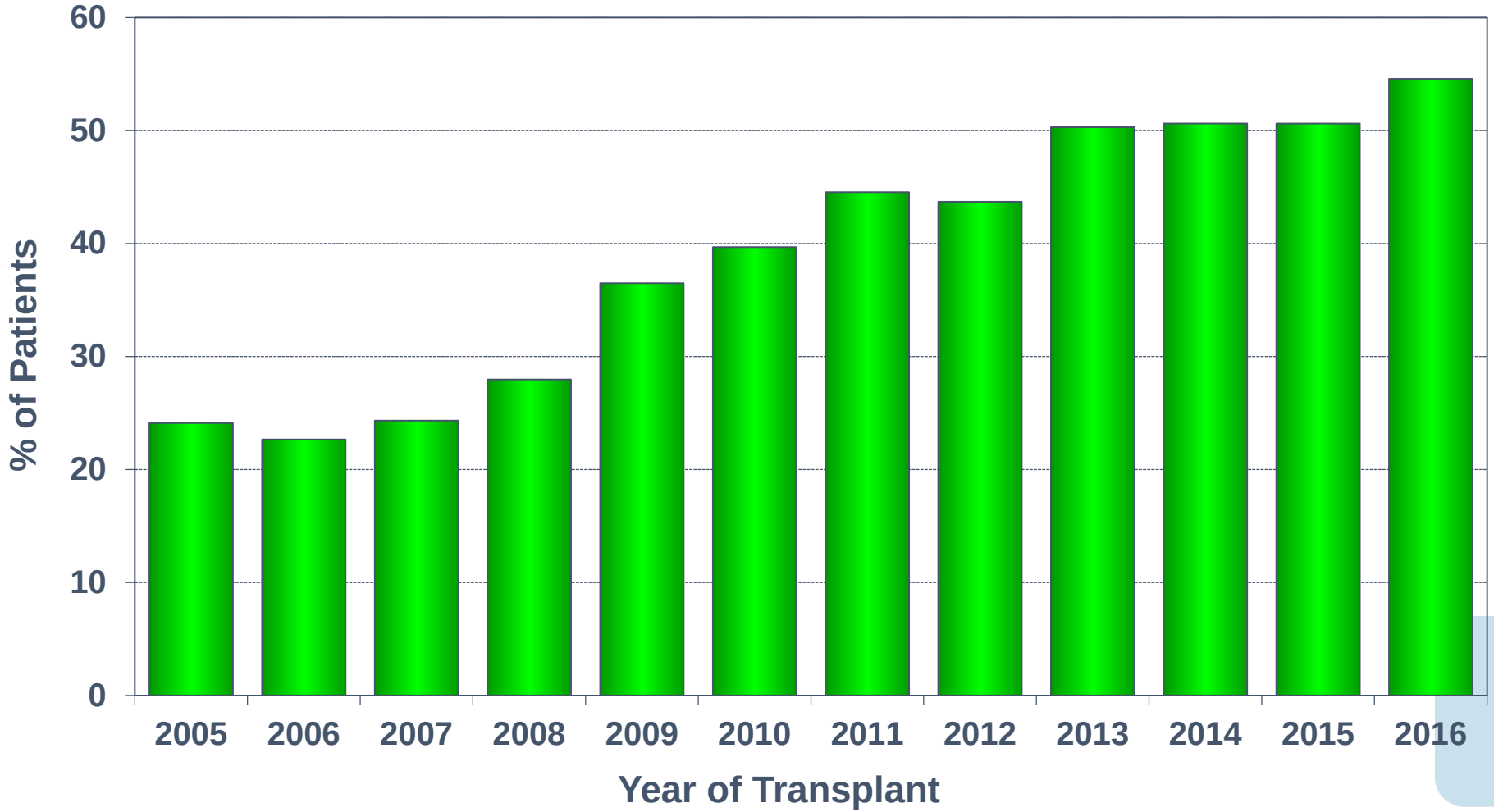
Survival: LVAD Outcomes Continue to Improve



Adult Heart Transplants

% of Patients Bridged with Mechanical Circulatory Support*

(Transplants: January 2005 – December 2016)



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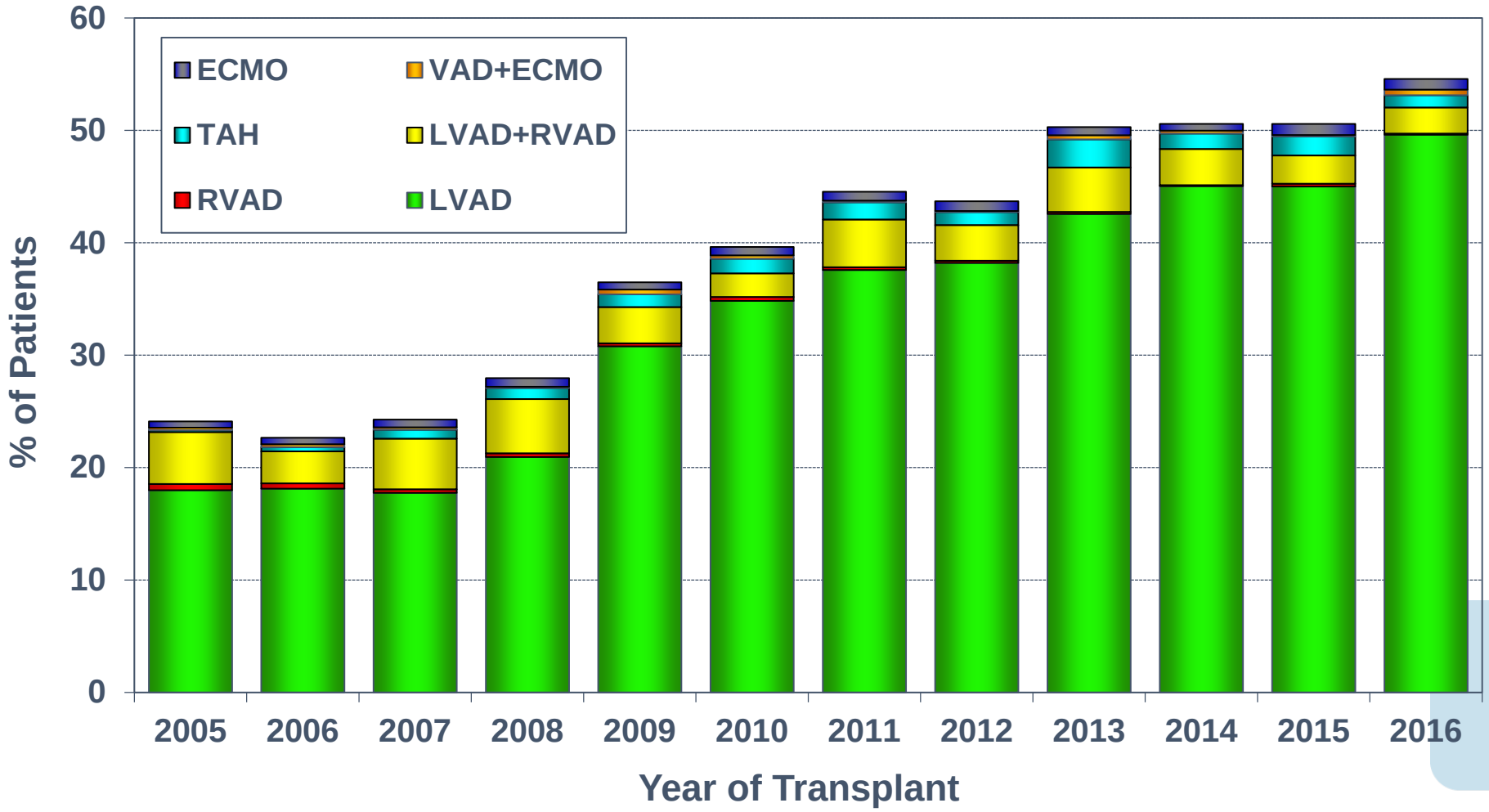
2018

JHLT. 2018 Oct; 37(10): 1155-1206

* LVAD, RVAD, TAH, ECMO

Adult Heart Transplants

% of Patients Bridged with Mechanical Circulatory Support* by Year and Device Type



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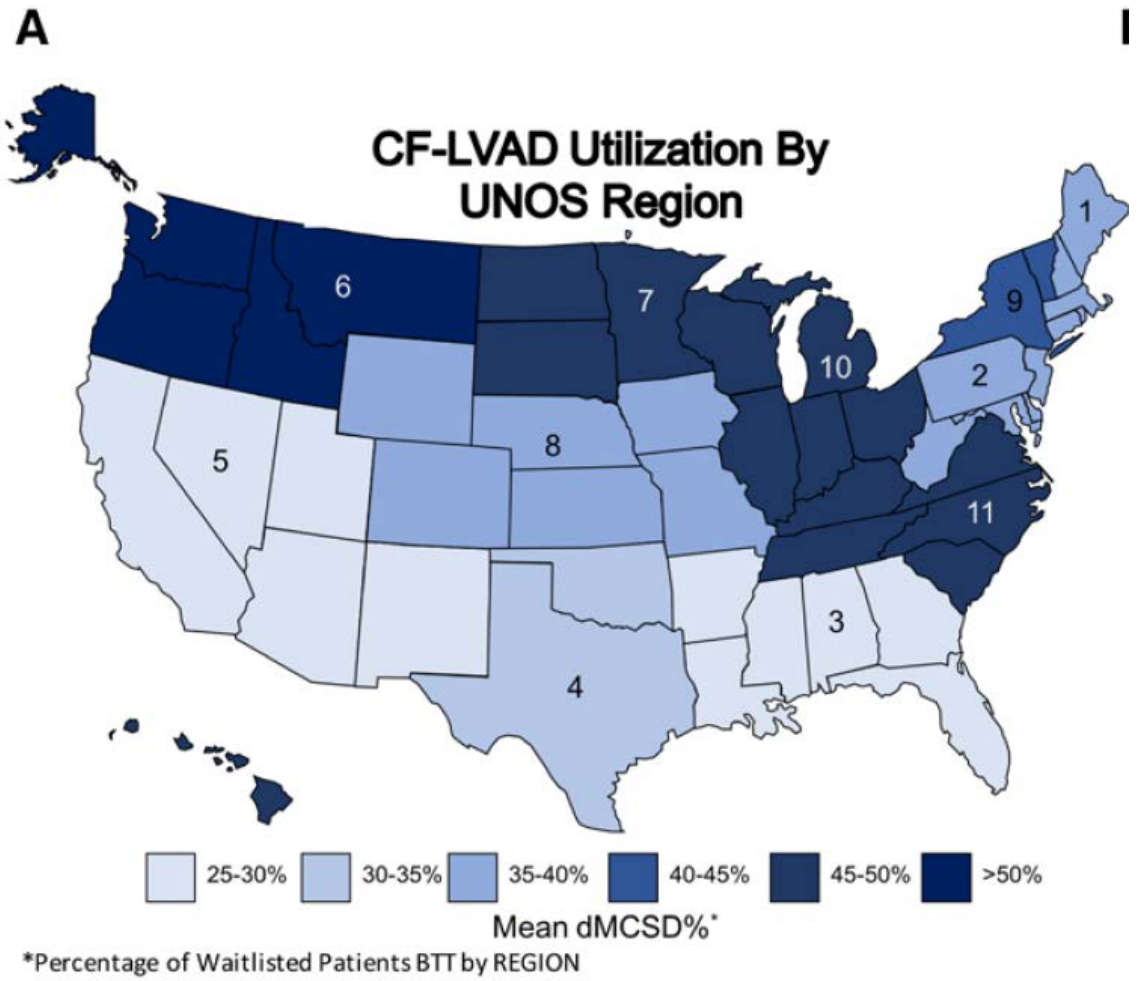
2018
JHLT. 2018 Oct; 37(10): 1155-1206

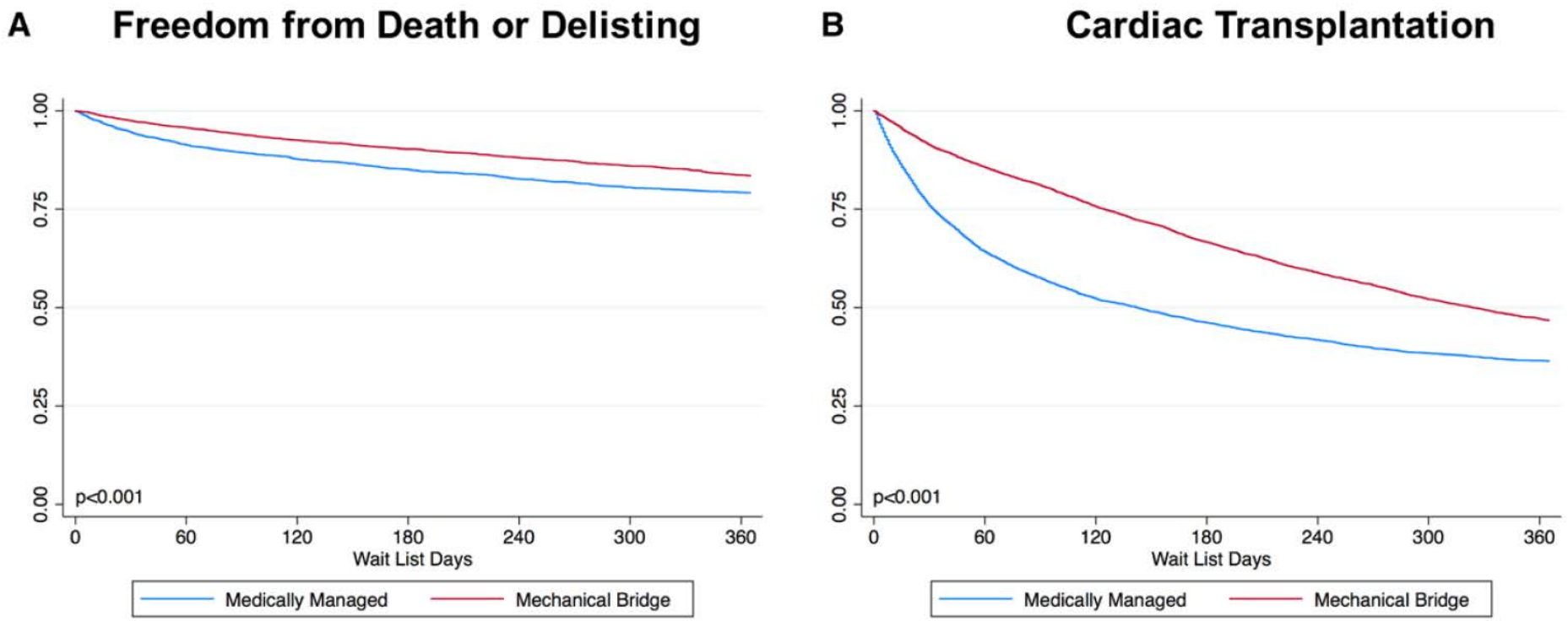
* LVAD, RVAD, TAH, ECMO

Nationwide Variability in CF-LVAD Use.



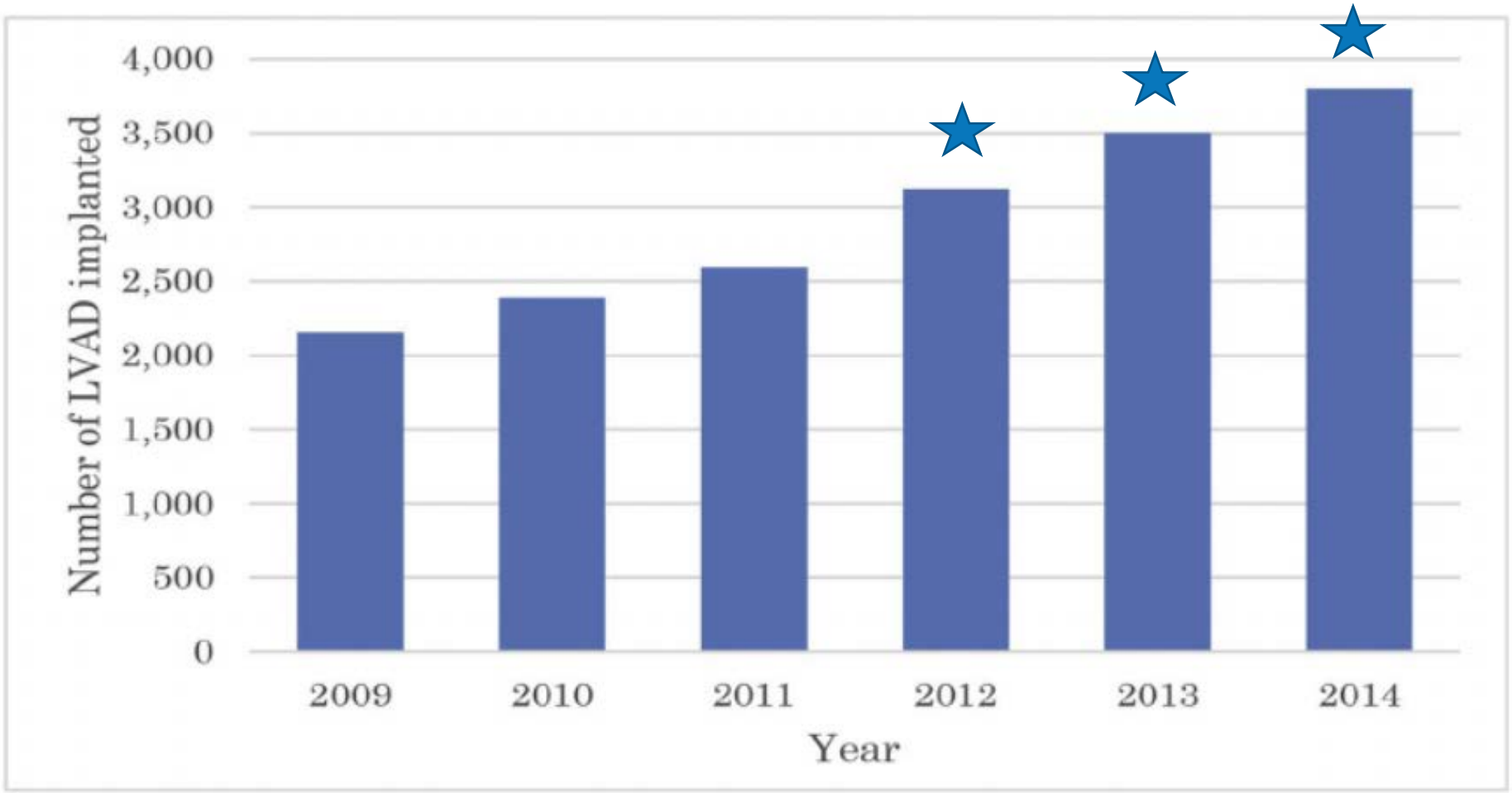
Circ Heart Fail. 2018;11:e004586. DOI: 10.1161/CIRCHEARTFAILURE.117.004586

Waitlist Outcomes by Bridging Strategy.



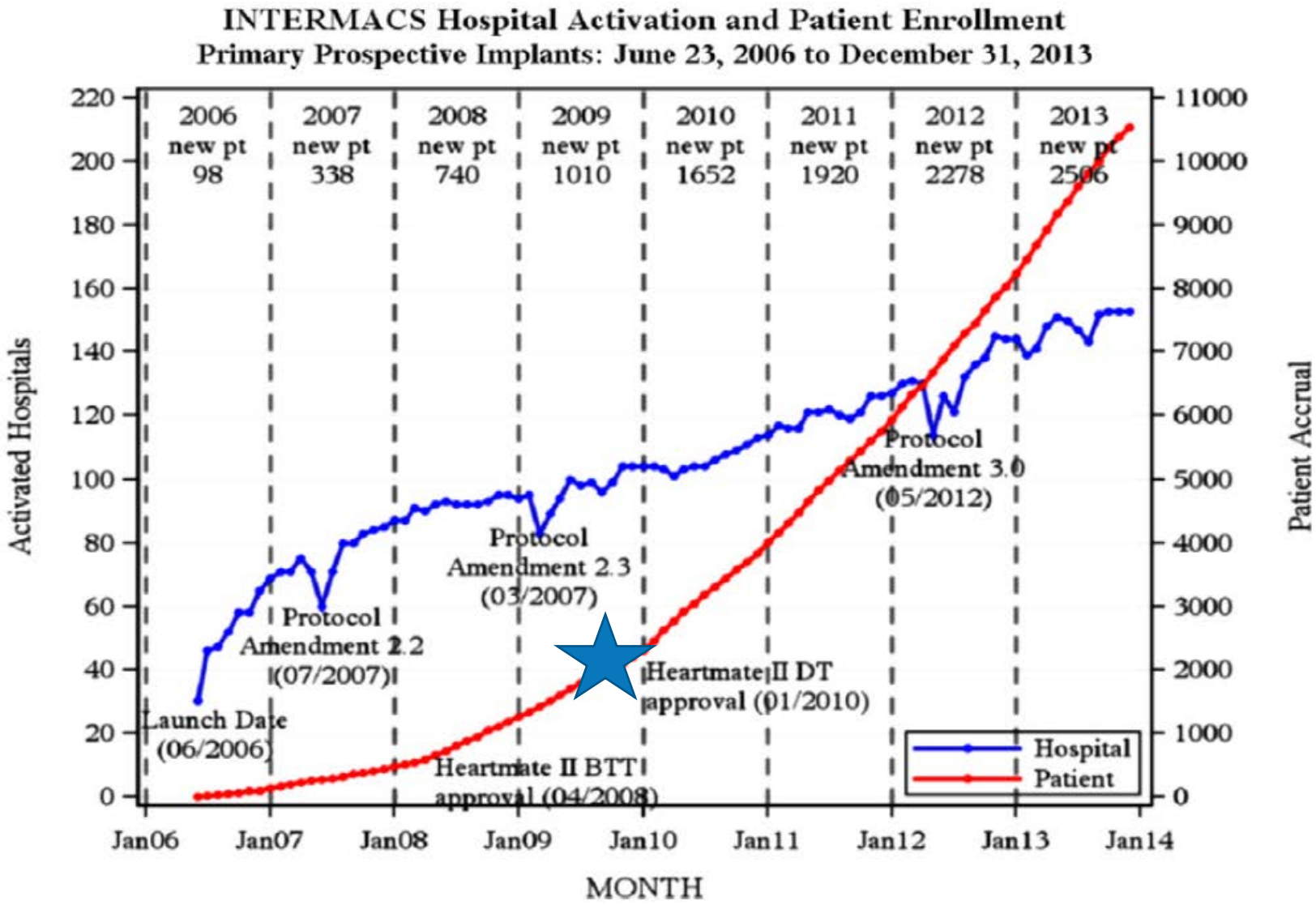
Circ Heart Fail. 2018;11:e004586. DOI: 10.1161/CIRCHEARTFAILURE.117.004586

Trend in CF-LVAD Use in the U.S.



Am J Cardiol 2018;121:1214–1218

Increased Utilizations of LVADS



Kirklin et al. 6th INTERMACS Annual Report. JHLT 2014;33:555-564

Patients May Not Qualify for Cardiac Transplant

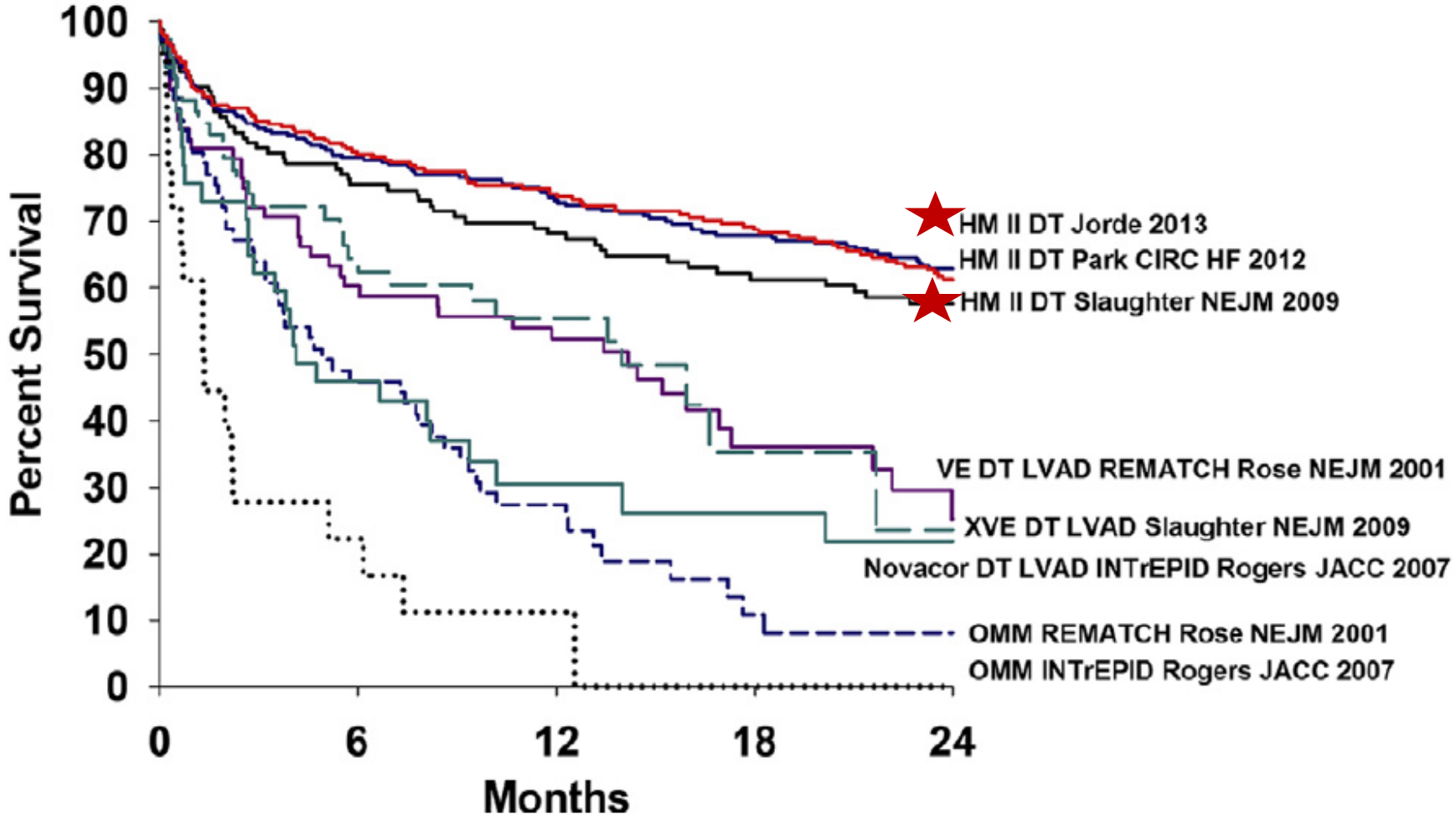
General	Specific	Relative
▪ Any condition limiting a successful transplant outcome	▪ Elevated pulmonary vascular resistance ▪ Active infection ▪ Shock with MOF ▪ Advanced renal or pulmonary disease ▪ Cross-match incompatibility ▪ Active psychiatric disease ▪ Substance abuse/smoking	▪ Age ▪ Peripheral vascular disease ▪ Malignancy ▪ Size/Obesity ▪ Diabetes with end organ damage

Contemporary DT LVAD Implantation Criteria

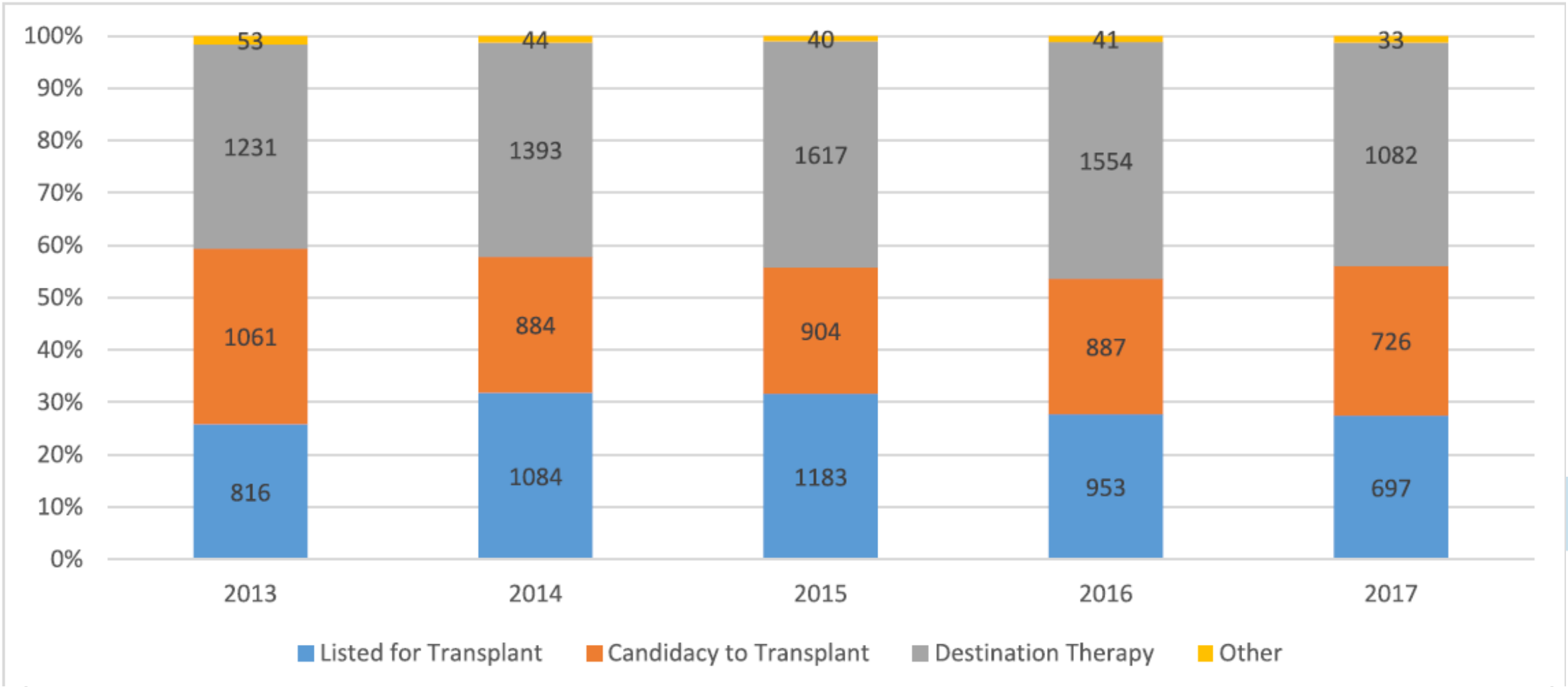
Destination Therapy

- LVEF ≤ 25%
- Peak VO2 < 14 ml/kg/min (or 50% age/sex predicted)
- And either
  - NYHA Class IIIb-IV symptoms despite optimal medical therapy for at least 45 of the prior 60 days, or
  - Dependence on IV inotropes for ≥14 days, or
  - Dependence on IABP for ≥ 7 days
- Not a transplant candidate

Survival Associated with DT Has Improved



3rd Annual IMACS Registry Report

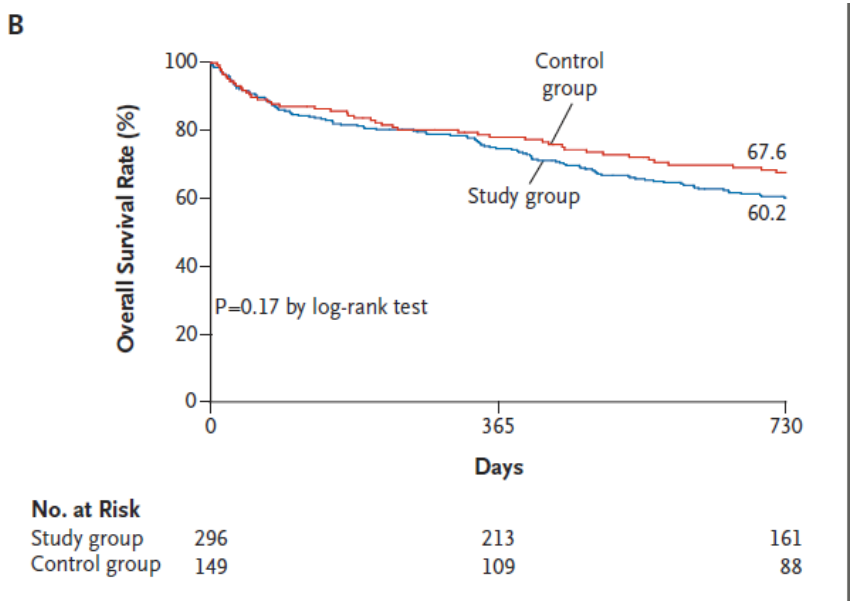


The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Intrapericardial Left Ventricular Assist Device for Advanced Heart Failure

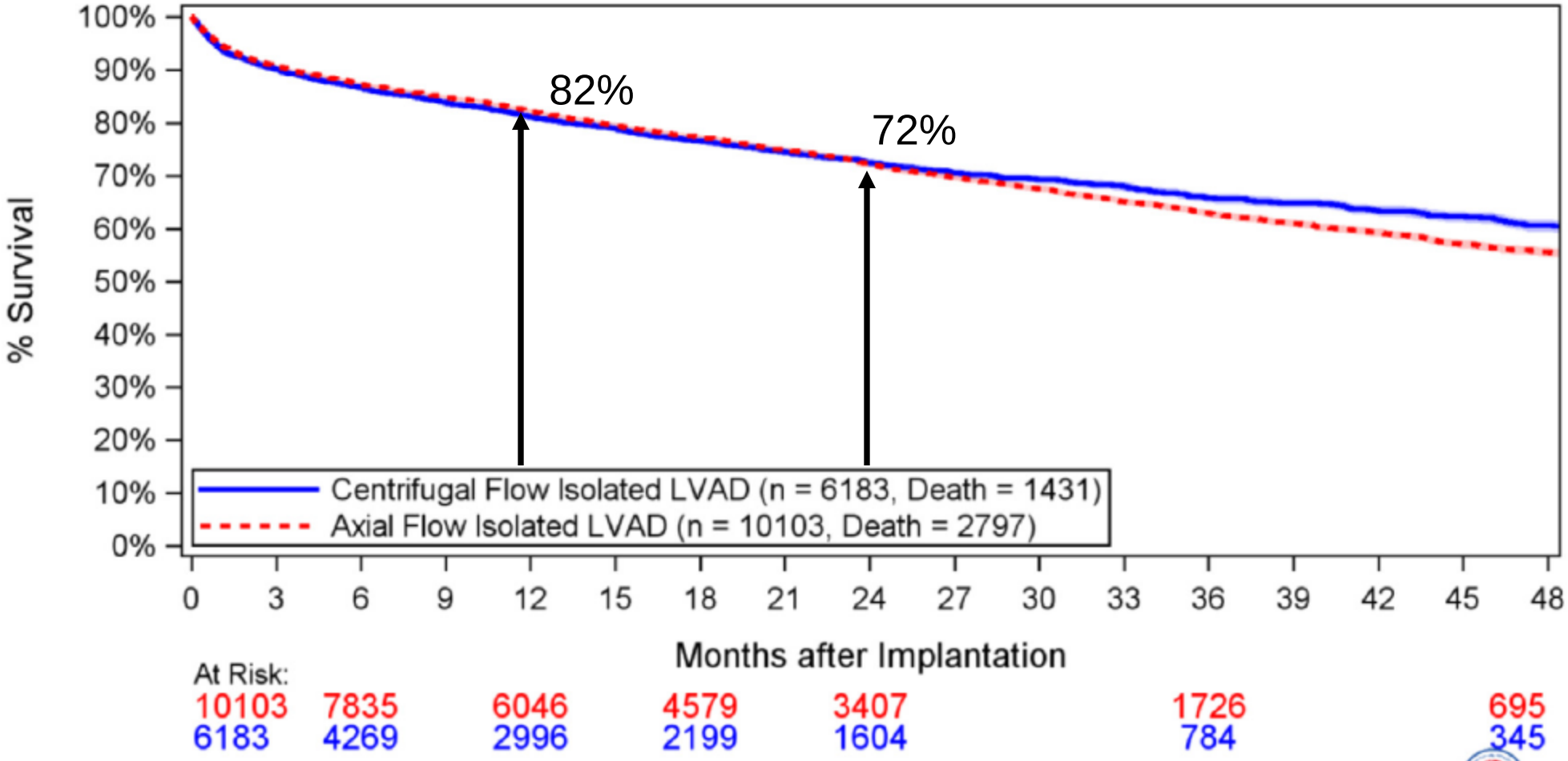
Joseph G. Rogers, M.D., Francis D. Pagani, M.D., Ph.D., Antone J. Tatooles, M.D., Geetha Bhat, M.D., Mark S. Slaughter, M.D., Emma J. Birks, M.B., B.S., Ph.D., Steven W. Boyce, M.D., Samer S. Najjar, M.D., Valluvan Jeevanandam, M.D., Allen S. Anderson, M.D., Igor D. Gregoric, M.D., Hari Mallidi, M.D., Katrin Leadley, M.D., Keith D. Aaronson, M.D., O.H. Frazier, M.D., and Carmelo A. Milano, M.D.



Control HM II
Study group HVAD

NEJM 2017

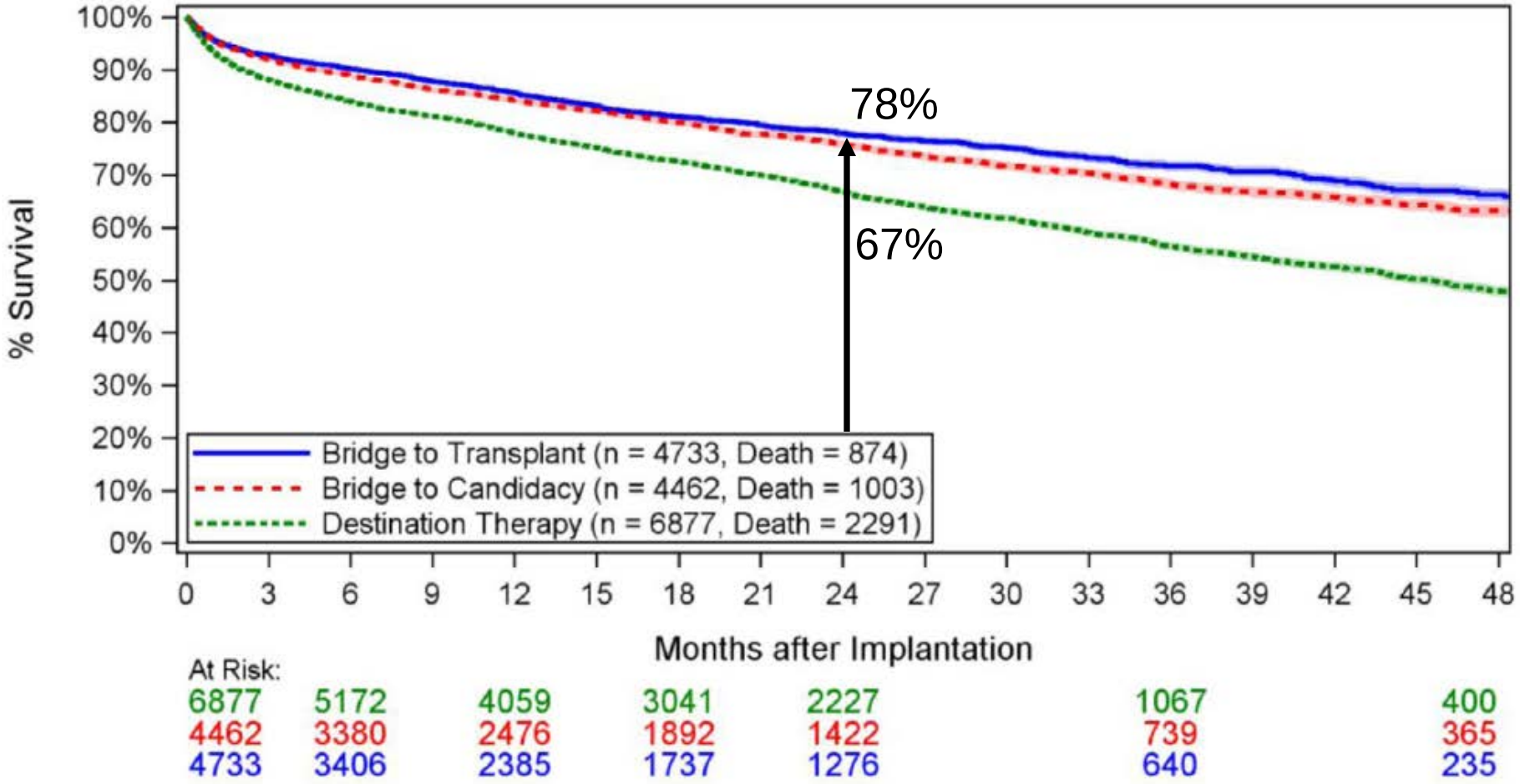
Outcome Based on LVAD Type



Imacs

Goldstein et al. JHLT 2019

Outcome Based on Device Strategy

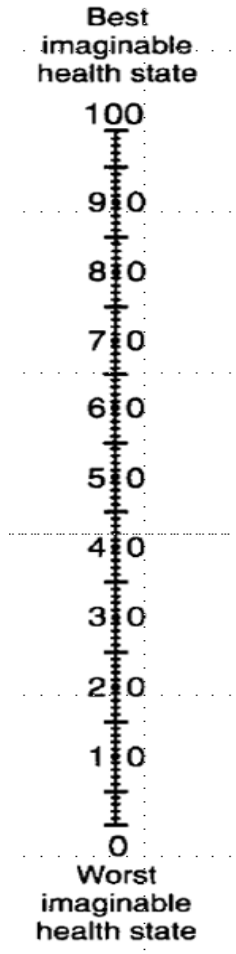


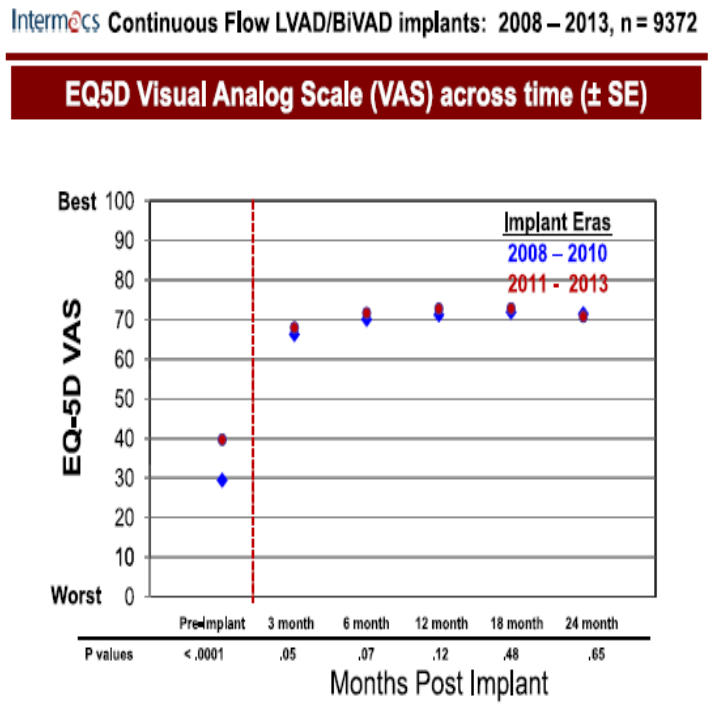
p (log-rank) = <.0001
Event: Death censored at transplant or recovery

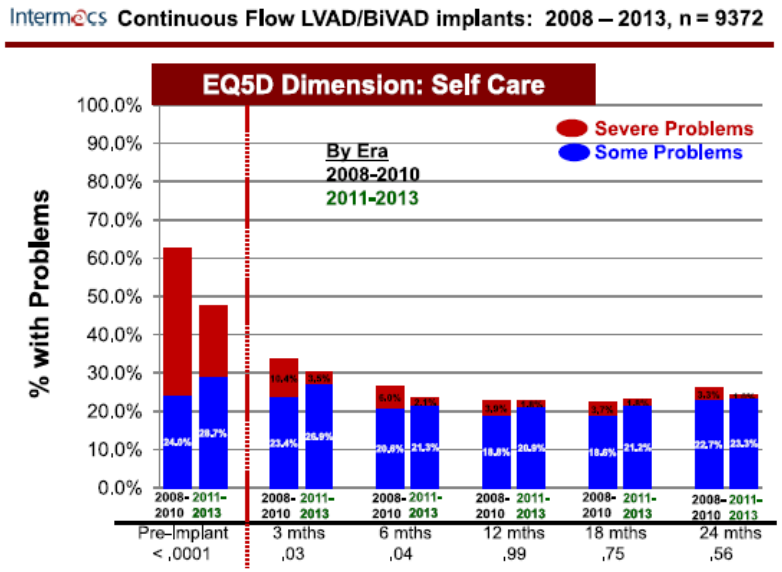
Goldstein et al. JHLT 2019

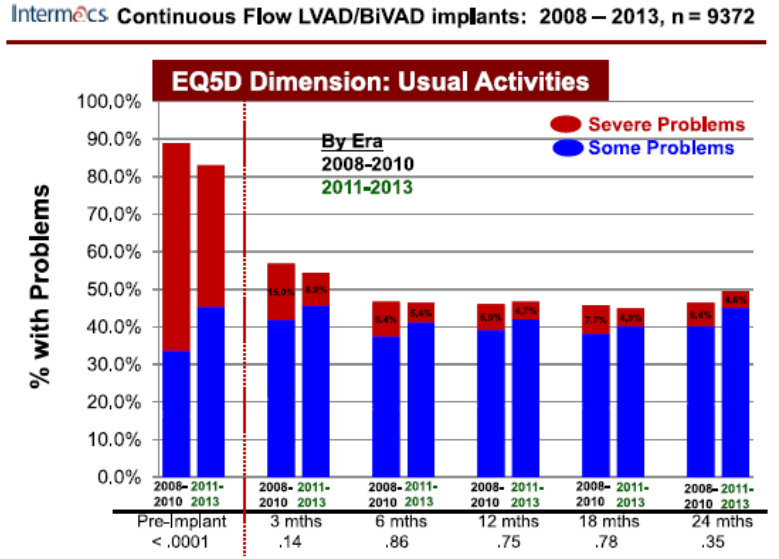
Imacs

Quality of Life is Improved After LVAD Placement



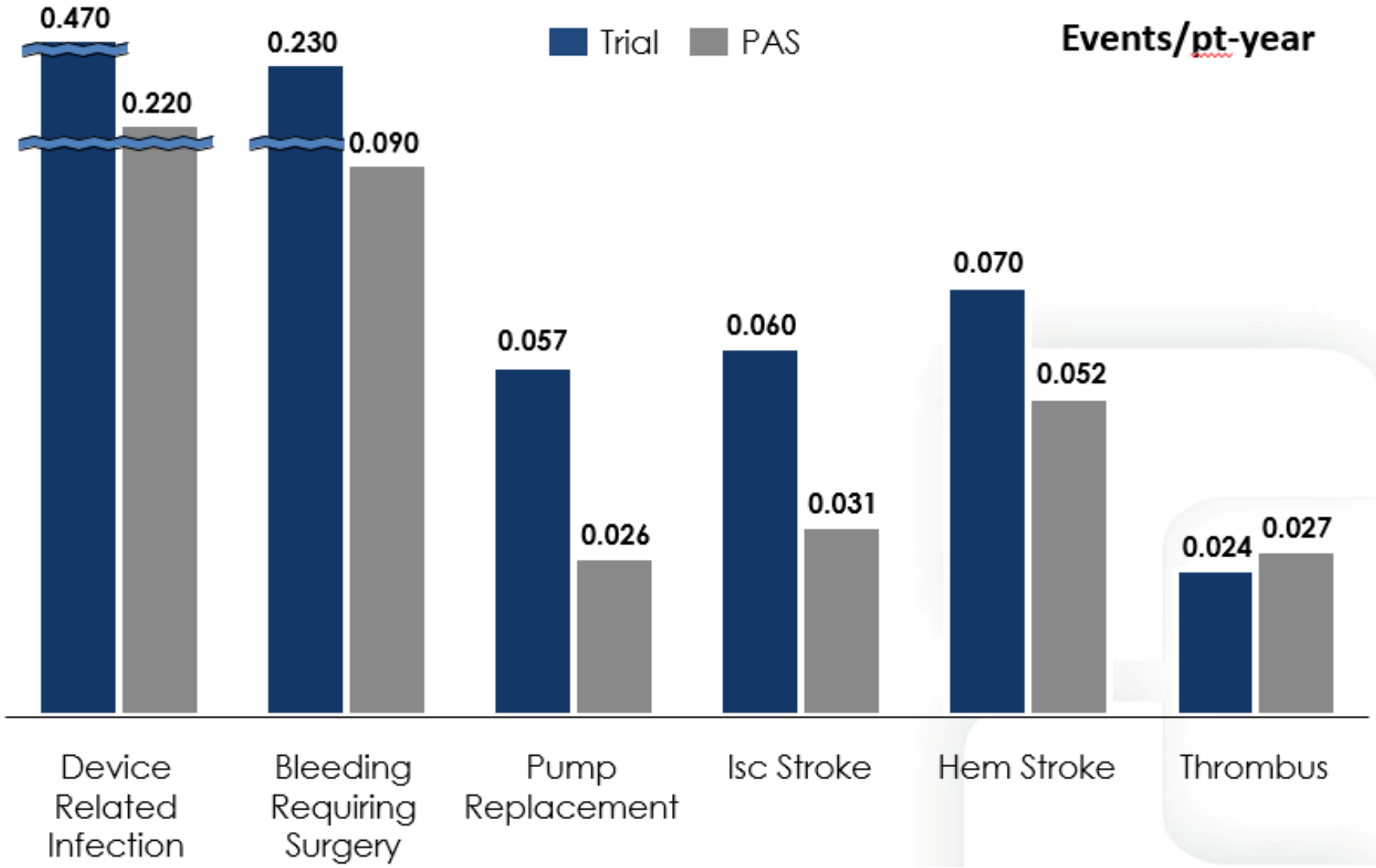






Kirklin et al. 6th INTERMACS Annual Report. JHLT 2014;33:555-564

Device Complications Decreasing Over Time



Jorde, Khushwaha, Tatooles, et al. JACC 2014.

Serious Adverse Events with Implantable Left Ventricular Assist Devices (LVADs): FDA Safety Communication

Date Issued: August 5, 2015

Audiences:

- Health care providers treating heart failure patients
- Patients with a LVAD
- Caregivers of patients with a LVAD

Summary of Problem and Scope:

The FDA is aware of serious adverse events associated with both devices.

Thoratec HeartMate II:

The FDA has received reports and information from a variety of sources indicating an increase in the rate of pump thrombosis events in patients implanted with the HeartMate II. Information also shows that patients are experiencing pump thrombosis events earlier than observed during the clinical trials conducted to support the product's approvals in 2008 (BTT) and 2010 (DT). For example, two analyses in the scientific literature reported the confirmed (after explant) HeartMate II pump thrombosis rate as high as 8.4% of implanted devices at 3 months (Starling et al, 2013) and 6% of implanted devices at 6 months (Kirklin et al, 2014). This is compared to 1.6% of implanted devices at one year during the BTT clinical trial and 3.8% of implanted devices at 2 years during the DT clinical trial.

Pump thrombosis is a serious complication that can require repeat surgery to replace the pump or can lead to death.

HeartWare HVAD:

The FDA is aware of recently reported results from a clinical trial designed to evaluate the safety and effectiveness of the HeartWare HVAD when used for the DT indication. Investigators reported 28.7% of HVAD patients experienced one or more strokes over two years, compared to 12.1% among patients implanted with the control device (HeartMate II). Although the HVAD is not currently approved for DT, it is the same device approved for the BTT indication.

Stroke is a serious complication that can lead to permanent patient disability and death.

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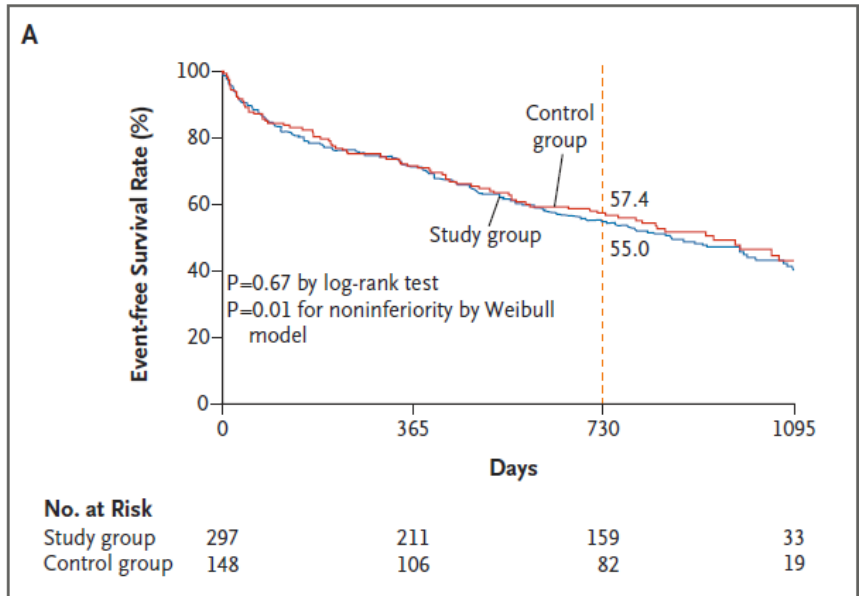


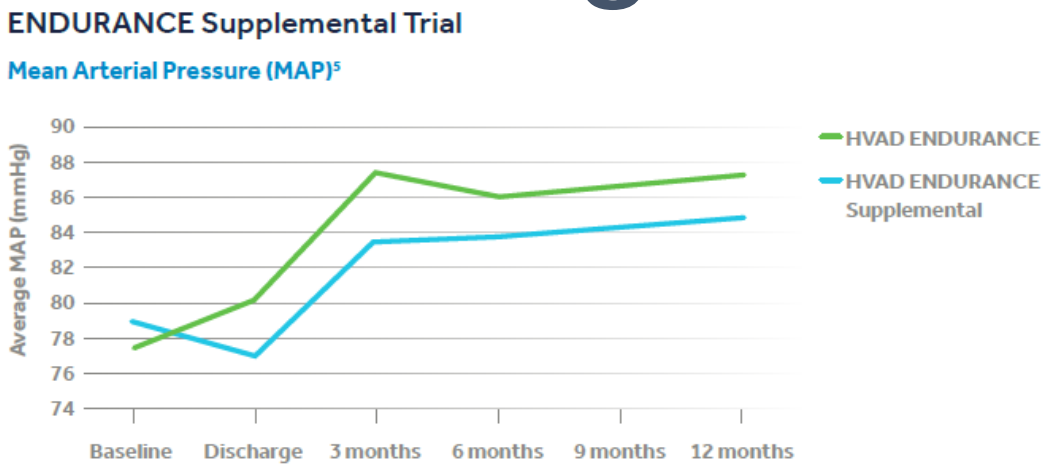
Control HM II
Study group HVAD

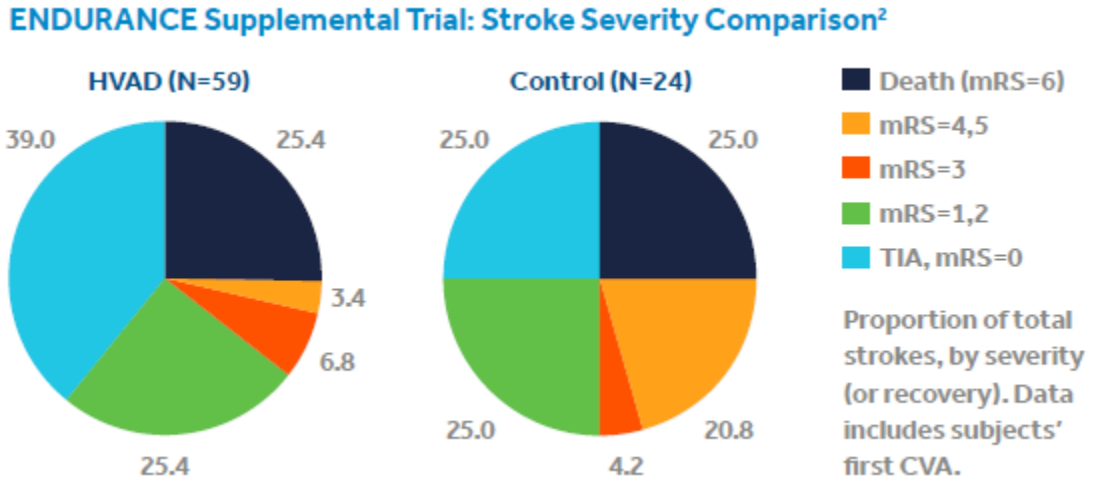
NEJM 2017

Table 3. Adverse Events in the As-Treated Population.*

Event	HVAD Study Group (N=296)			HM II Control Group (N=149)			P Value†
	no. of patients (%)	*no. of events*	*events/ patient-yr*	*no. of patients (%)*	*no. of events*	*events/ patient-yr*	
Bleeding events	178 (60.1)	410	1.00	90 (60.4)	199	0.98	>0.99
Requiring reoperation‡	45 (15.2)	52	0.13	27 (18.1)	28	0.14	0.52
Requiring transfusion of >4 units of packed red cells within 7 days‡	45 (15.2)	47	0.11	33 (22.1)	36	0.18	0.09
Gastrointestinal bleeding	104 (35.1)	230	0.56	51 (34.2)	91	0.45	0.92
Cardiac arrhythmia	112 (37.8)	178	0.43	61 (40.9)	83	0.41	0.54
Hepatic dysfunction	14 (4.7)	14	0.03	12 (8.1)	12	0.06	0.20
Hypertension	47 (15.9)	62	0.15	25 (16.8)	29	0.14	0.79
Sepsis	70 (23.6)	84	0.20	23 (15.4)	28	0.14	0.048
Drive-line exit-site infection	58 (19.6)	752	0.18	23 (15.4)	27	0.13	0.30
Stroke	88 (29.7)	117	0.29	18 (12.1)	19	0.09	<0.001
Ischemic cerebrovascular event	52 (17.6)	70	0.17	12 (8.1)	12	0.06	0.007
Hemorrhagic cerebrovascular event	44 (14.9)	47	0.11	6 (4.0)	7	0.03	<0.001
Transient ischemic attack§	25 (8.4)	28	0.07	7 (4.7)	7	0.03	0.18
Renal dysfunction	44 (14.9)	53	0.13	18 (12.1)	20	0.10	0.47
Respiratory dysfunction	86 (29.1)	116	0.28	38 (25.5)	49	0.24	0.502
Right heart failure	114 (38.5)	133	0.32	40 (26.8)	46	0.23	0.02
Need for RVAD‡	8 (2.7)	8	0.02	5 (3.4)	6	0.03	0.77
Pump replacement¶	23 (7.8)	NA	NA	20 (13.4)	NA	NA	0.06
Exchange owing to pump thrombosis	19 (6.4)	NA	NA	16 (10.7)	NA	NA	0.12
Device malfunction or failure	93 (31.4)	124	0.30	38 (25.5)	43	0.21	0.23
Rehospitalization	249 (84.1)	1167	2.85	118 (79.2)	478	2.34	0.23
Death	116 (39.2)	NA	NA	48 (32.2)	NA	NA	0.18

Medical Management is Key





<u>Supplemental Protocol</u>

-Mean BP ≤ 85 mmHg (cuff) or Mean BP ≤ 90 mmHg (Doppler)

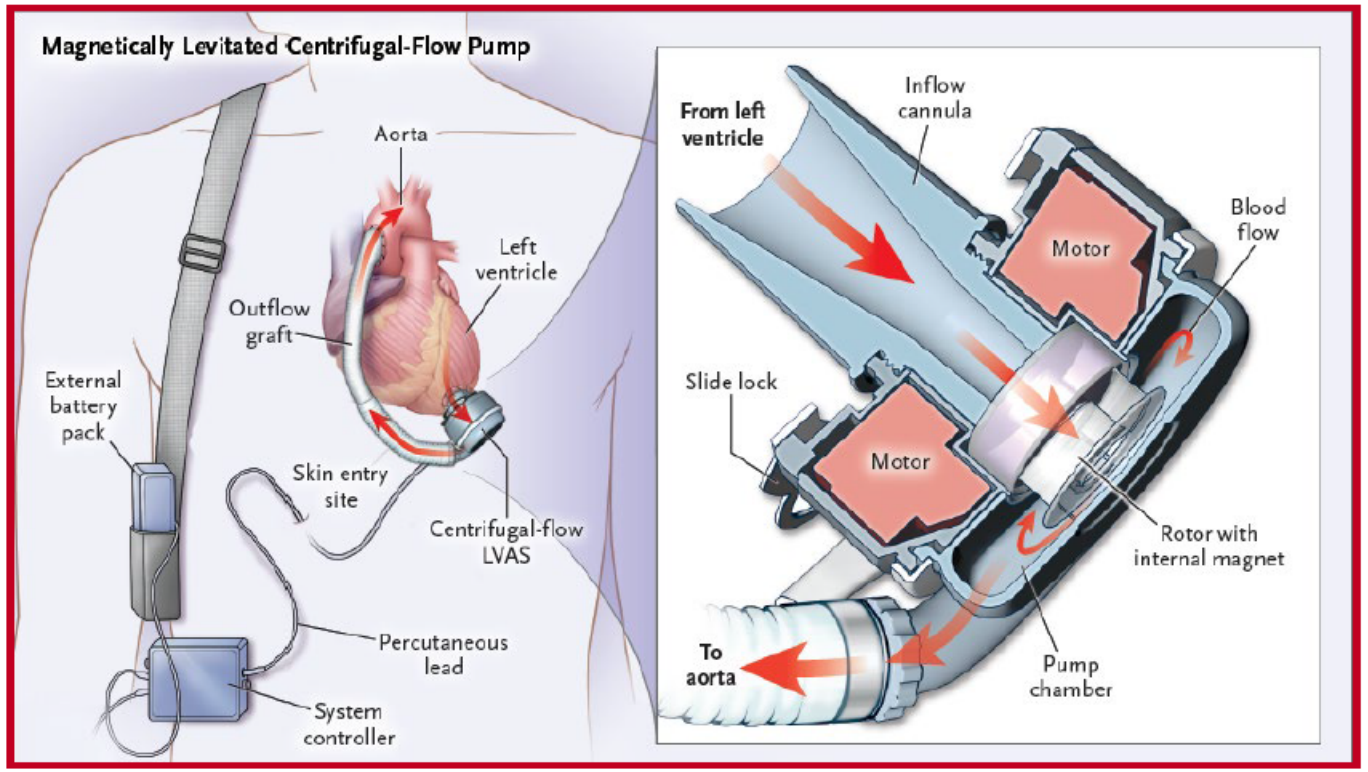
-Patient daily BP monitoring

-Patients instructed to report out of range values

Reduction in Stroke Rate including a reduction in HCVA rates

Milano, C. et al, Impact of Blood Pressure Management on Patient Outcomes with the HeartWare HVAD: the ENDURANCE Supplemental Trial. 2017, in press.

HeartMate 3 LVAS

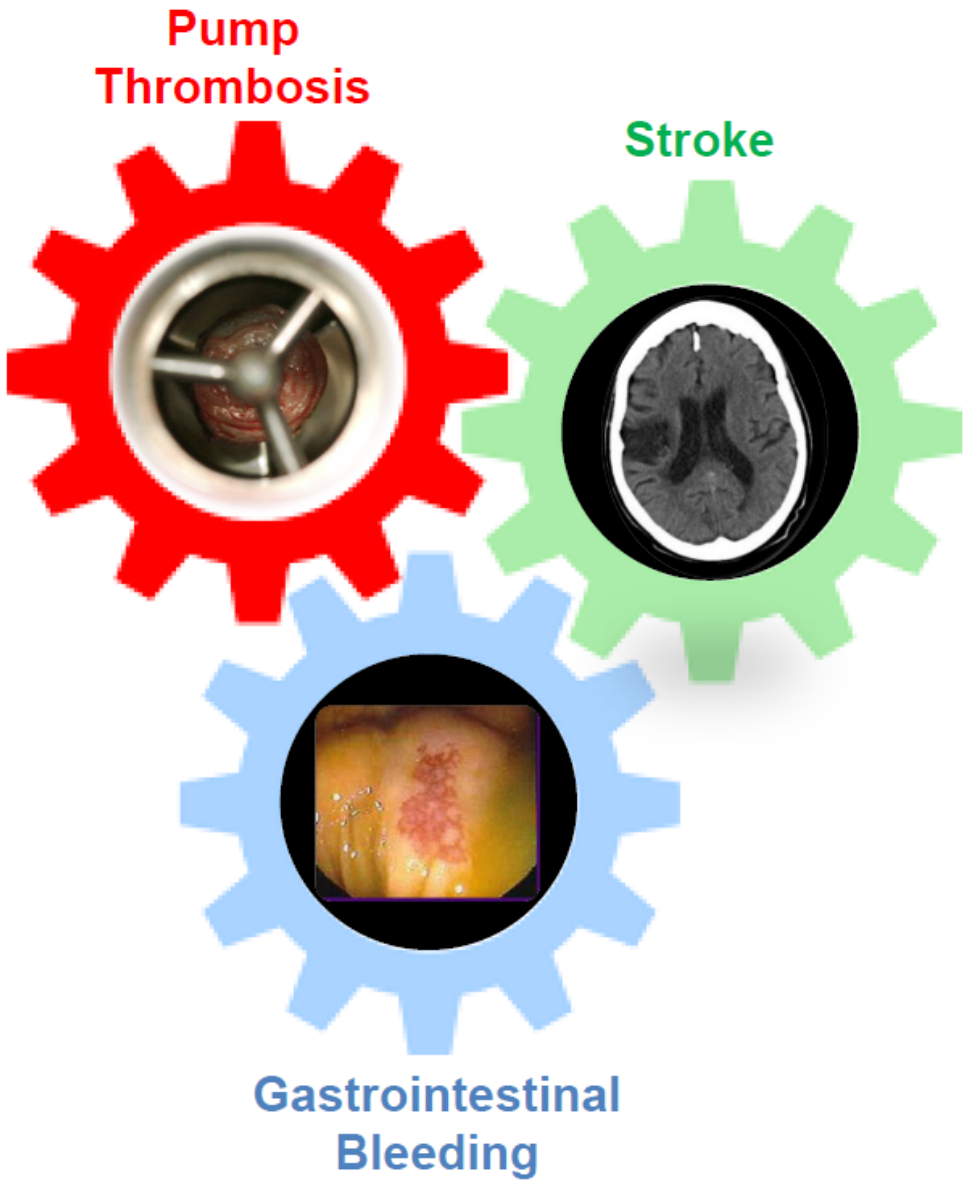


- **Wide** blood-flow passages to reduce shear stress
- **Frictionless** with absence of mechanical bearings
- **Intrinsic Pulse** designed to reduce stasis and avert thrombosis

Background

- Despite improving survival and quality of life, patients with continuous-flow LVADs are burdened with ***hemocompatibility-related complications***[1]

- Consequences of adverse interactions between the ***pump and circulating blood elements***
  - Pump thrombosis
  - Stroke
  - Gastrointestinal bleeding



[1]Mehra MR. The burden of haemocompatibility with left ventricular assist systems: a complex weave. Eur Heart J 2019;40(8):673-7

Published Work Related to the HM3

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Fully Magnetically Levitated Circulatory Pump for Advanced Heart Failure

Mandeep R. Mehra, M.D., Yoshifumi Naka, M.D., Nir Uriel, M.D., Daniel J. Goldstein, M.D., Joseph C. Cleveland, Jr., M.D., Paolo C. Colombo, M.D., Mary N. Walsh, M.D., Carmelo A. Milano, M.D., Chetan B. Patel, M.D., Ulrich P. Jorde, M.D., Francis D. Pagani, M.D., Keith D. Aaronson, M.D., David A. Dean, M.D., Kelly McCants, M.D., Akinobu Itoh, M.D., Gregory A. Ewald, M.D., Douglas Horstmanshof, M.D., James W. Long, M.D., and Christopher Salerno, M.D., for the MOMENTUM 3 Investigators*

ORIGINAL ARTICLE

Two-Year Outcomes with a Magnetically Levitated Cardiac Pump in Heart Failure

M.R. Mehra, D.J. Goldstein, N. Uriel, J.C. Cleveland, Jr., M. Yuzefpolskaya, C. Salerno, M.N. Walsh, C.A. Milano, C.B. Patel, G.A. Ewald, A. Itoh, D. Dean, A. Krishnamoorthy, W.G. Cotts, A.J. Tatooles, U.P. Jorde, B.A. Bruckner, J.D. Estep, V. Jeevanandam, G. Sayer, D. Horstmanshof, J.W. Long, S. Gulati, E.R. Skipper, J.B. O'Connell, G. Heatley, P. Sood, and Y. Naka, for the MOMENTUM 3 Investigators*

Comprehensive Analysis of Stroke in the Long-Term Cohort of the MOMENTUM 3 Study

A Randomized Controlled Trial of the HeartMate 3 Versus the HeartMate II Cardiac Pump

Paolo C. Colombo, Mandeep R. Mehra ✉, Daniel J. Goldstein, Jerry D. Estep, Christopher Salerno, Ulrich P. Jorde, Jennifer A. Cowger, Joseph C. ClevelandJr, Nir Uriel, Gabriel Sayer, Eric R. Skipper, Francis X. Downey, Masahiro Ono, Robert HookerJr, Anelechi C. Anyanwu, Michael M. Givertz, Claudius Mahr, Ia Topuria, Sami I. Somo, Daniel L. Crandall, Douglas A. Horstmanshof

Originally published 17 Sep 2018 | https://doi.org/10.1161/CIRCULATIONAHA.118.037231 | Circulation. 2018;139:155–168

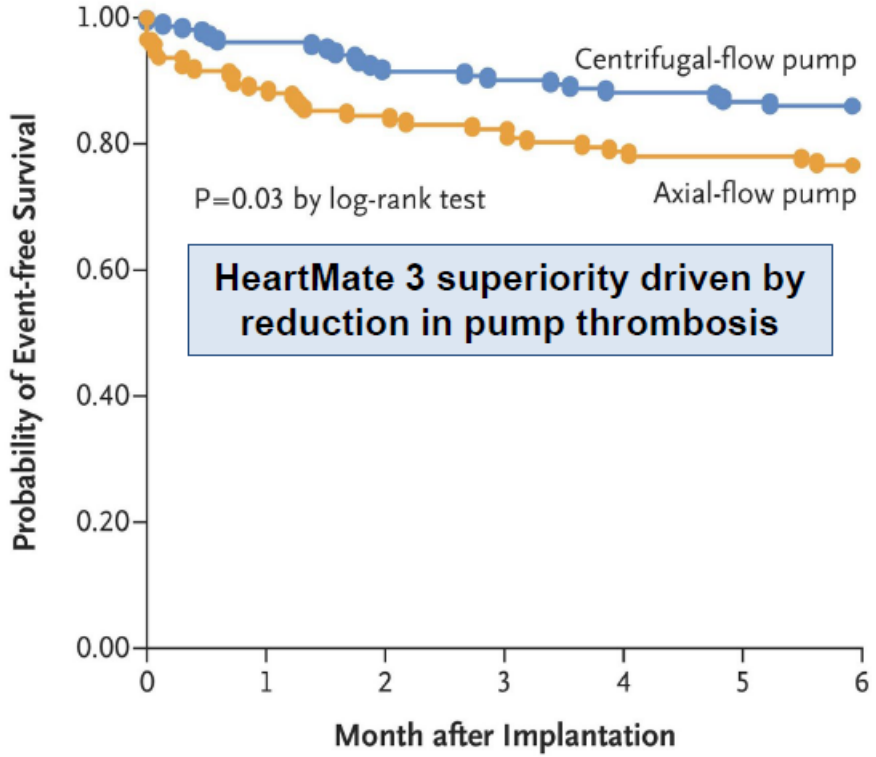
ORIGINAL ARTICLE

A Fully Magnetically Levitated Left Ventricular Assist Device — Final Report

M.R. Mehra, N. Uriel, Y. Naka, J.C. Cleveland, Jr., M. Yuzefpolskaya, C.T. Salerno, M.N. Walsh, C.A. Milano, C.B. Patel, S.W. Hutchins, J. Ransom, G.A. Ewald, A. Itoh, N.Y. Raval, S.C. Silvestry, R. Cogswell, R. John, A. Bhimaraj, B.A. Bruckner, B.D. Lowes, J.Y. Um, V. Jeevanandam, G. Sayer, A.A. Mangi, E.J. Molina, F. Sheikh, K. Aaronson, F.D. Pagani, W.G. Cotts, A.J. Tatooles, A. Babu, D. Chomsky, J.N. Katz, P.B. Tessmann, D. Dean, A. Krishnamoorthy, J. Chuang, I. Topuria, P. Sood, and D.J. Goldstein, for the MOMENTUM 3 Investigators*

Two Interim Analyses

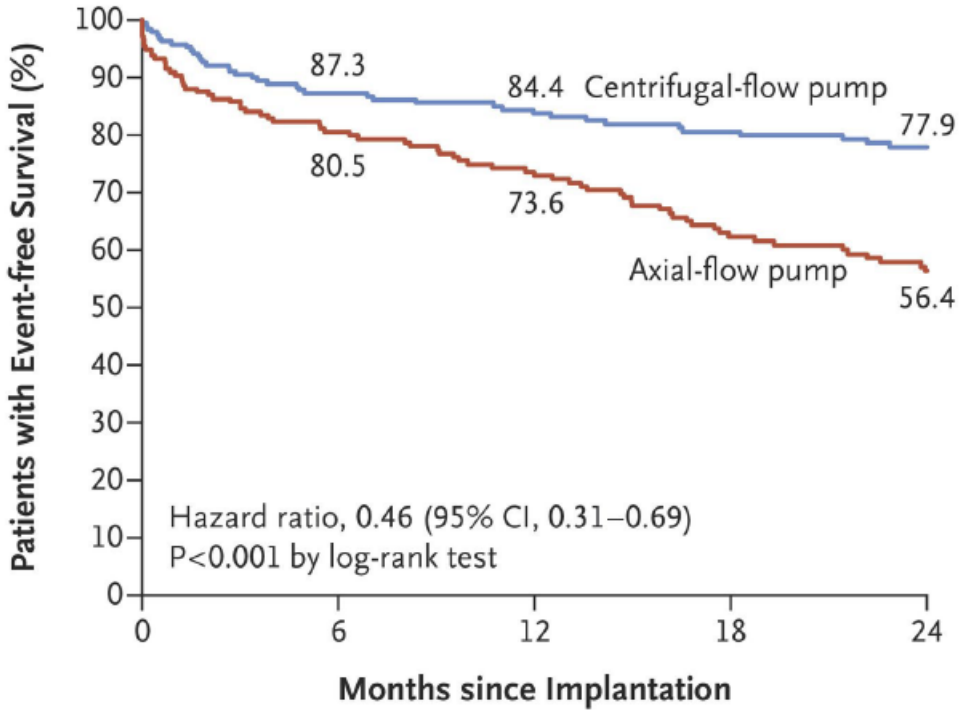
*ST Cohort: 294 Patients at 6 Months[1]



HeartMate 3 superiority driven by reduction in pump thrombosis

No. at Risk							
Centrifugal-flow pump	152	146	138	135	130	128	127
Axial-flow pump	142	125	119	116	110	106	103

*LT Cohort: 366 Patients at 2 Years[2,3]



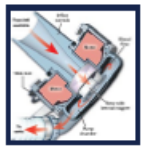
No. at Risk					
Centrifugal-flow pump	190	161	141	122	111
Axial-flow pump	176	134	114	90	75

*Primary endpoint is survival at 2 years free of disabling stroke (>3 mRS) or reoperation to replace or remove a malfunctioning device

[1]Mehra MR et al. A Fully Magnetically Levitated Circulatory Pump for Advanced Heart Failure. *N Engl J Med* 2017;376(5):440-50.
[2]Mehra MR et al. Two-Year Outcomes with a Magnetically Levitated Cardiac Pump in Heart Failure. *N Engl J Med* 2018;378(15):1386-95
[3]Colombo PC et al. Comprehensive Analysis of Stroke in the Long-Term Cohort of the MOMENTUM 3 Study. *Circ* 2019;139 (2):155-68

MOMENTUM 3

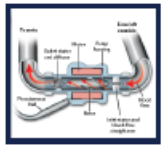
Adaptive Trial Design



HeartMate 3

Advanced Heart Failure Irrespective of Intended Goal of Therapy

(Bridge to Transplant or Destination Therapy)



HeartMate II

Randomization 1:1

Short Term (ST) Cohort[1]
N=294
6-month follow-up

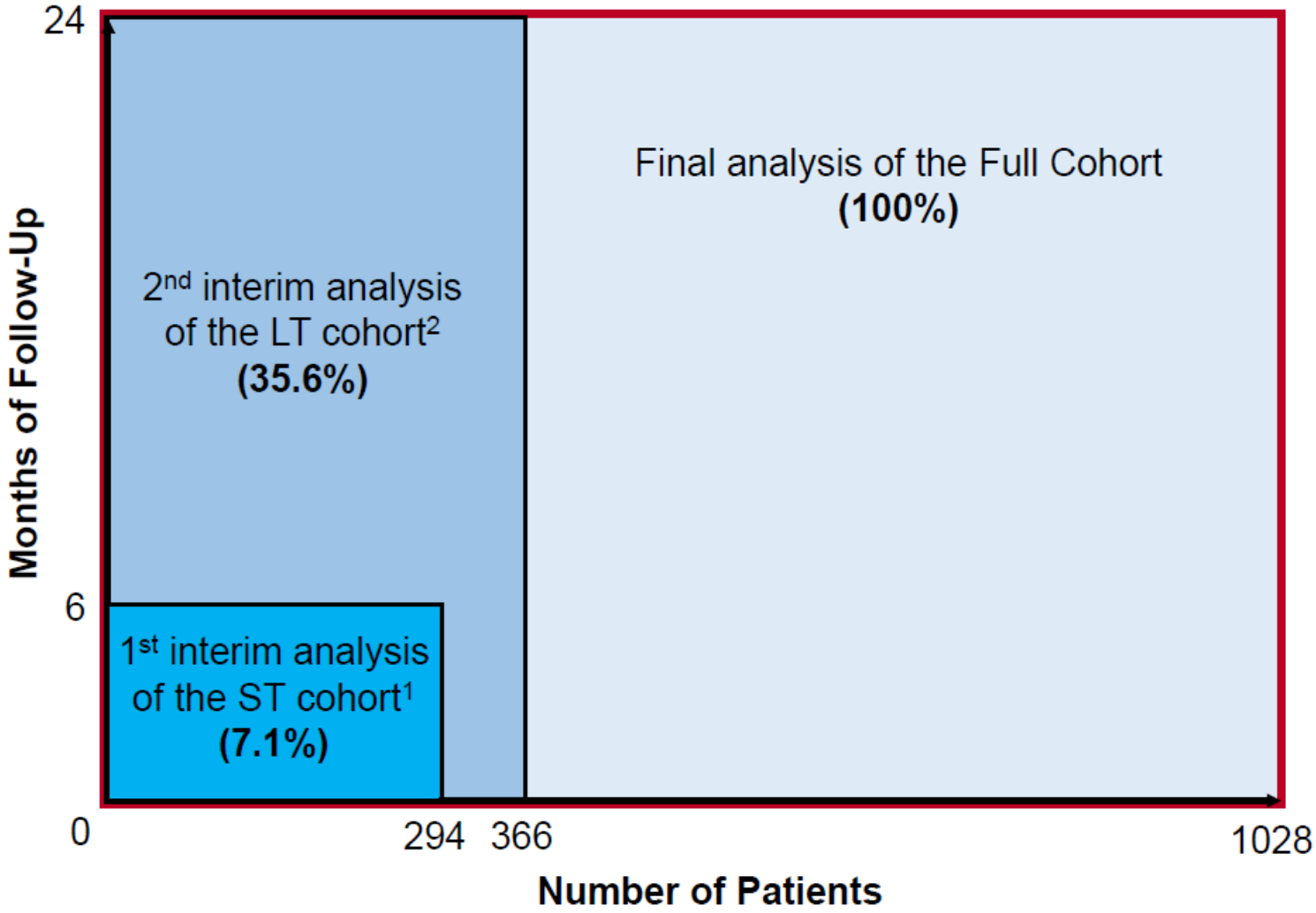
Additional 72 patients enrolled

Long Term (LT) Cohort[2]
N=366
2-year follow-up

Additional 662 patients enrolled

Full Cohort
N=1028
2-year follow-up

Net Trial Experience

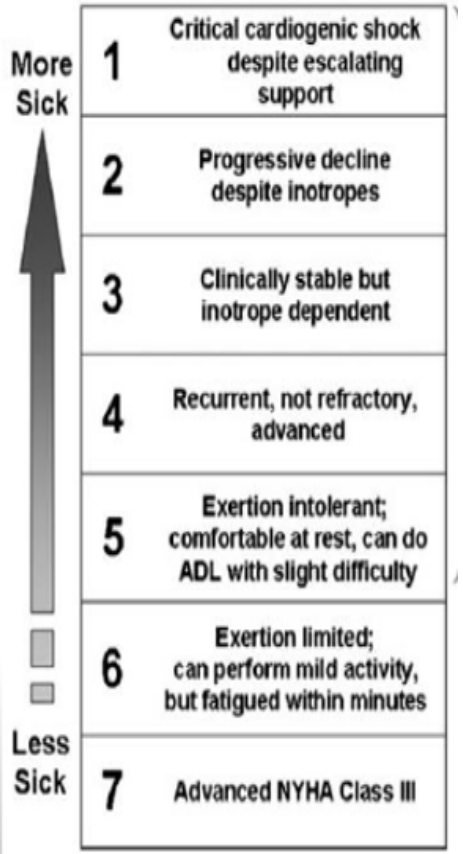


MOMENTUM 3

[1]Mehra MR et al. A Fully Magnetically Levitated Circulatory Pump for Advanced Heart Failure. *N Engl J Med* 2017;376(5):440-50

[2]Mehra MR et al. Two-Year Outcomes with a Magnetically Levitated Cardiac Pump in Heart Failure. *N Engl J Med* 2018;378(15):1386-95

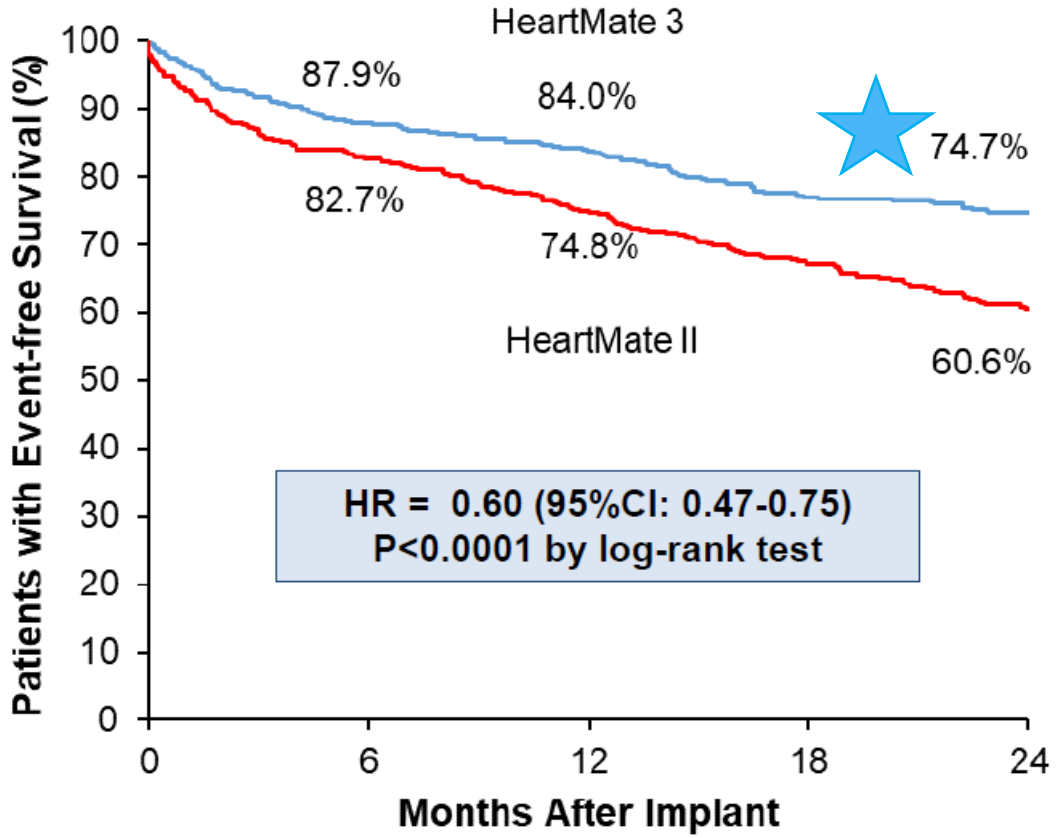
Patient Profile



Characteristic	HeartMate 3 (n=516)	HeartMate II (n=512)
Mean age - years	59 ± 12	60 ± 12
Male - no. (%)	411 (79.7)	419 (81.8)
Race - no. (%)		
White	342 (66.3)	367 (71.7)
Black or African American	145 (28.1)	120 (23.4)
Asian	8 (1.6)	3 (0.6)
Native Hawaiian or Pacific islander	0 (0)	4 (0.8)
Other	21 (4.1)	18 (3.5)
Ischemic cause of heart failure - no. (%)	216 (41.9)	240 (46.9)
Intravenous inotropic agents - no. (%)	445 (86.2)	423 (82.6)
Intra aortic balloon pump - no. (%)	64 (12.4)	79 (15.4)
Serum creatinine - mg/dl	1.4 ± 0.4	1.4 ± 0.4
Serum sodium – mmol/liter	135.4 ± 4.1	135.5 ± 4.2
Mean arterial pressure - mmHg	79.2 ± 10.4	79.2 ± 10.1
INTERMACS profile - no. (%)		
1	11 (2.1)	18 (3.5)
2	156 (30.2)	146 (28.5)
3	272 (52.7)	251 (49.0)
4	67 (13.0)	82 (16.0)
5-7 or not provided*	10 (1.9)	15 (2.9)
Intended goal of pump support - no. (%)		
Bridge to transplantation (BTT)	113 (21.9)	121 (23.6)
Bridge to candidacy for transplantation	86 (16.7)	81 (15.8)
Destination therapy (DT)	317 (61.4)	310 (60.5)

Primary End Point (ITT)

Survival at 2 years free of disabling stroke (>3 mRS) or reoperation to replace or remove a malfunctioning device



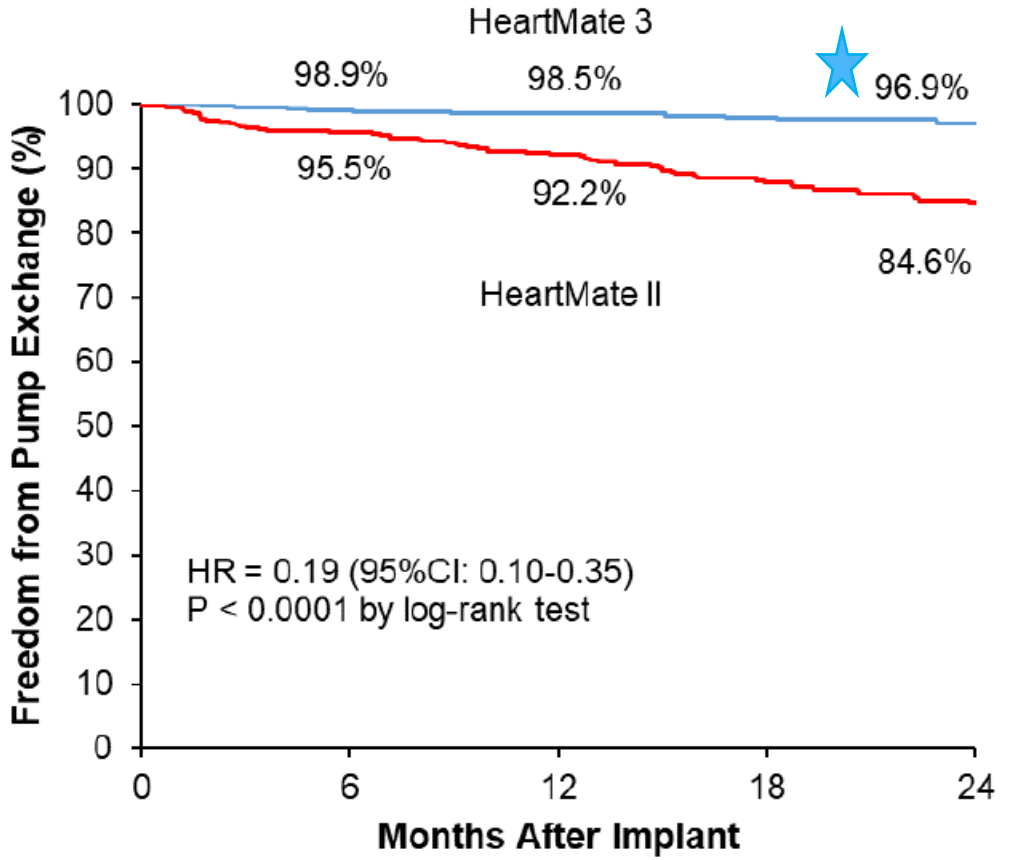
No. at Risk:					
HeartMate 3	516	438	373	313	280
HeartMate II	512	401	321	264	223

MOMENTUM 3

mRS denotes modified Rankin Score; HR, hazard ratio; CI, confidence interval

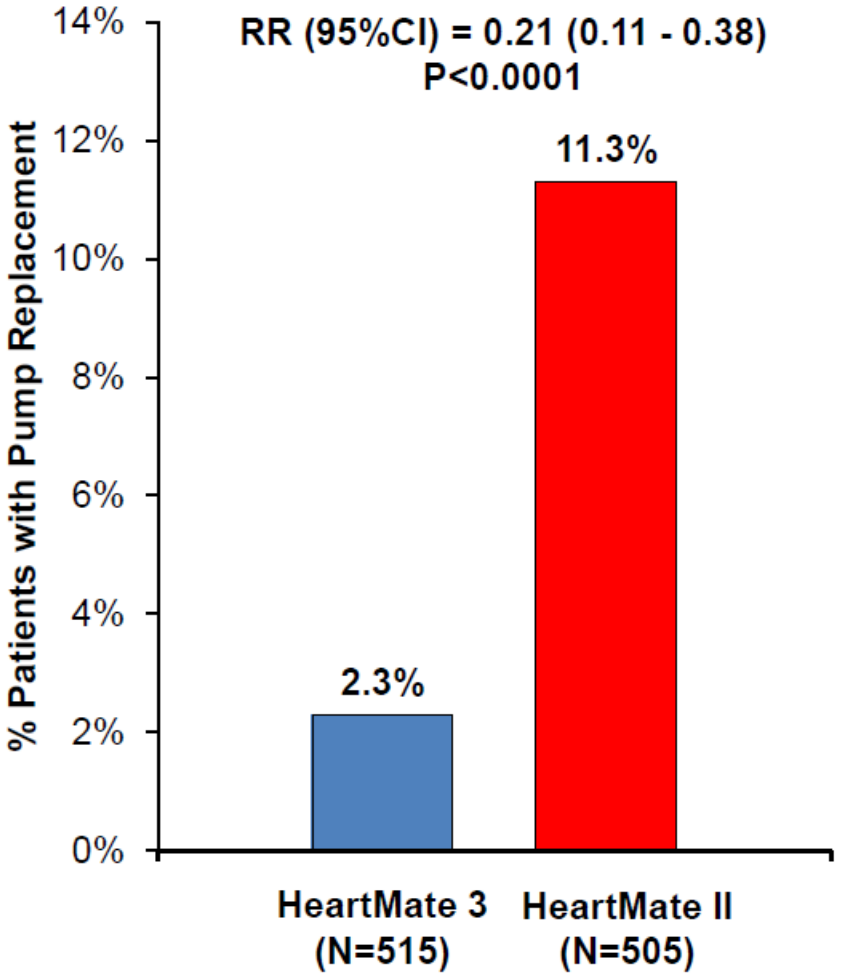
Principal Secondary End Point

Pump replacement at 2 years



No. at Risk:

HeartMate 3	515	444	379	317	283
HeartMate II	505	403	322	264	226

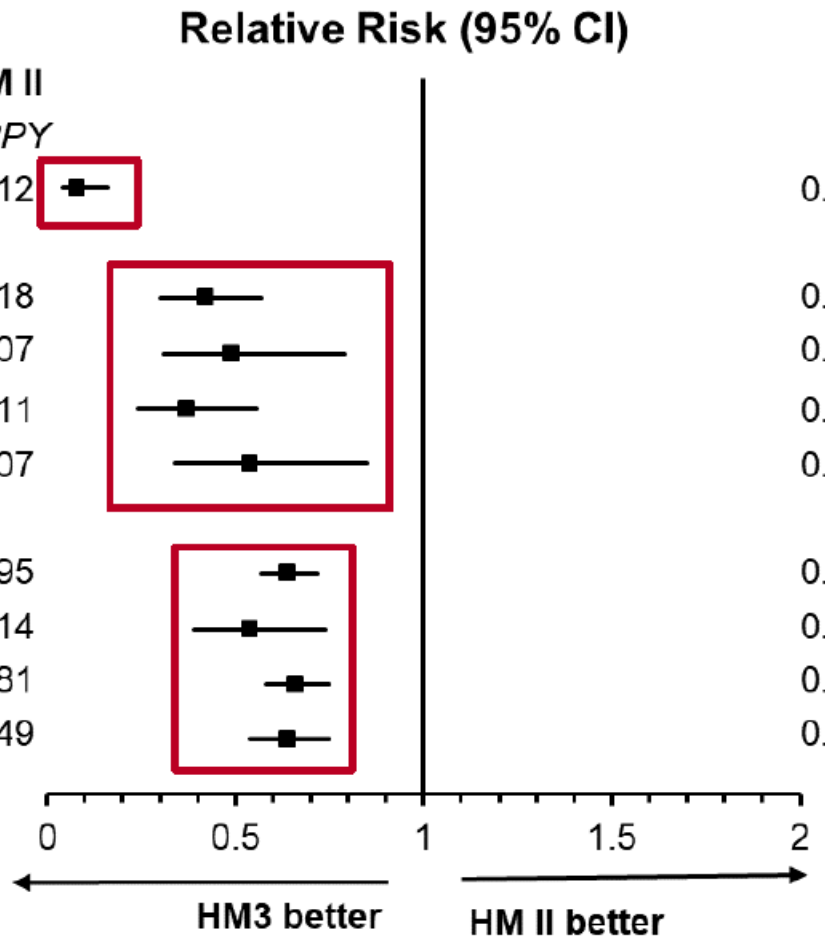


MOMENTUM 3

RR denotes relative risk; CI, confidence interval; HR, hazard ratio

Principal Hemocompatibility-Related Adverse Events

Adverse Event	HM3 *n (%)*	HM II *n (%)*	HM3 *EPPY*	HM II *EPPY*	Relative Risk (95% CI)	*P-Value**
Suspected pump thrombosis	7 (1.4)	70 (13.9)	0.01	0.12	0.08 (0.04 - 0.16)	<0.0001
Any stroke	51 (9.9)	98 (19.4)	0.08	0.18	0.42 (0.30 - 0.57)	<0.0001
Hemorrhagic stroke	25 (4.9)	43 (8.5)	0.03	0.07	0.49 (0.31 - 0.79)	0.004
Ischemic stroke	29 (5.6)	65 (12.9)	0.04	0.11	0.37 (0.24 - 0.56)	<0.0001
Disabling stroke	26 (5.0)	38 (7.5)	0.04	0.07	0.54 (0.34 - 0.85)	0.008
Any bleeding	225 (43.7)	278 (55.0)	0.61	0.95	0.64 (0.57 - 0.72)	<0.0001
Requiring surgery	50 (9.7)	89 (17.6)	0.08	0.14	0.54 (0.39 - 0.74)	<0.001
Not requiring surgery	197 (38.3)	251 (49.7)	0.53	0.81	0.66 (0.58 - 0.75)	<0.0001
Gastrointestinal bleeding	126 (24.5)	156 (30.9)	0.31	0.49	0.64 (0.54 - 0.75)	<0.0001

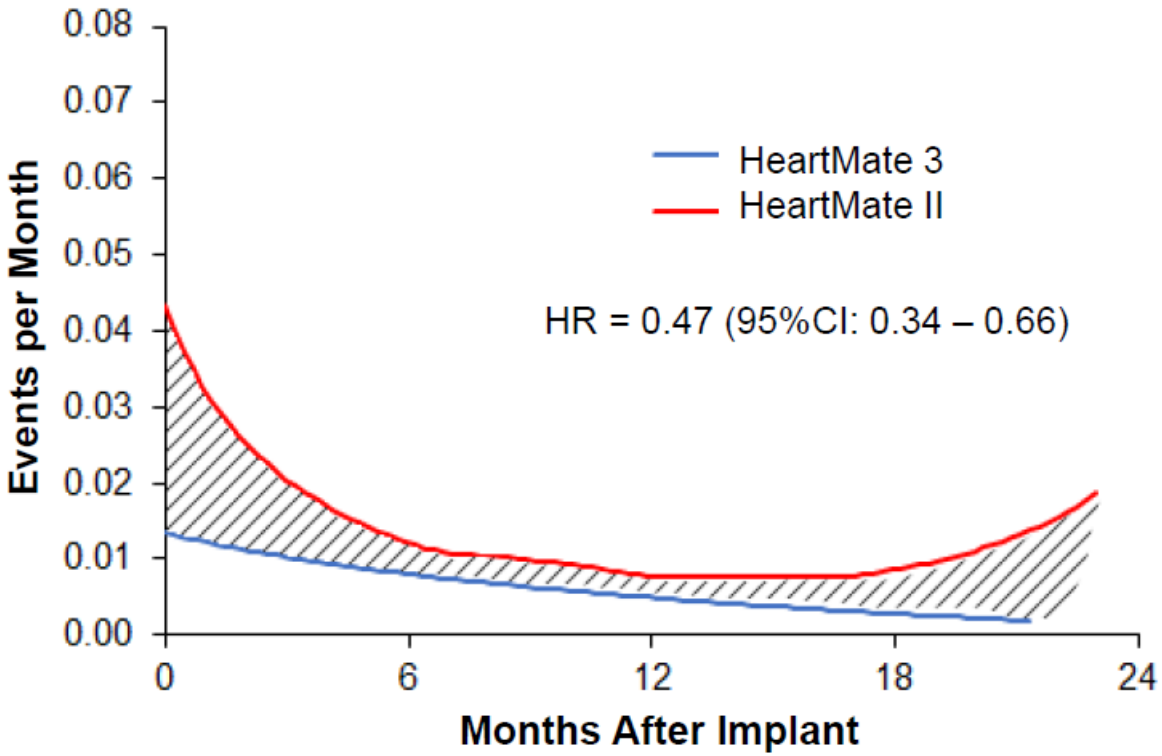


MOMENTUM 3

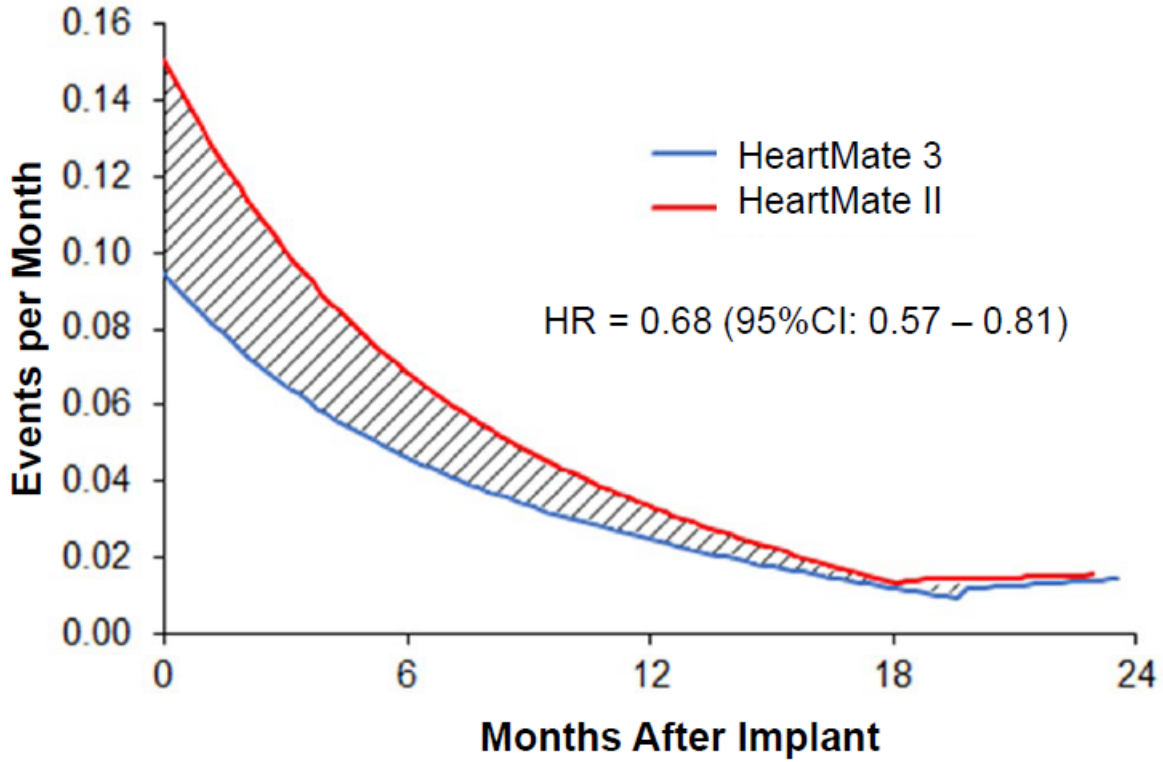
HM3 denotes HeartMate 3; HMII HeartMate II; EPPY events per patient year; CI, confidence interval. *P values were calculated with Poisson regression.

Stroke and Bleeding Hazard Functions

Hazard Function for All Stroke



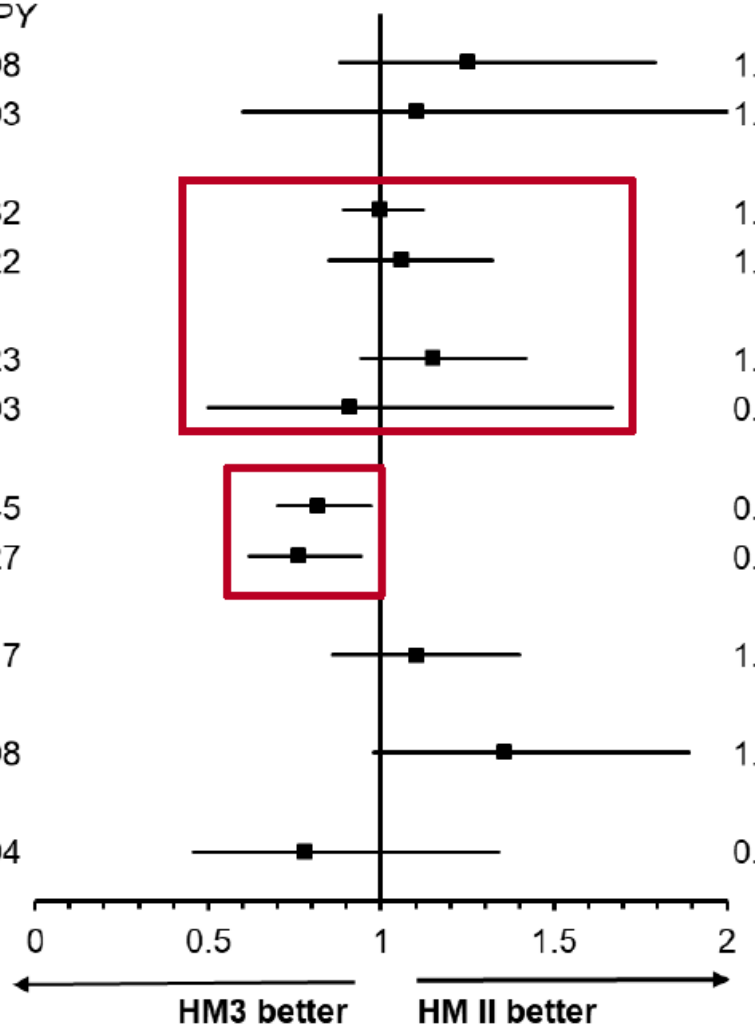
Hazard Function for All Bleeding



Mean arterial blood pressure, *aspirin* usage, and *INR* did not differ between the treatment arms during the trial

Other Adverse Events

Adverse Event	HM3 *n (%)*	HM II *n (%)*	HM3 *EPPY*	HM II *EPPY*	Relative Risk (95% CI)	*P-Value**
Other neurologic event+	59 (11.5)	47 (9.3)	0.09	0.08	1.25 (0.88 - 1.79)	0.21
TIA	16 (3.1)	19 (3.8)	0.03	0.03	1.10 (0.60 - 2.02)	0.75
Any major infection	300 (58.3)	285 (56.4)	0.82	0.82	1.00 (0.89 - 1.12)	0.96
LVAS driveline infection	120 (23.3)	98 (19.4)	0.23	0.22	1.06 (0.85 - 1.32)	0.60
Any right heart failure	176 (34.2)	143 (28.3)	0.27	0.23	1.15 (0.94 - 1.42)	0.18
Managed with RVAS	21 (4.1)	21 (4.2)	0.03	0.03	0.91 (0.50 - 1.67)	0.76
Cardiac arrhythmia	185 (35.9)	207 (41.0)	0.37	0.45	0.82 (0.70 - 0.97)	0.02
Ventricular arrhythmia	107 (20.8)	128 (25.3)	0.20	0.27	0.76 (0.62 - 0.94)	0.01
Respiratory failure	111 (21.6)	98 (19.4)	0.19	0.17	1.10 (0.86 - 1.40)	0.44
Renal dysfunction	73 (14.2)	56 (11.1)	0.11	0.08	1.36 (0.98 - 1.89)	0.07
Hepatic dysfunction	25 (4.9)	27 (5.3)	0.03	0.04	0.78 (0.46 - 1.34)	0.38



HM3 denotes HeartMate 3; HMII HeartMate II; EPPY events per patient year; CI, confidence interval; TIA transient ischemic attack; RVAS right ventricular assist system.
*P values were calculated with Poisson regression. +Includes TIA, encephalopathy, seizure and neurologic events other than stroke

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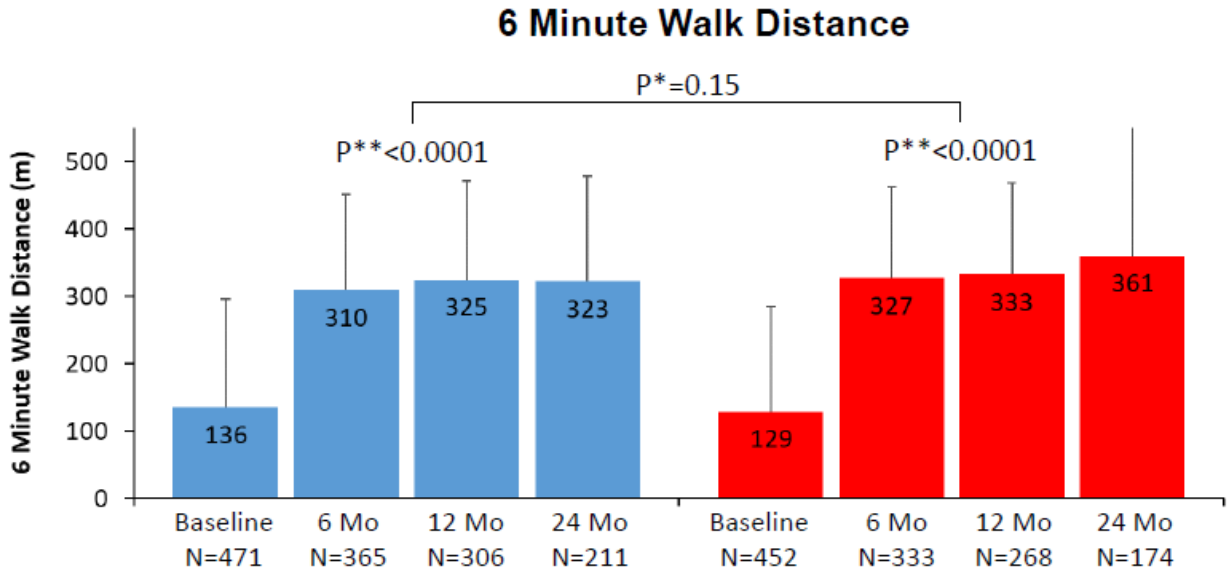
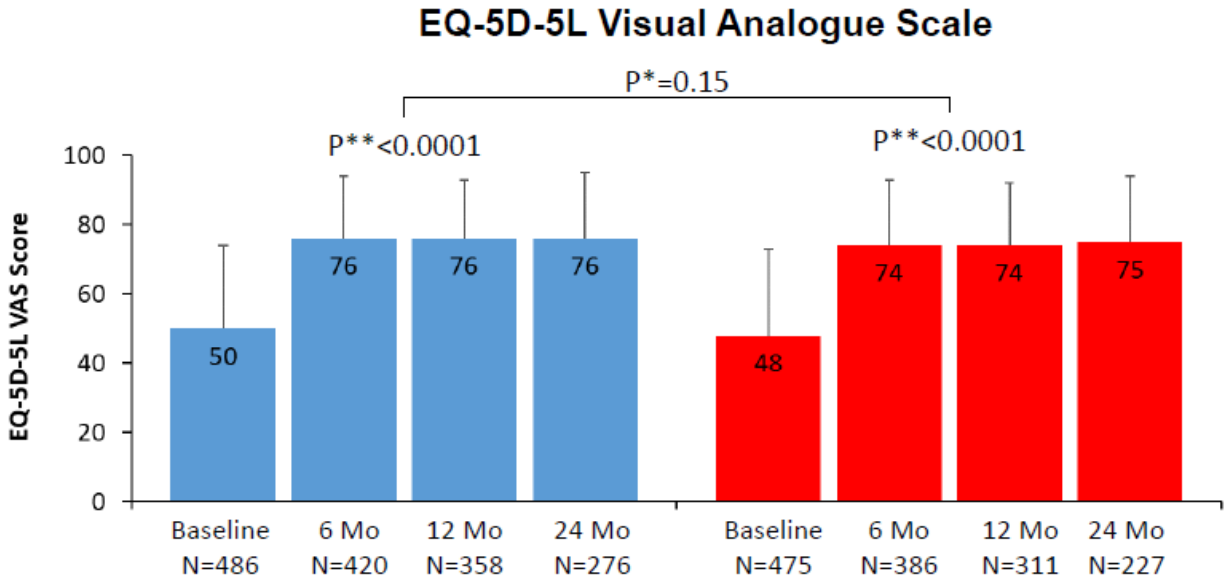
Hospitalization Profiles, Days Out of the Hospital and Readmissions

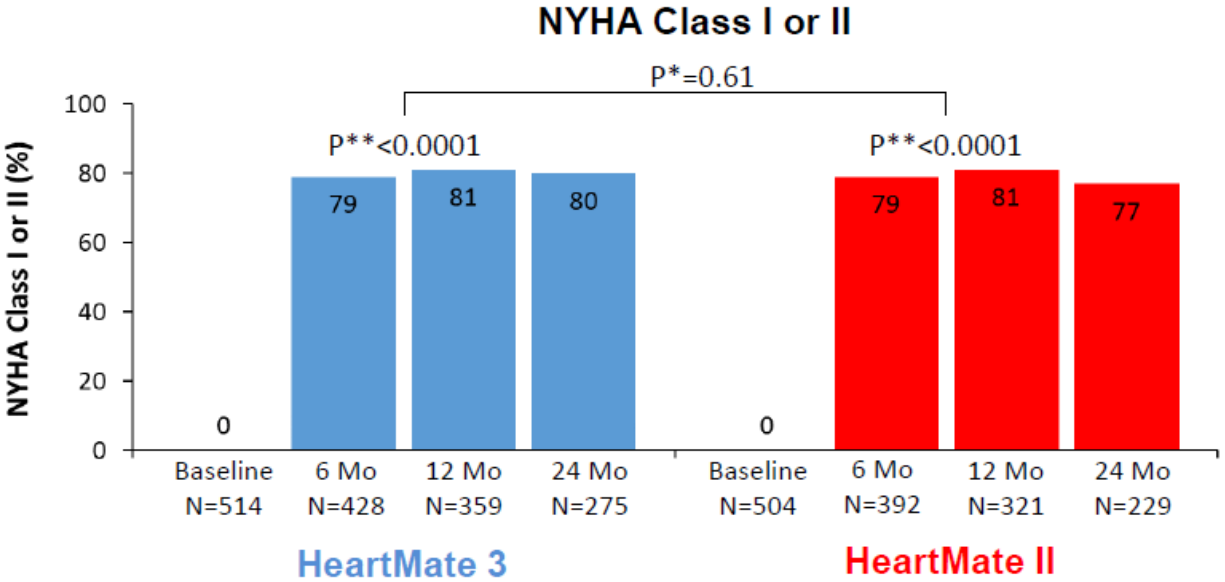
Patients Discharged on LVAD Support	HeartMate 3 (N=485)	HeartMate II (N=471)	Difference or HR (95%CI)	P*
Implant Hospitalization				
Median length of stay [interquartile range] - days	19 [14 to 25]	17 [14 to 24]	2 (0.7 to - 3.3)	0.11
Post-Discharge				
Median duration of rehospitalization [interquartile range] - days	13 [4 to 37]	18 [6 to 40]	-5 (-8.7 to -1.3)	0.02
Median duration on LVAD support ***outside*** of hospital [interquartile range] - days	653 [333 to 696]	605 [259 to 690]	48 (-0.8 to 96.8)	0.008
Rate of rehospitalization for any cause - EPPY	2.26	2.47	0.92 (0.86 - 0.99)⁺	0.03

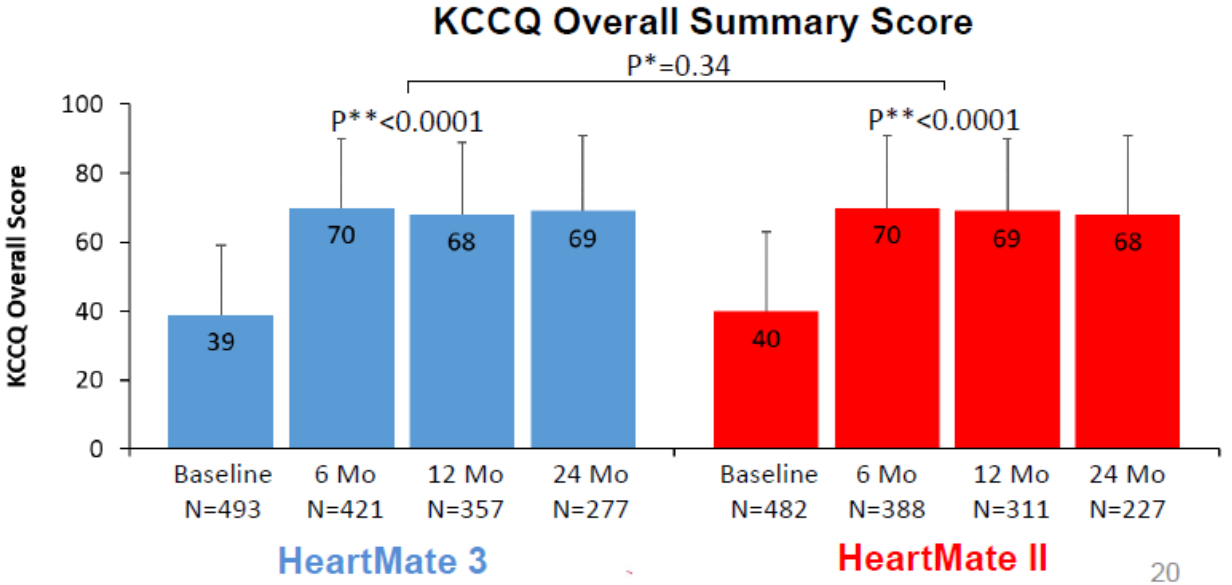
EPPY denotes events per patient year; HR, hazard ratio; CI, confidence interval.
*P values for differences in duration are from Wilcoxon Rank Sum test. ⁺HR was calculated from the Andersen-Gill model.

Functional Status and Quality of Life







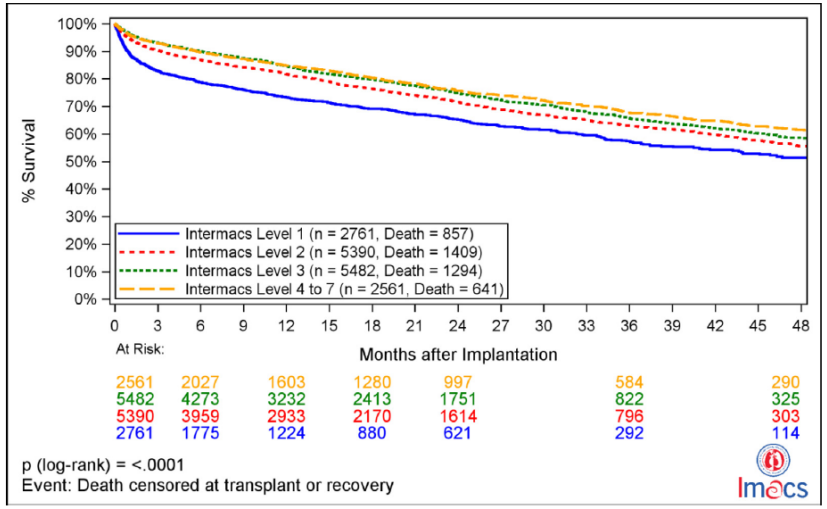


*P-value between treatment arms over time. **P-value for treatment over time. Longitudinal changes were analyzed with linear mixed-effects models using data from baseline, 3, 6, 12, 18, and 24 month visits.

Summary: A More Forgiving Pump

- In the largest LVAD study performed, the centrifugal-flow HeartMate 3 LVAS has demonstrated superior performance compared to the axial-flow HeartMate II pump with respect to:
  - Reduction in Pump Thrombosis and need for **Pump replacement**
  - Reduction in Strokes of ***any type*** and of ***any severity***
  - Reduction in any Bleeding, particularly ***gastrointestinal*** *bleeds*
  - Reduction in Cardiac Arrhythmias, particularly ***ventricular arrhythmias***
  - Reduction in ***re-hospitalizations*** and *days spent* in the hospital

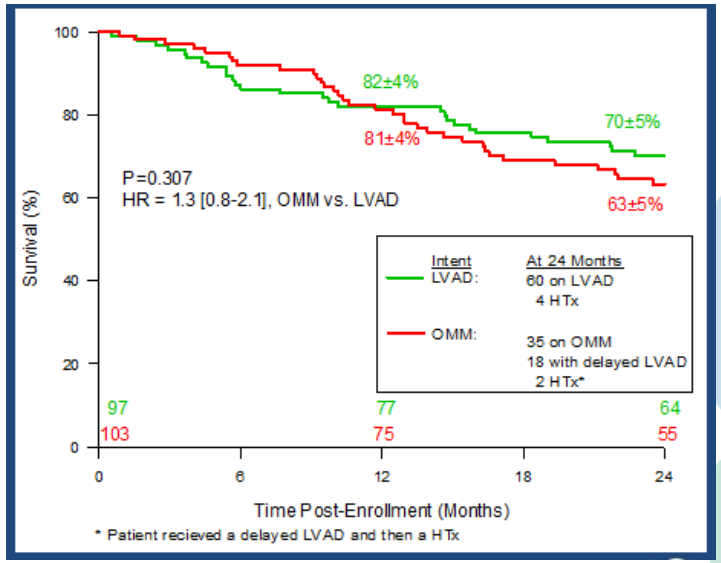
INTERMACS Profile and Outcome



IM 4-7 85% 1 yr Survival

IM 1 73% 1 yr Survival

Goldstein et al. JHLT 2019

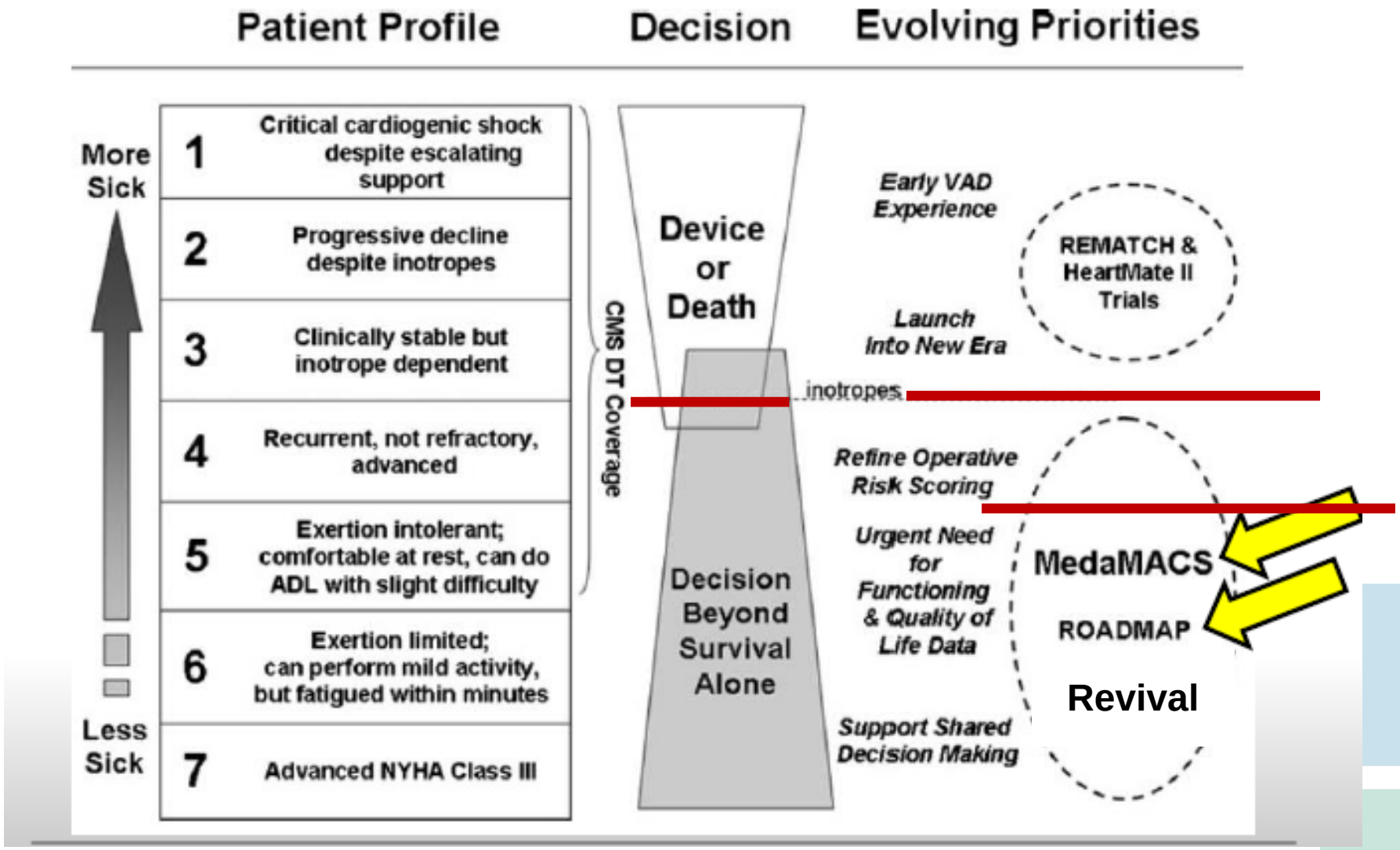


LVAD 82% 1 yr Survival

OMM 81% 1 yr Survival

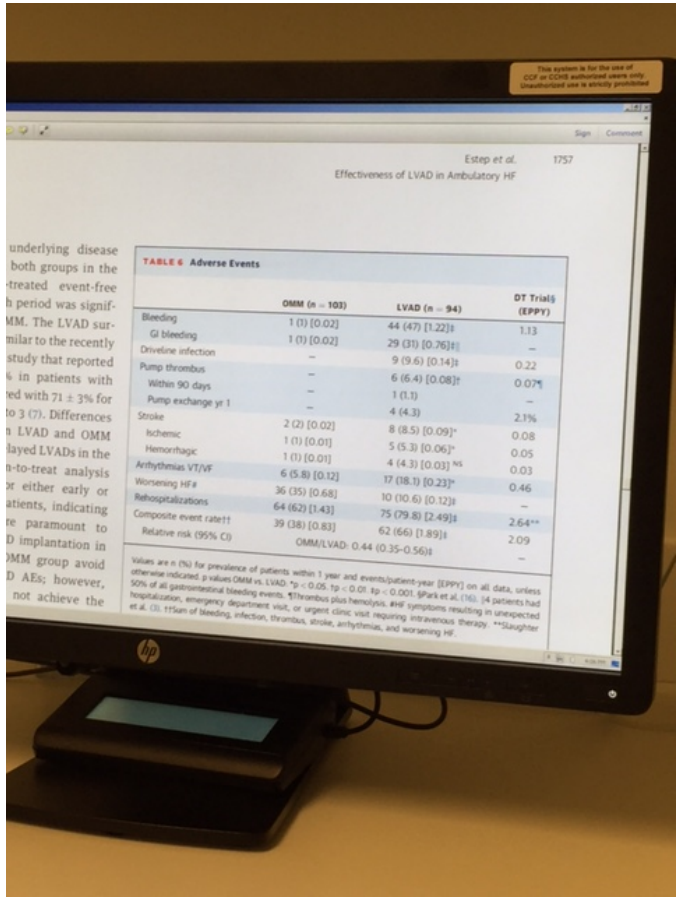
Starling, Estep et al
JACC HF 2017

Advanced Heart Failure and Durable LVADs



Stewart GC et al. Curr Cardiol Rep. 2013 Sep;15(9):394.

Enhanced Shared Decision Making with the Patient



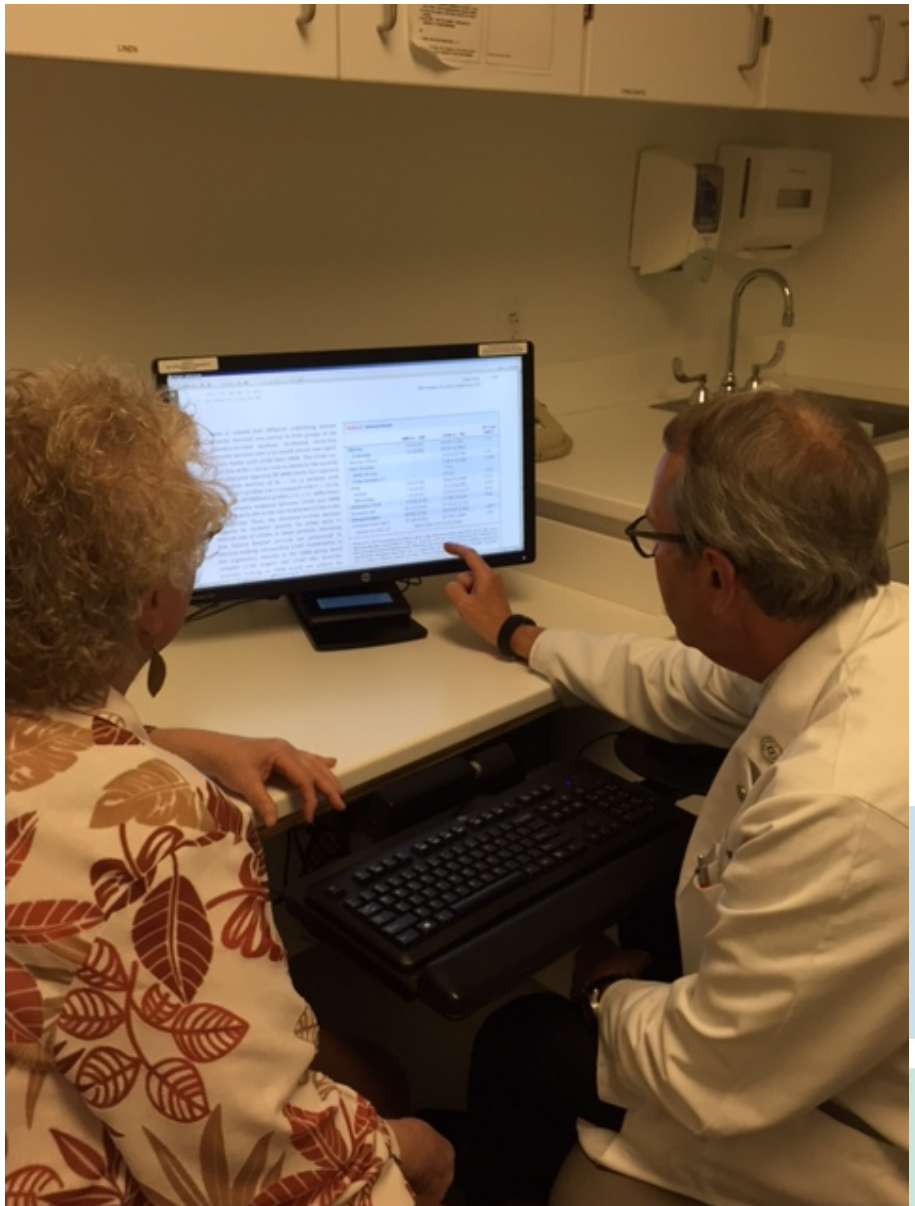
Estep et al. 1757
Effectiveness of LVAD in Ambulatory HF

underlying disease
both groups in the
treated event-free
h period was signif-
MM. The LVAD sur-
milar to the recently
study that reported
% in patients with
ed with 71 ± 3% for
to 3 (7). Differences
n LVAD and OMM
layed LVADs in the
n-to-treat analysis
or either early or
atients, indicating
re paramount to
D implantation in
OMM group avoid
D AEs; however,
not achieve the

TABLE 6 Adverse Events

	OMM (n = 103)	LVAD (n = 94)	DT Trial§ (EPPY)
Bleeding	1 (1) [0.02]	44 (47) [1.22]‡	1.13
GI bleeding	1 (1) [0.02]	29 (31) [0.76]‡	–
Driveline infection	–	9 (9.6) [0.14]‡	0.22
Pump thrombus	–	6 (6.4) [0.08]†	0.07¶
Within 90 days	–	1 (1.1)	–
Pump exchange yr 1	–	4 (4.3)	2.1%
Stroke	2 (2) [0.02]	8 (8.5) [0.09]*	0.08
Ischemic	1 (1) [0.01]	5 (5.3) [0.06]*	0.05
Hemorrhagic	1 (1) [0.01]	4 (4.3) [0.03] NS	0.03
Arrhythmias VT/VF	6 (5.8) [0.12]	17 (18.1) [0.23]*	0.46
Worsening HF#	36 (35) [0.68]	10 (10.6) [0.12]‡	–
Rehospitalizations	64 (62) [1.43]	75 (79.8) [2.49]‡	2.64**
Composite event rate††	39 (38) [0.83]	62 (66) [1.89]‡	2.09
Relative risk (95% CI)	OMM/LVAD: 0.44 (0.35–0.56)‡		–

Values are n (%) for prevalence of patients within 1 year and events/patient-year [EPPY] on all data, unless otherwise indicated. p values OMM vs. LVAD. *p < 0.05. †p < 0.01. ‡p < 0.001. §Park et al. (16). ||4 patients had 50% of all gastrointestinal bleeding events. ¶Thrombus plus hemolysis. #HF symptoms resulting in unexpected hospitalization, emergency department visit, or urgent clinic visit requiring intravenous therapy. **Slaughter et al. (3). ††Sum of bleeding, infection, thrombus, stroke, arrhythmias, and worsening HF.



2 Published LVAD Decision Aids

JAMA Internal Medicine | Original Investigation

Effectiveness of an Intervention Supporting Shared Decision Making for Destination Therapy Left Ventricular Assist Device
The DECIDE-LVAD Randomized Clinical Trial

Larry A. Allen, MD, MHS; Colleen K. McIlvennan, DNP, ANP; Jocelyn S. Thompson, MA; Shannon M. Dunlay, MD, MS; Shane J. LaRue, MD, MPHS; Eldrin F. Lewis, MD, MPH; Chetan B. Patel, MD; Laura Blue, DNP, ANP; Diane L. Fairclough, PhD; Erin C. Leister, MS; Russell E. Glasgow, PhD; Joseph C. Cleveland Jr., MD; Clifford Phillips; Vicie Baldridge; Mary Norine Walsh, MD; Daniel D. Matlock, MD, MPH

IMPORTANCE Shared decision making helps patients and clinicians elect therapies aligned with patients' values and preferences. This is particularly important for invasive therapies with considerable trade-offs.

OBJECTIVE To assess the effectiveness of a shared decision support intervention for patients considering destination therapy left ventricular assist device (DT LVAD) placement.

DESIGN, SETTING, AND PARTICIPANTS From 2015 to 2017, a randomized, stepped-wedge trial was conducted in 6 US LVAD implanting centers including 248 patients being considered for DT LVAD. After randomly varying time in usual care, sites were transitioned to an intervention consisting of clinician education and use of DT LVAD pamphlet and video patient decision aids. Follow up occurred at 1 and 6 months.

Editorial

Supplemental content

Clinical Trials

A Multisite Randomized Controlled Trial of a Patient-Centered Ventricular Assist Device Decision Aid (VADDA Trial)

KRISTIN M. KOSTICK, PhD,[1] COURTENAY R. BRUCE, JD, MA,[1] CHARLES G. MINARD, PhD, MS,[2] ROBERT J. VOLK, PhD,[3] ANDREW CIVITELLO, MD,[4] SELIM R. KRIM, MD,[5] DOUGLAS HORSTMANSHOF, MD,[6] VINAY THOHAN, MD,[7] MATTHIAS LOEBE, MD,[8] MAZEN HANNA, MD,[9] BRIAN A. BRUCKNER, MD,[10] J.S. BLUMENTHAL-BARBY, PhD,[1,**] AND JERRY D. ESTEP, MD[9]

Houston, Texas; New Orleans, Louisiana Oklahoma City, Oklahoma; Milwaukee, Wisconsin; Miami, Florida; and Cleveland, Ohio

- Multi-Site (Cleveland Clinic-Houston Methodist, Texas Heart, Ochsner Clinic, Baptist Integris, and Aurora Health) RCT, N=98
- Overall aim: Develop a patient-centered decision aid for decision-making about advanced heart failure treatment
  - Arm 1 (Control): Normal LVAD Education
  - Arm 2: Normal Education + LVAD Decision Aid
- Main Outcome: Knowledge (1 week, 1 month)

Lvad Decision Aid

HOW TO DECIDE

"I read, informed myself, watched videos and talked one-on-one with two patients who had an LVAD."

Thousands of people have been in the same situation you are in now. Here are some ways that they and the people close to them have made the right choices for them. These ideas can help as you make your decision.

WHAT'S IMPORTANT TO YOU?

People make different choices about whether to get an LVAD. No single option is right for everyone. The key to making a decision that you are satisfied with is making that decision based on your own values. What is most important to you about how you live the rest of your life? Talk about your values with your loved ones and with your medical team. You can use the tool in this kit called **LVAD and Your Values** to help others understand what is most important to you.

GET THE INFORMATION YOU NEED

This kit has lots of general information that can help you decide whether to get an LVAD. But it's also important to ask questions about your specific situation. For example, your overall health can make it more likely or less likely that you would experience complications during LVAD surgery. In this kit, you will find a list of questions that you can ask your doctor.

You should also talk with someone who has an LVAD. This kit includes questions to ask a current LVAD patient as well.

LEARN MORE ↙

OTHER PARTS OF THIS KIT EXPAND ON THE INFORMATION IN THIS TABLE

The LVAD Surgery section of this book has more information about the risks of the operation.

The Living with an LVAD section of this book gives details on how people with the device may feel, what LVAD maintenance involves, and the complications that send LVAD patients back to the hospital.

The About Palliative Care and Hospice section of this book has more information on medication management of heart failure and "comfort care."

The Caregivers' Guide explains how life changes for people caring for a loved one who has an LVAD.

LVAD by the Numbers lists survival rates for LVAD patients and LVAD decliners. It also lists the frequency of LVAD medical complications.

COMPARE YOUR OPTIONS

BENEFITS OF GETTING AN LVAD

The LVAD can prolong life.

People with LVADs feel better (feel less shortness of breath, walk farther without getting tired, etc.)

BENEFITS OF NOT GETTING AN LVAD

People who opt not to get the device avoid the medical risks of surgery and living with the LVAD.

People who opt not to get an LVAD avoid the lifestyle changes associated with the device.

RISKS & CHALLENGES OF GETTING AN LVAD

The surgery carries risks, such as bleeding, stroke, renal failure, and respiratory failure.

People living with LVADs are at risk for infections and stroke that can happen over time and send them back to the hospital.

An LVAD requires maintenance such as caring for the driveline site and monitoring battery life.

An LVAD requires lifestyle changes for both the patient (special preparations for showering, carrying the device and batteries on all trips outside the home, etc.) and his or her caregiver (helping the patient with daily needs in the first weeks after surgery, managing medical appointments, etc.).

RISKS & CHALLENGES OF NOT GETTING AN LVAD

People who decline an LVAD deal with continuing heart failure symptoms and hospitalization.

People who decline an LVAD have lower one-year survival rates than people who get the device.

LVAD DA Randomized Controlled Trial – Results

- Patient-level results
  - **DA improved LVAD knowledge** during crucial decision-making period
    - 68% vs. 59% on validated Knowledge Quiz at 1-week post-education (p=0.01)
  - Patients receiving DA could **more accurately envision life post-LVAD**
    - 75% vs. 43% reported LVAD outcomes were "Very close to what I expected" (p=0.08)
  - Patients receiving DA were **more satisfied with life post-implant**
    - Scored 28 vs. 23 out of 30 on Satisfaction with Life Scale (p=0.008)
  - **DA did not bias decision making**
    - No observed differences in rates of acceptance vs. decline of LVAD (85% vs. 78%, p=0.74)
- Clinician-level results
  - Agreed that DA:
    - **Improved patient understanding & value-based decision-making**
    - Standardized patient education & **sped up clinical flow**
    - Reduced imposing their own values & **fostered realistic post-surgery expectations**

Current Project – LVAD DA Dissemination & Implementation

Baylor College of Medicine

CENTER FOR MEDICAL ETHICS & HEALTH POLICY

Cleveland Clinic

HOUSTON Methodist LEADING MEDICINE

THE UNIVERSITY OF CHICAGO MEDICAL CENTER

Miami Transplant Institute | Jackson Health System | UHealth

Montefiore

INTEGRIS

Ochsner Health System

Baylor St. Luke's Medical Center

BRIGHAM HEALTH BRIGHAM AND WOMEN'S HOSPITAL

Aurora Health Care

- Goals:
  - Facilitate wider dissemination of the DA for 2 years
  - Support LVAD coordinators and clinicians in using the LVAD DA to promote SDM
  - Evaluate dissemination success
  - Assist with long-term sustainability plan for LVAD DA
- 10 partner sites across the U.S.
- Not a research study
  - Funds will support the printing of DAs for ten sites
  - Opportunity to translate research into practice
- Implement DA as part of your standard of care

New Horizons / New Heart Allocation Policy

Cleveland Metropark Lakefront Reservation

Heart Organ Allocation

- 1988: 2 tiered system, prioritizing sickest patients in tier 1
- 1998: Creation of a 3 tiered system: 1A/1B/2
- 2018: Creation of a 6 tiered system with exceptions allowed for “disadvantaged groups” such as restrictive heart disease

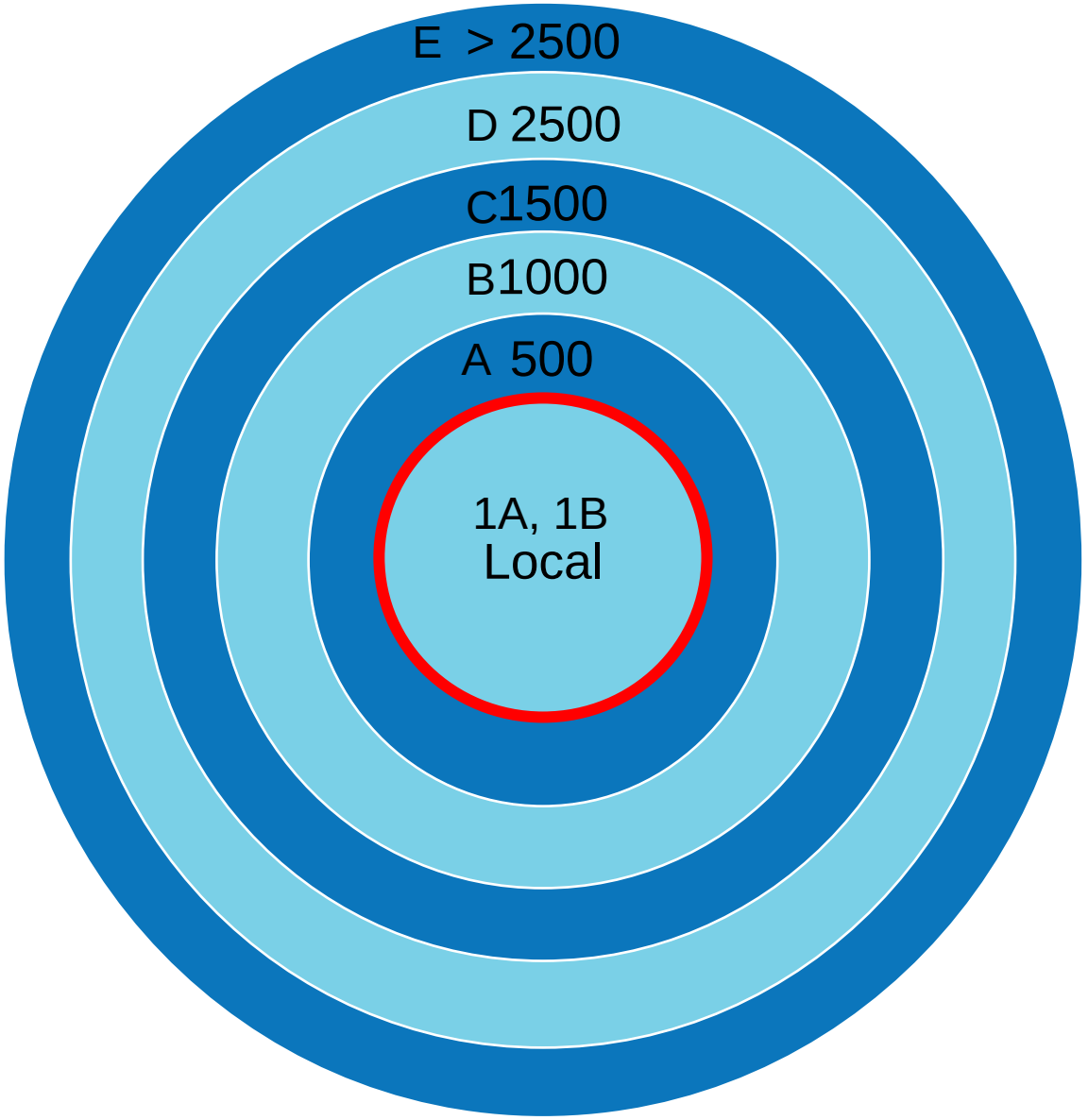
1998- 2018 UNOS allocation System

Table 1. Adapted From Organ Procurement and Transplantation Network Policies Dated September 1, 2013[4]

Status 1A	Requires admission to listing transplant center hospital and have at least one of the following indications, devices, or therapies in place
	Acute hemodynamic instability requiring mechanical circulatory support. This may include:
	Total artificial heart
	Intra-aortic balloon pump
	Extracorporeal membrane oxygenation (ECMO)
	Patients with LVAD and/or RVAD are afforded 30 days at any point after implantation if deemed clinically stable
	Patients with significant device-related complications while receiving mechanical circulatory support
	Continuous mechanical ventilation
	Continuous hemodynamic monitoring while receiving continuous infusion of a single high-dose or multiple intravenous inotropes
Status 1B	Requires at least one of the following devices or therapies in place
	LVAD and/or RVAD outside of the 30 days of Status 1A listing
	Continuous infusion of intravenous inotropes
Status 2	Transplant candidates who do not meet criteria for Status 1A or 1B
Status 7	Transplant candidates who are deemed temporarily unsuitable to receive a heart transplant

RVAC, right ventricular assist device.

Heart Geographic Distribution



<u>Prior Allocation System:</u>

Heart goes to 1A local,
1B local, then
1A in Zone A, then
1B in Zone A, then
status 2 local, then
status 2 Zone A.

Cold ischemic time: <4 hours

Proposed Solutions

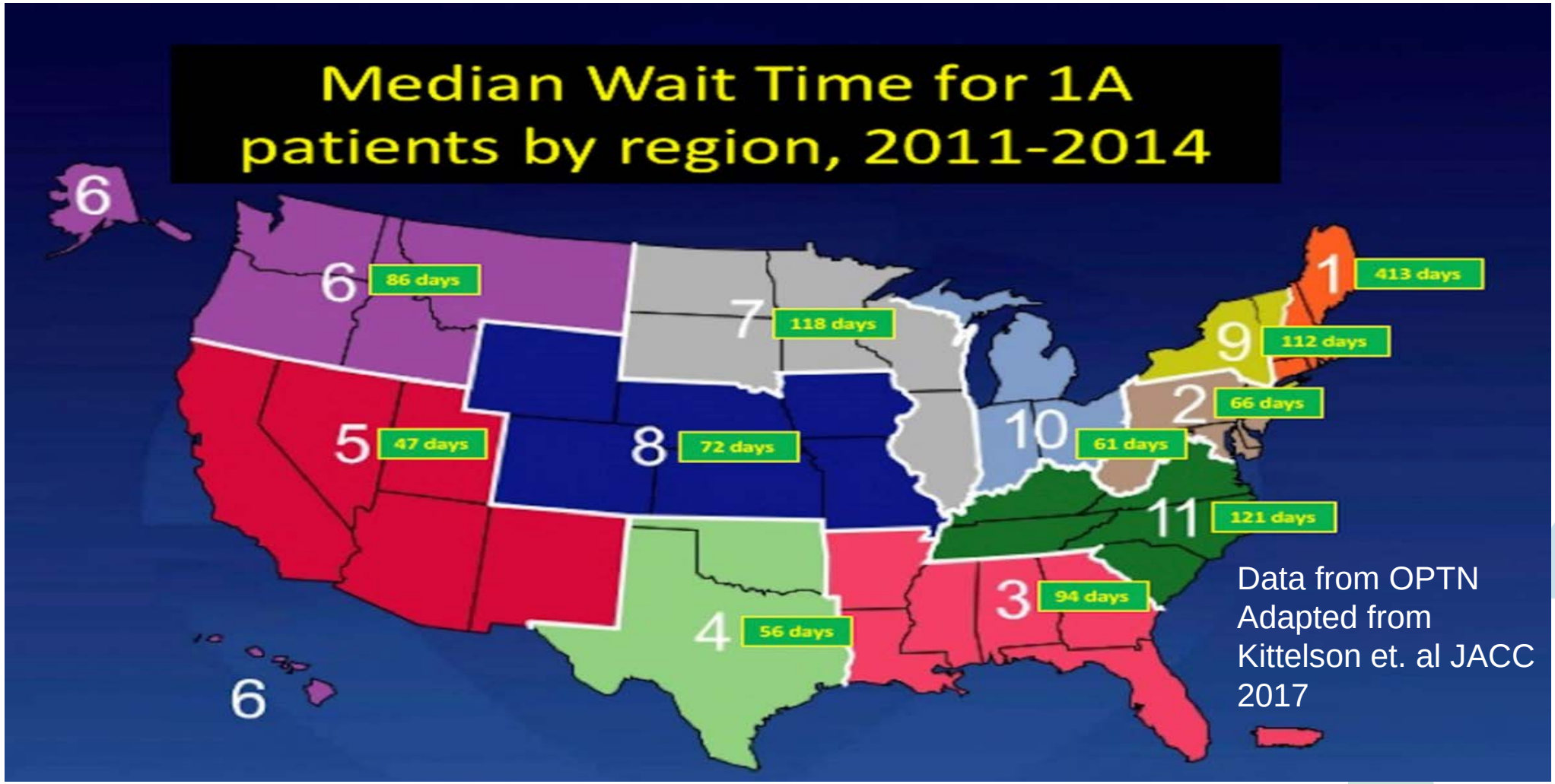
- Increase donor pool
- Increase donor ultilization
- Revise donor allocation to prioritize sickest patients first, thus minimizing waitlist mortality and reducing disparities

Noted Issues / Opportunities

- The use of MCSD or inotropes did not require hemodynamics criteria to be met-> need for objective data
- Not all MCSD support is created the same (i.e. ECMO ≠ LVAD)
- Survival on durable MCSD (especially HMIII) has improved over the past 10 years, and the 1998 allocation system does not fully reflect this.
- High number of exceptions were being filed

Potential Opportunity

Geographic disparity in wait times due to population and donor pool differences in regions



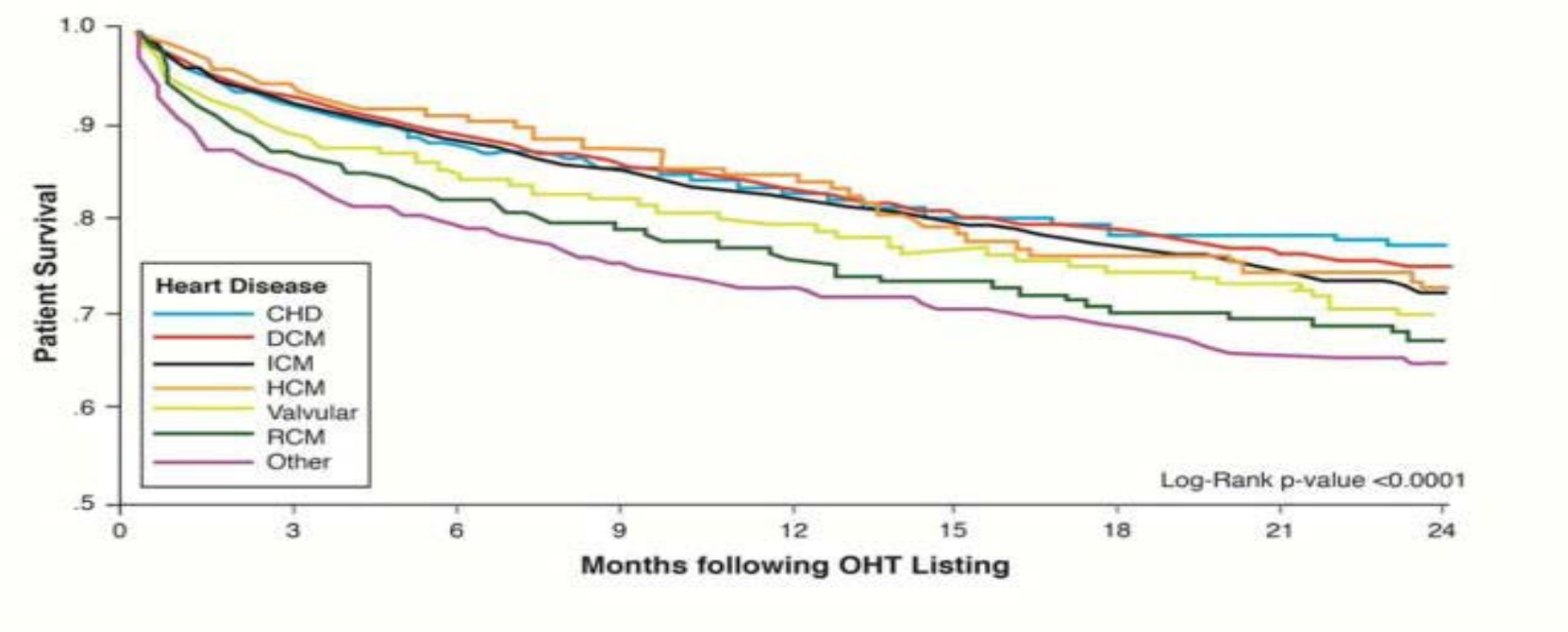
OPTN Broader sharing Policy "The Final Rule"

"Patients who need an organ transplant should not have to gamble that an organ will become available in their local area, nor should they have to travel to transplant centers far from home simply to improve their chances of getting an organ. Instead, patients everywhere in the country should have an equal chance to receive an organ, based on their medical condition and the judgment of their physicians. (DHHS, 1998a)"

- Goal is to "level the playing field" in organ allocation whereby the sickest patients get the organs first, regardless of patient's place of residence
- Standardization of degree of illness
- Allows status 1A and 1B candidates within a zone to be prioritized over local status 2 patients

Potential Opportunity

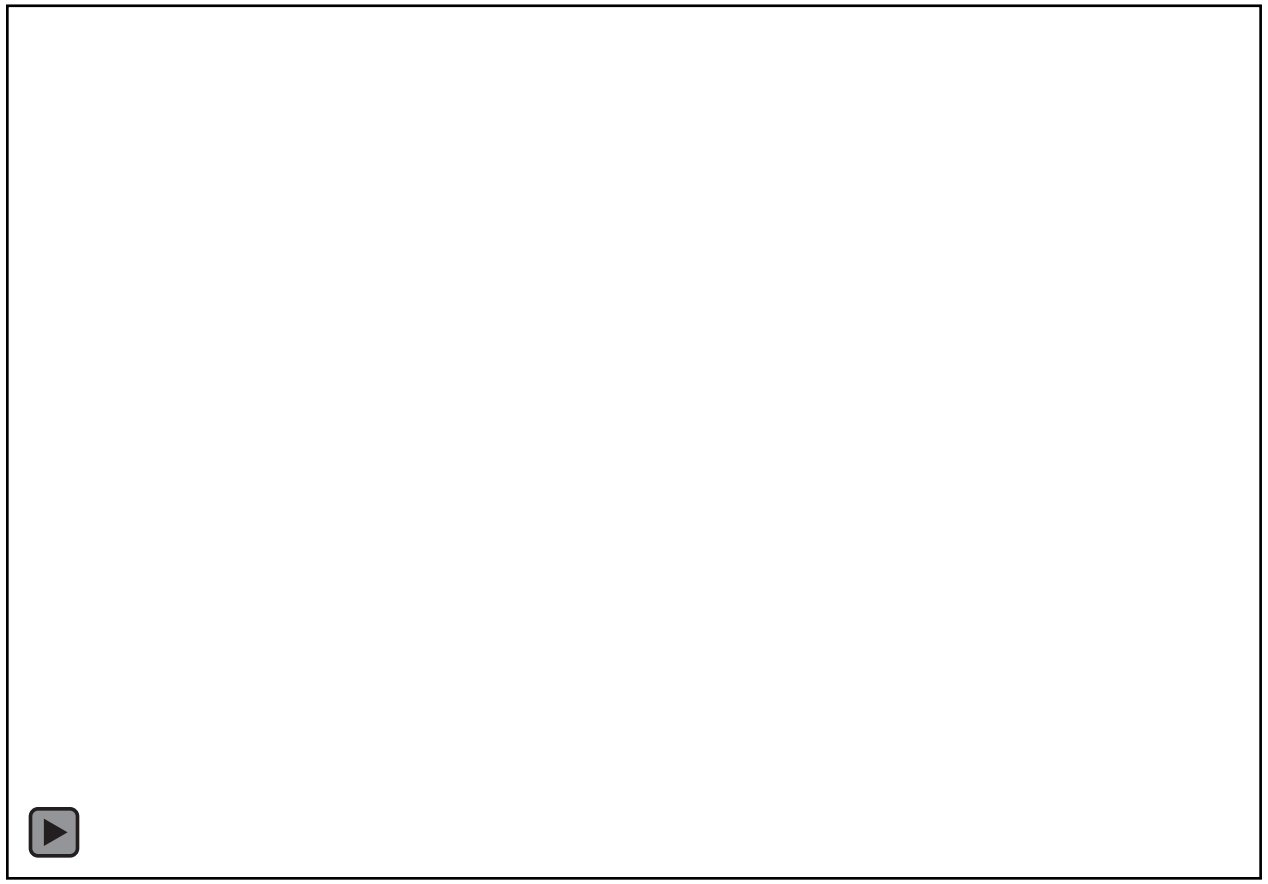
- Patients with restrictive cardiomyopathy (HCM, amyloid) and congenital heart disease may not be suitable for durable MCS, and possibly have longer wait times or higher waitlist mortality

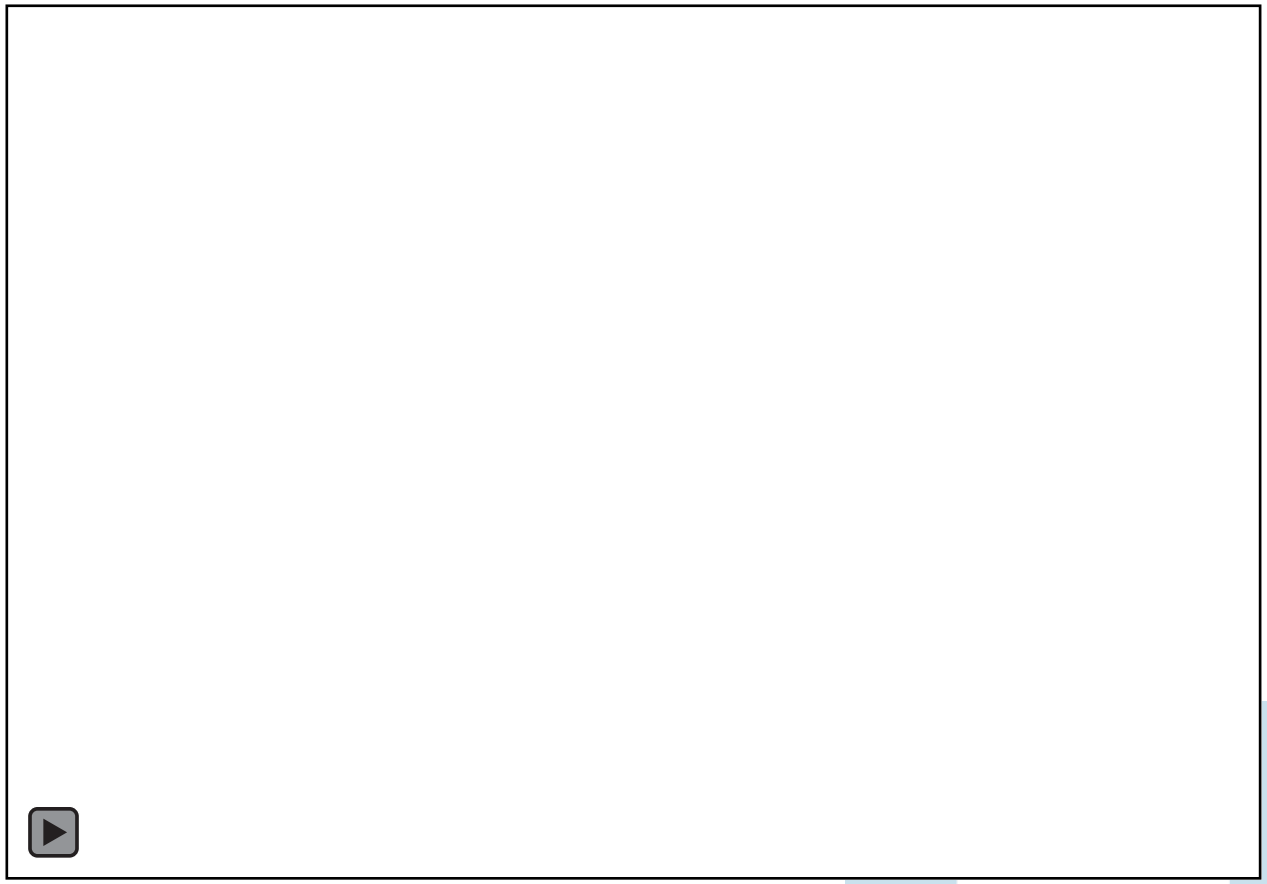


Kaplan- Meier survival curves while awaiting OHT according to subtype of heart disease with censoring at time of heart transplantation

Hsich et al. JACC 2016

Cardiac Phenotype Not Ideal for a Durable LVAD





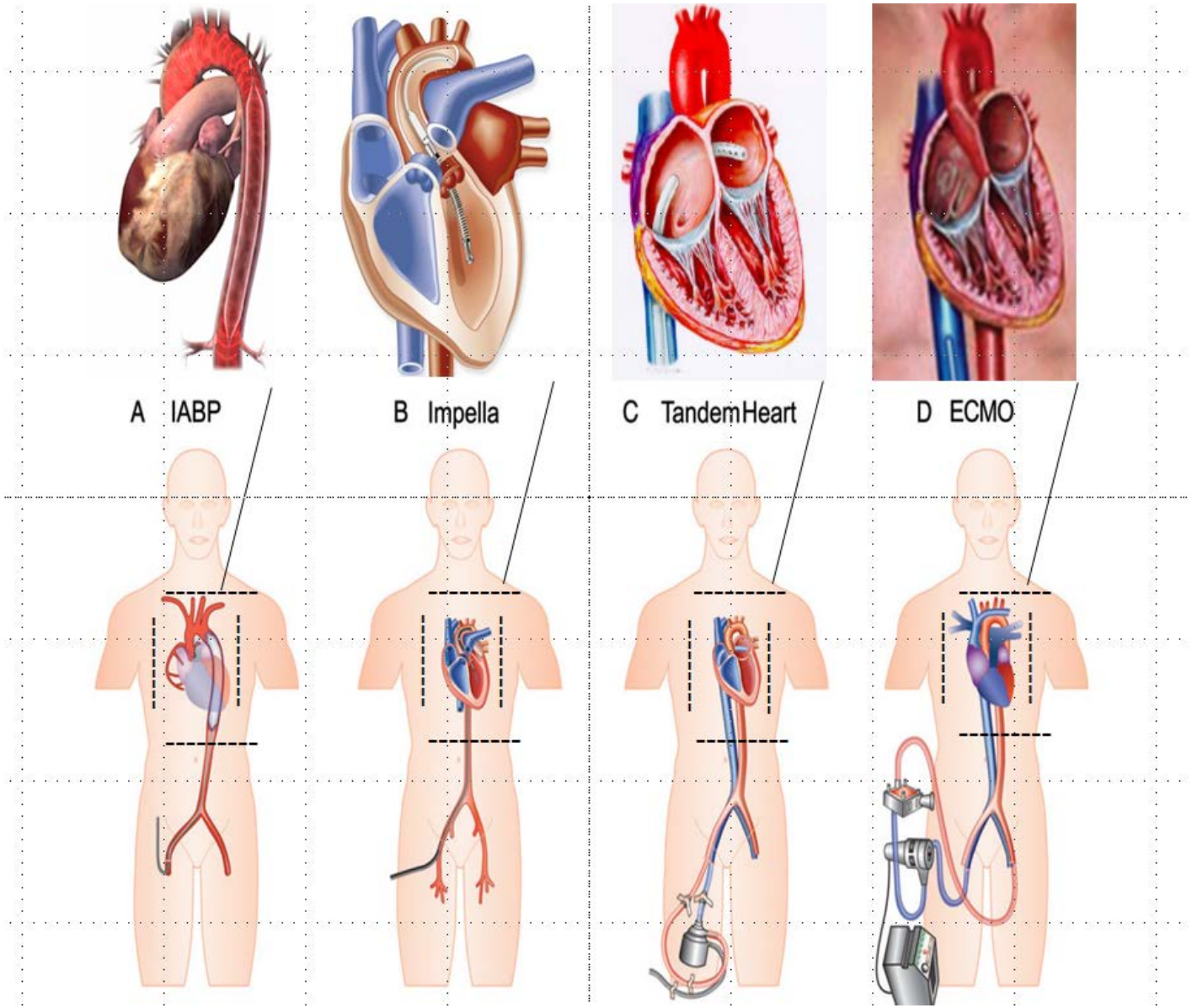
2018 UNOS ALLOCATION SYSTEM

- 6 active tiers by priority of illness
- More granular definitions of cardiogenic shock
- More distinctions between various modes of mechanical circulatory support devices (MCSD)
- High listing status (1-3) require frequent rejustification and attempted wean of temporary MSCD or inotrope to maintain status
- More clearly defined LVAD malfunction to justify higher listing status
- Exceptions for HCM/RCM and congenital heart disease categories

Status	Criteria
Status 1	VA ECMO
	Non-dischargeable, surgically implanted, non-endovascular biventricular support device
	MCSD with life threatening ventricular arrhythmia
Status 2	Non-dischargeable, surgically implanted, non-endovascular left ventricular support device (LVAD)
	TAH, BiVAD, RVAD, or VAD for single ventricle patients
	MCSD with malfunction
	Percutaneous endovascular MCSD
	Intra-Aortic Balloon Pump (IABP)
	Ventricular Tachycardia (VT) or Ventricular Fibrillation (VF)

Status 3	Dischargeable LVAD for discretionary 30 days
	Multiple inotropes or a single high dose inotrope and hemodynamic monitoring
	MCSD with Hemolysis
	MCSD with Pump Thrombosis
	MCSD with Right Heart Failure
	MCSD with Device Infection
	MCSD with Mucosal Bleeding
	MCSD with Aortic Insufficiency (AI)
	VA ECMO after 7 Days
	Non-dischargeable, surgically implanted, non-endovascular LVAD after 14 Days
	Percutaneous Endovascular Circulatory Support Device after 14 Days
	IABP after 14 Days
Status 4	Dischargeable LVAD without discretionary 30 days
	Inotropes without Hemodynamic Monitoring
	Congenital Heart Disease
	Ischemic Heart Disease with Intractable Angina
	Amyloidosis, or Hypertrophic or Restrictive Cardiomyopathy
	Heart Re-transplant
Status 5	On the Waitlist for at least one other organ at the same hospital
Status 6	Adult Candidate Suitable for Transplant

Percutaneous MCS Device Types and Configurations



Modified from Werdan K, et al. Mechanical circulatory support in cardiogenic shock. *Eur Heart J*.2014;35:156-67.

Status 1

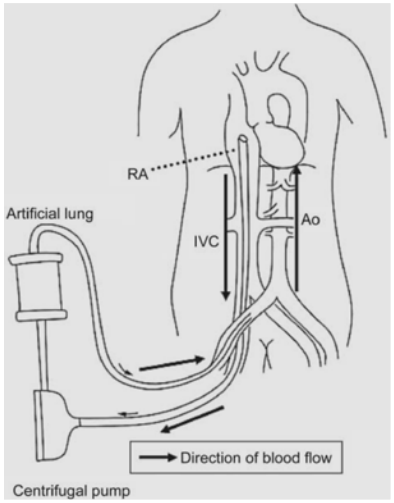
- **VA ECMO (7 days)**
  - SBP <90mmHg
  - CI <1.8 L/min/m^2(no inotrope), or <2.0 L/min/m^2 (on inotrope)
  - PCWP >15mmHg
  - Or CPR, SBP <70, lactate >4, AST or ALT >1000 if no RHC
  - Rejustification after 7 days with LVAD contraindication with demonstrated hemodynamics parameters of failing ECMO wean

- Non-dischargeable, surgically implanted, non-endovascular **biventricular support** device (Bi-V CentriMag) (14 days)

- **MCSD with life-threatening ventricular arrhythmia** (14 days)
  - ≥3 VT or VF episodes > 1 hour apart over 14 days with normal K and Mag and
  - Electrical cardioversion despite IV antiarrythmic therapy

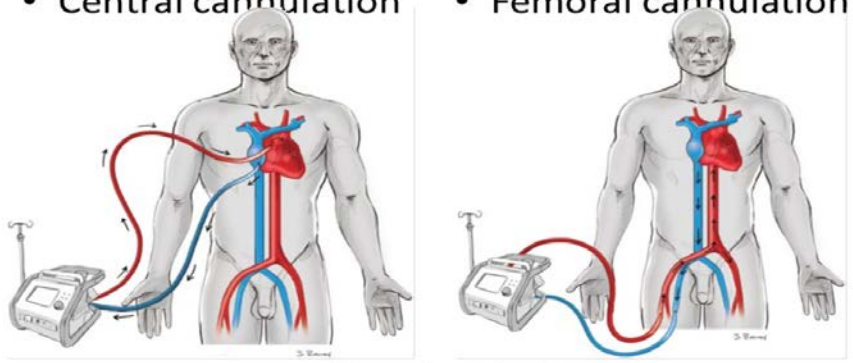
Extracorporeal veno-arterial Membrane oxygenation (VA ECMO)

- The pump has capacity to assume responsibility for the entire cardiac output (biventricular support)
- The gas exchange unit can improve
  - pH
  - PCO2
  - PO2



V-A ECMO Cannulation Options

- Central cannulation
- Femoral cannulation



Problem with ***peripheral*** VA ECMO:

- Lower body receives better perfusion
  - Possible poor perfusion of coronary and cerebral vessels
- Oxygenated blood returned to aorta so lungs get little O_2 rich blood -> may exacerbate lung ischemia

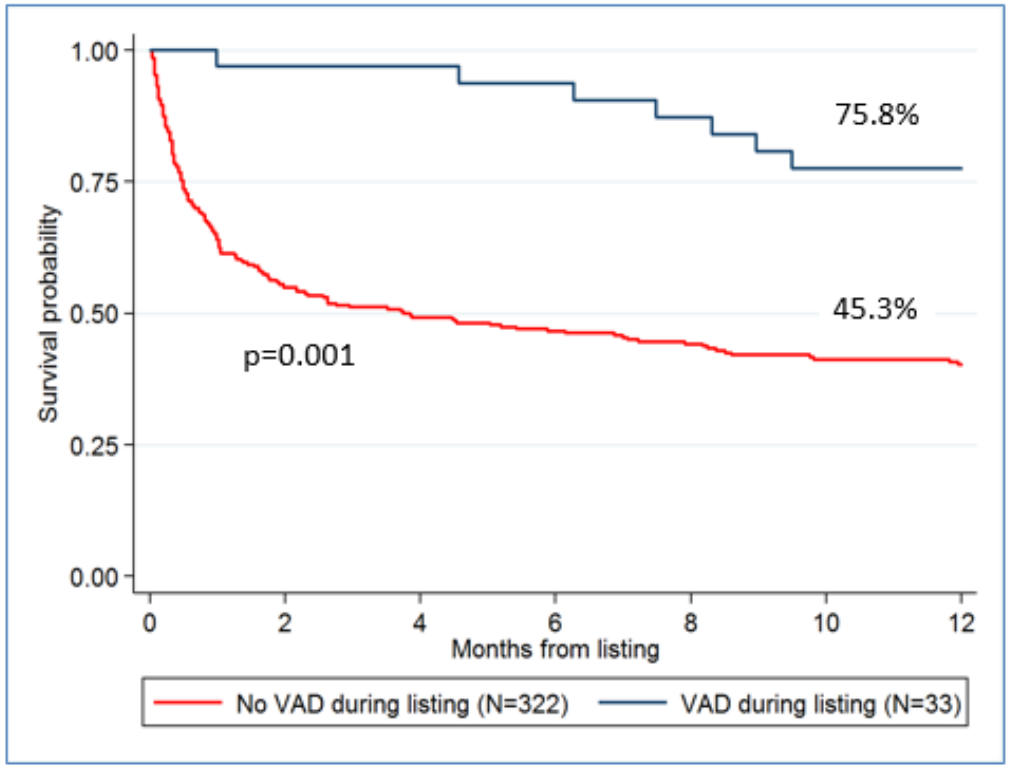
Extra Corporeal Membrane Oxygenation (ECMO) as a Bridge to Adult Heart Transplantation: Bridge to Bridge Strategy vs. Direct ECMO Bridge Strategy (UNOS analysis)

Bashar Hannawi, Jerry Estep, Duc Nguyen, Brian Bruckner, Barry Trachtenberg, Arvind Bhimaraj, Myung Park, Edward Graviss, Ashrith Guha

27,106 patients >18 years listed for OHT from 2006-2014

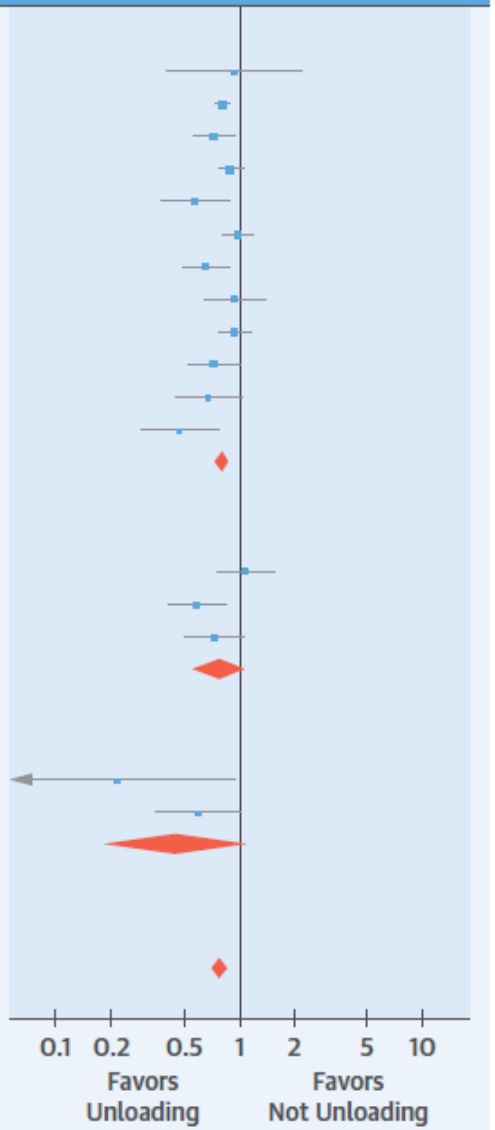
355 patients listed on VA-ECMO included in analysis

1-y outcomes



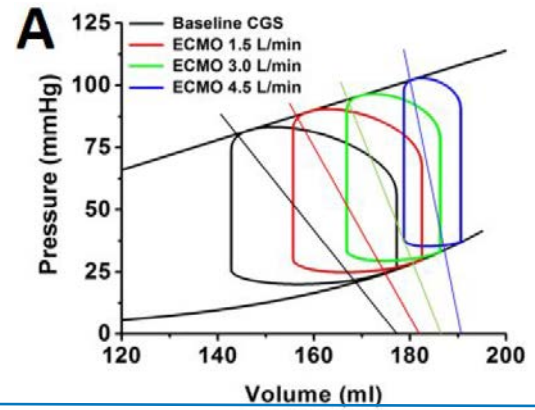
CENTRAL ILLUSTRATION Left Ventricular Unloading During Venoarterial Extracorporeal Membrane Oxygenation

Study or Subgroup	Unloading Events	Unloading Total	No Unloading Events	No Unloading Total	Weight
1.1.1 Intra-Aortic Balloon Pump					
Aoyama, 2014	22	35	2	3	1.2%
Aso, 2016	330	604	708	1,046	14.3%
Brechot, 2018	45	104	92	155	7.5%
Doll, 2004	105	143	62	76	11.7%
Kai Chen, 2018	17	38	17	22	3.9%
Lin, 2016	144	302	110	227	10.3%
Overtchouk, 2018	33	63	34	43	6.7%
Park, 2014	21	41	30	55	4.5%
Ro, 2014	41	60	139	193	9.7%
Sakamoto, 2012	62	94	4	4	5.6%
Tepper, 2018	15	30	22	30	3.9%
Wang, 2013	13	41	31	46	3.0%
Subtotal (95% CI)		1,555		1,900	82.3%
Total events	848		1,251		
1.1.2 Percutaneous Left-Ventricular Support					
Akanni, 2018	16	29	100	196	5.0%
Pappalardo, 2017	16	34	98	123	4.7%
Patel, 2018	17	30	28	36	4.9%
Subtotal (95% CI)		93		355	14.6%
Total events	49		226		
1.1.3 Right Upper Pulmonary Vein or Transseptal Left Atrial Cannula					
Poptsov, 2014	2	28	6	18	0.4%
Shmack, 2017	9	20	21	28	2.7%
Subtotal (95% CI)		48		46	3.1%
Total events	11		27		
Total (95% CI)		1,696		2,301	100.0%
Total events	908		1,504		

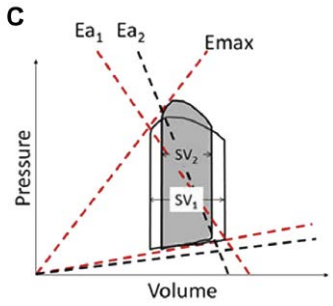


Russo, J.J. et al. J Am Coll Cardiol. 2019;73(6):654-62.

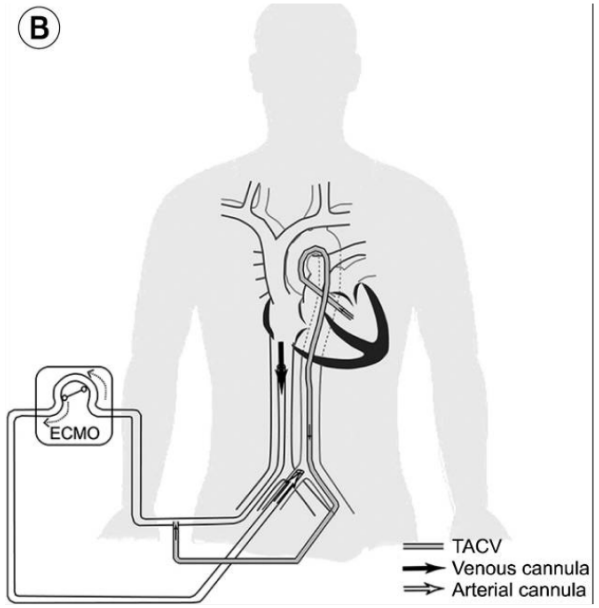
Efforts to Minimize Pulmonary Edema with Peripheral VA ECMO



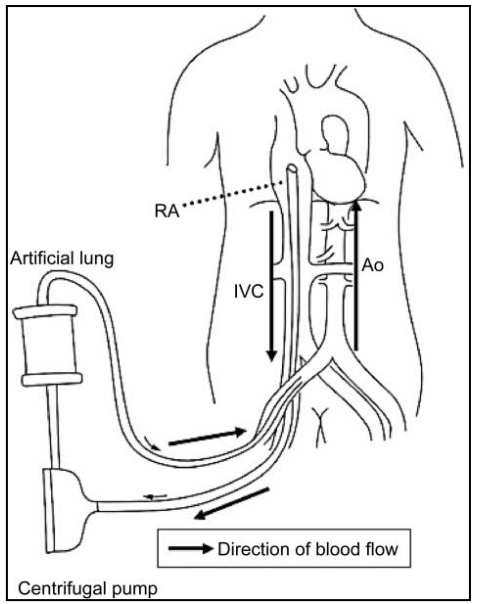
Increasing PCWP and/or surrogates of congestion possible during Peripheral VA ECMO[1]



ECMO

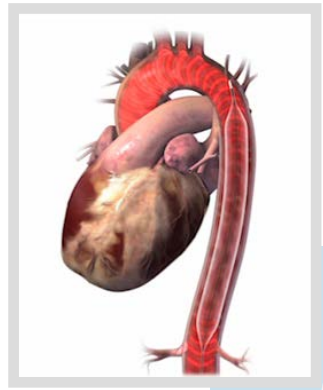


ECMO + Impella



ECMO

+



IABP

1-Nicolas Brechot et al. IABP protects against hydrostatic pulmonary oedema during peripheral VA-ECMO. European Heart Journal 2016

Status 2 and the New Heart Allocation Policy

Status	Criteria
Status 1	VA ECMO
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	Inotropes without Hemodynamic Monitoring
	Congenital Heart Disease
	Ischemic Heart Disease with Intractable Angina
	Amyloidosis, or Hypertrophic or Restrictive Cardiomyopathy
	Heart Re-transplant
Status 5	On the Waitlist for at least one other organ at the same hospital
Status 6	Adult Candidate Suitable for Transplant

Table 1 Focus Areas to Use

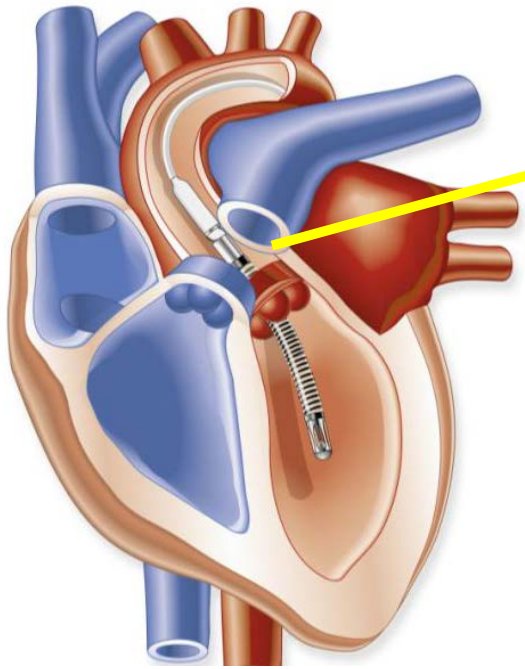
Focus areas to guide IABP use	Fried et al study criteria[4]	Adult heart Status 2 requirements[15]
Hemodynamic criteria to define CS	All of the following were true • SBP < 90 [illegible] • [illegible]/min/m^2 or need for vasoactive drug to achieve this • PCWP not mandated	All of the following need to be true[a] • SBP < 90 mm Hg • CI < 1.8 liters/min/m^2 if not supported by inotropes or < 2.0 liters/min/m^2 if supported by inotropes • PCWP > 15 mm Hg
Criteria if hemodynamics cannot be obtained	Not applicable (all 132 patients had pre- and post-IABP implant measurements)	At least one of the following needs to be true • CPR was performed on the candidate • SBP < 70 mm Hg • Arterial lactate > 4 mmol/L • AST or ALT > 1,000 U/L
Extended support and weaning use criteria	Not defined	Every 14 days both of the following need to be true • Documented contraindication to being supported by a durable device • Within 48 hours before status expiring IABP wean failure as evidence by at least one of the following: a) MAP < 60 mm Hg b) CI < 2.0 liters/min/m^2 c) PCWP > 15 mm Hg d) Svo_2 < 50%

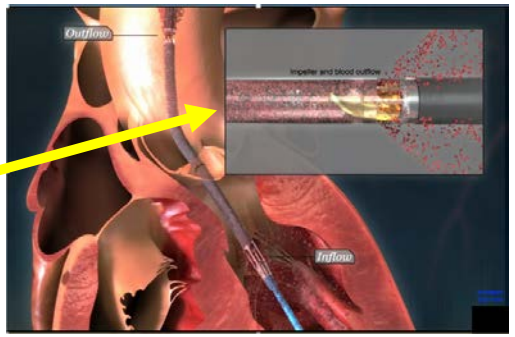
ALT, alanine aminotransferase; AST, aspartate aminotransferase; CI, cardiac index; CPR, cardiac pulmonary resuscitation; CS, cardiogenic shock; IABP, intra-aortic balloon pump; MAP, mean arterial pressure; PCWP, pulmonary capillary wedge pressure; SBP, systolic blood pressure; Svo_2, mixed venous oxygen saturation.

[a]Documented hemodynamics within one 24-hour period within 7 days before IABP support.

Estep JHLT Volume 37, Issue 11, Pages 1301–1303 2018

Impella Devices

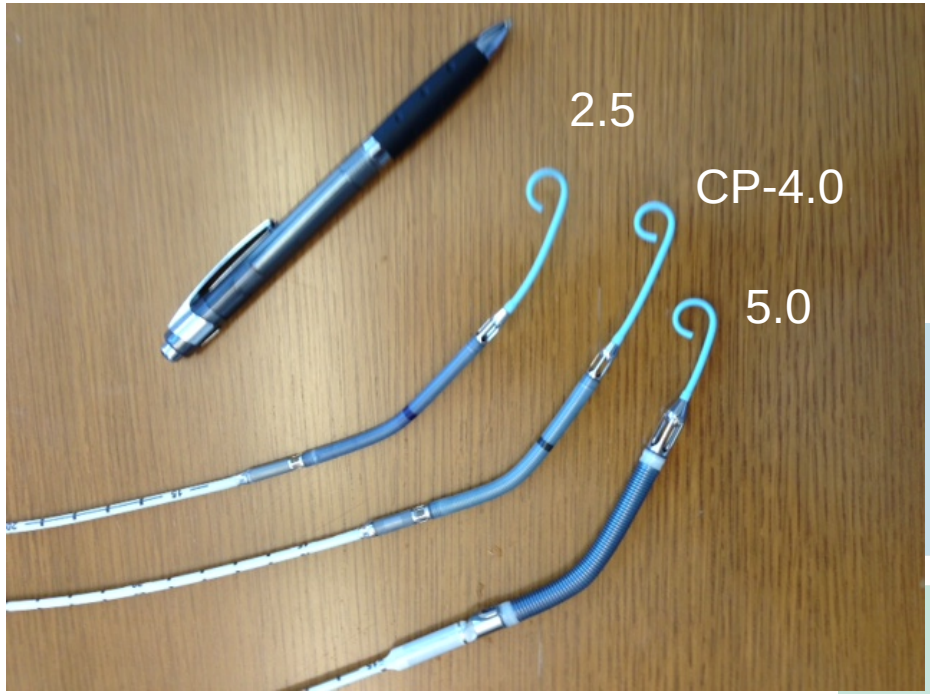




Impella LD

Impella Devices

- 2.5-9F ID,11F OD
- 4.0-14F ID, 16F OD
- ★5.0-21/22F OD



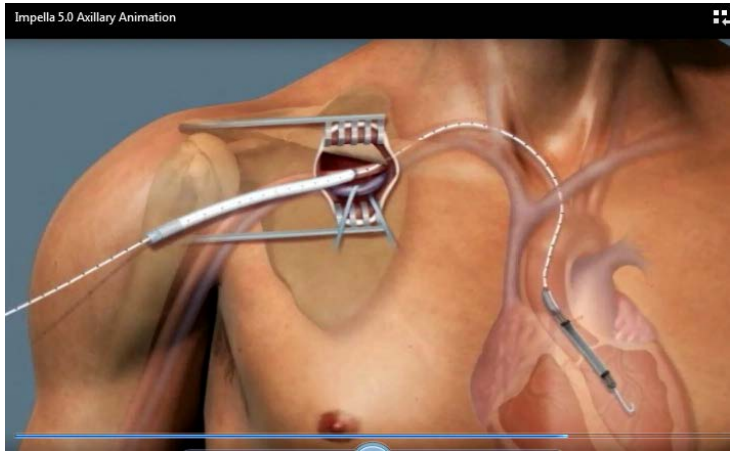
FDA Indication

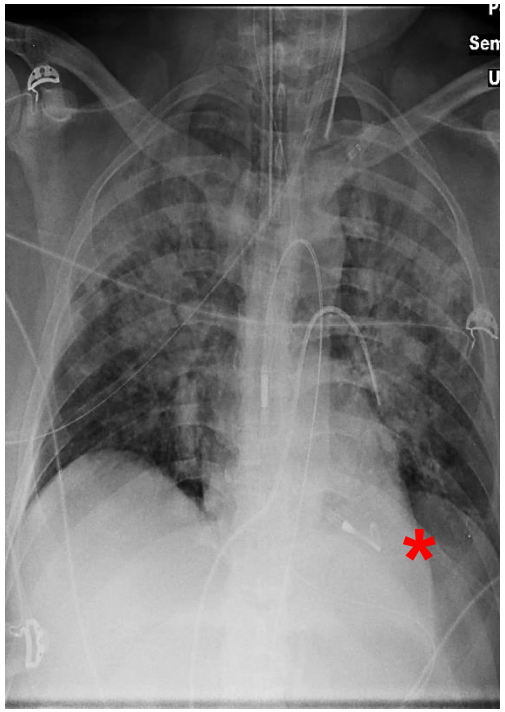
The Impella 2.5™, Impella CP®, **Impella 5.0™** and Impella LD™ catheters, in conjunction with the Automated Impella Controller console, are intended for short-term use (≤4 days for the Impella 2.5 and Impella CP and **≤6 days for the Impella 5.0 and Impella LD)** and indicated for the treatment of ongoing cardiogenic shock that occurs immediately (<48 hours) following acute myocardial infarction (AMI) or open heart surgery as a result of isolated left ventricular failure that is not responsive to optimal medical management and conventional treatment measures with or without an intra-aortic balloon pump.

The intent of the Impella system therapy is to **reduce ventricular work and to provide the circulatory support necessary to allow heart recovery and early assessment of residual myocardial function.**

* Optimal medical management and conventional treatment measures include volume loading and use of pressors and inotropes, with or without IABP

5.0 RIGHT AXILLARY IMPELLA





Impella 5.0 Offers Significant Hemodynamic Support

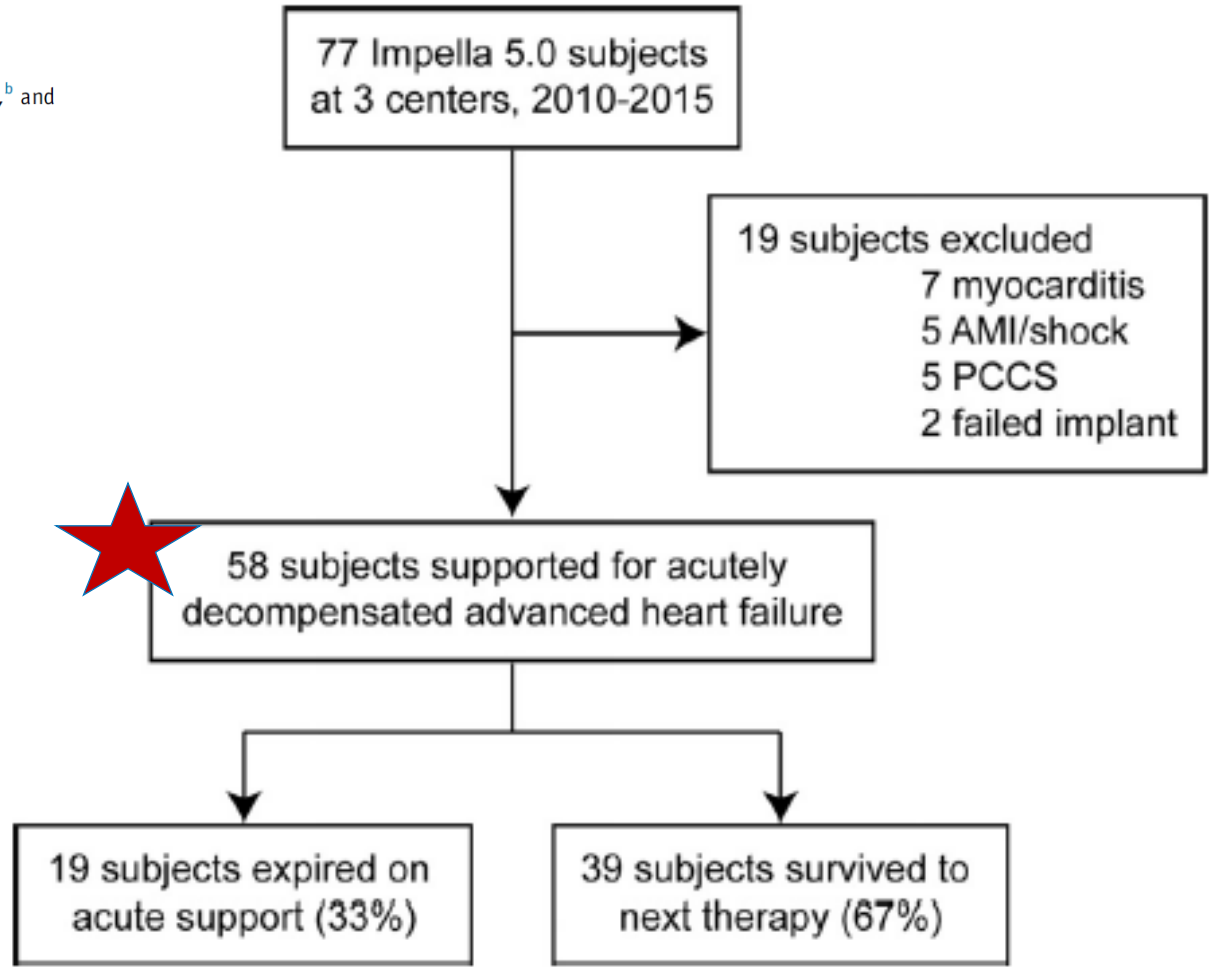
ELSEVIER

The Journal of Heart and Lung Transplantation
http://www.jhltonline.org

ORIGINAL CLINICAL SCIENCE

Use of a percutaneous temporary circulatory support device as a bridge to decision during acute decompensation of advanced heart failure

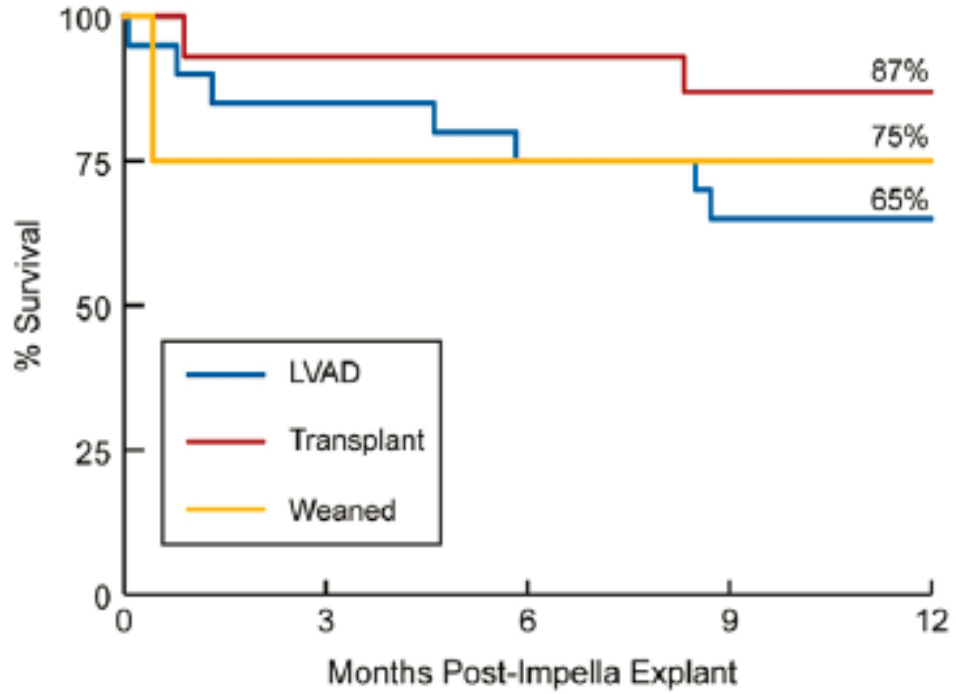
Shelley A. Hall, MD,[a] Nir Uriel, MD,[b] Sandra A. Carey, PhD,[c] Michelle Edens, BS,[c] Geoffrey Gong, MD,[d] Michele Esposito, MD,[e] Ryan O'Kelly, BS,[e] Shiva Annamalai, MD,[e] Nima Aghili,[e] S. Adatya, MD,[b] and Navin K. Kapur, MD[e]



(9 ± 5 days of support)

Hall et al. JHLT 2017

Impella 5.0 Use as a Bridge to Next Therapy



Number at risk					
LVAD	20	17	15	13	12
Transplant	15	14	14	13	13
Weaned	4	3	3	2	2

Figure 4 Intermediate outcomes of acute support survivors. LVAD, left ventricular assist device.

Hall et al. JHLT 2017

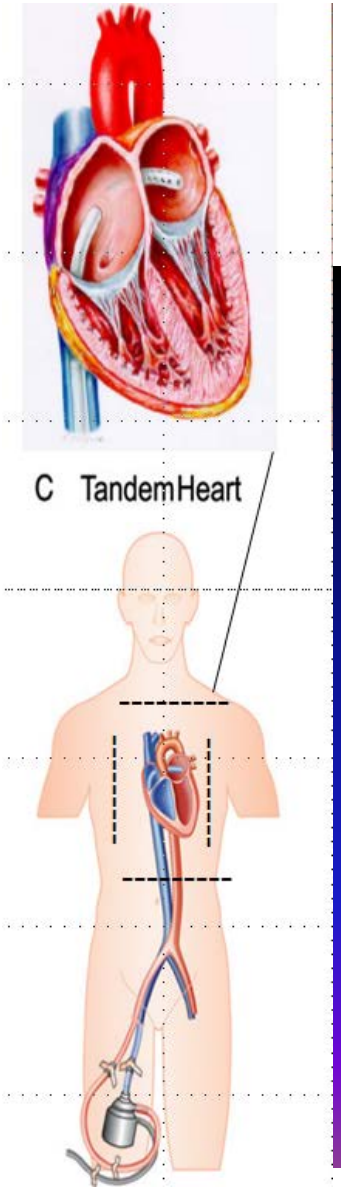
Impella Related Complications

Table 3 In-Hospital Complications

Complication	% of patients
Bleeding requiring transfusion	16
Bleeding requiring surgery	0
Hemolysis	7
Cerebrovascular accident/stroke	0
Vascular complication requiring surgery	2
Infection	19
Hematoma	5
Valve injury	2
Device malfunction	7

Hall et al. JHLT 2017

TandemHeart

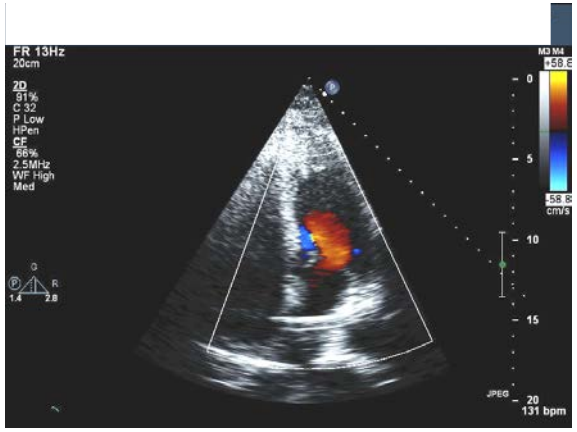


- Provides better hemodynamic support
- Associated with higher rate of complications
- Net benefit determined by balance between
  - benefit of increased support
  - risk of increased complications

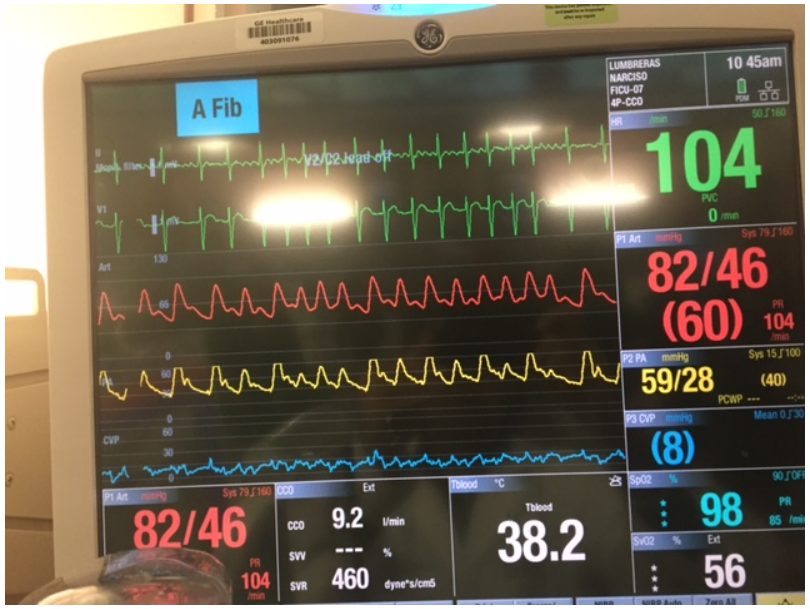
ASD
LA Thrombus
Stroke
Perforation
Canula Displacement
Leg ischemia

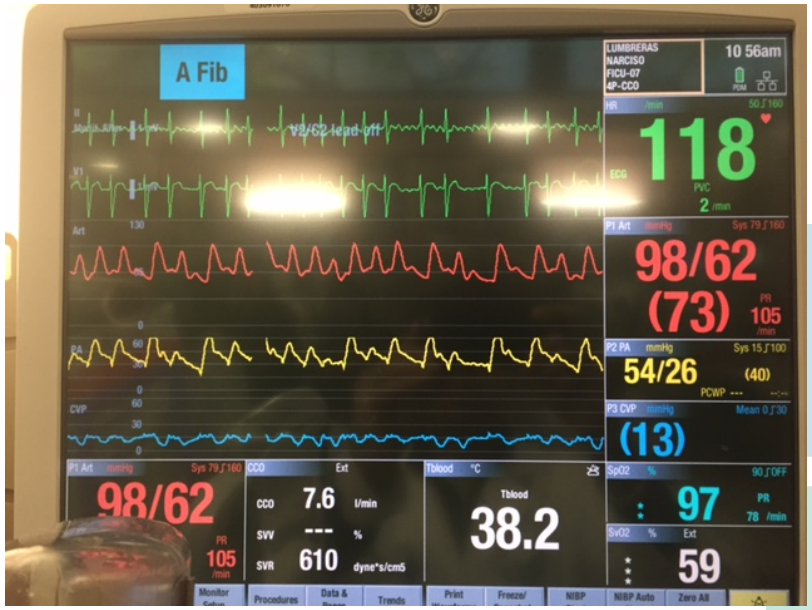
Thiele, European Heart J 2005; 26: 1276-83

TandemHeart Offers Significant Hemodynamic Support

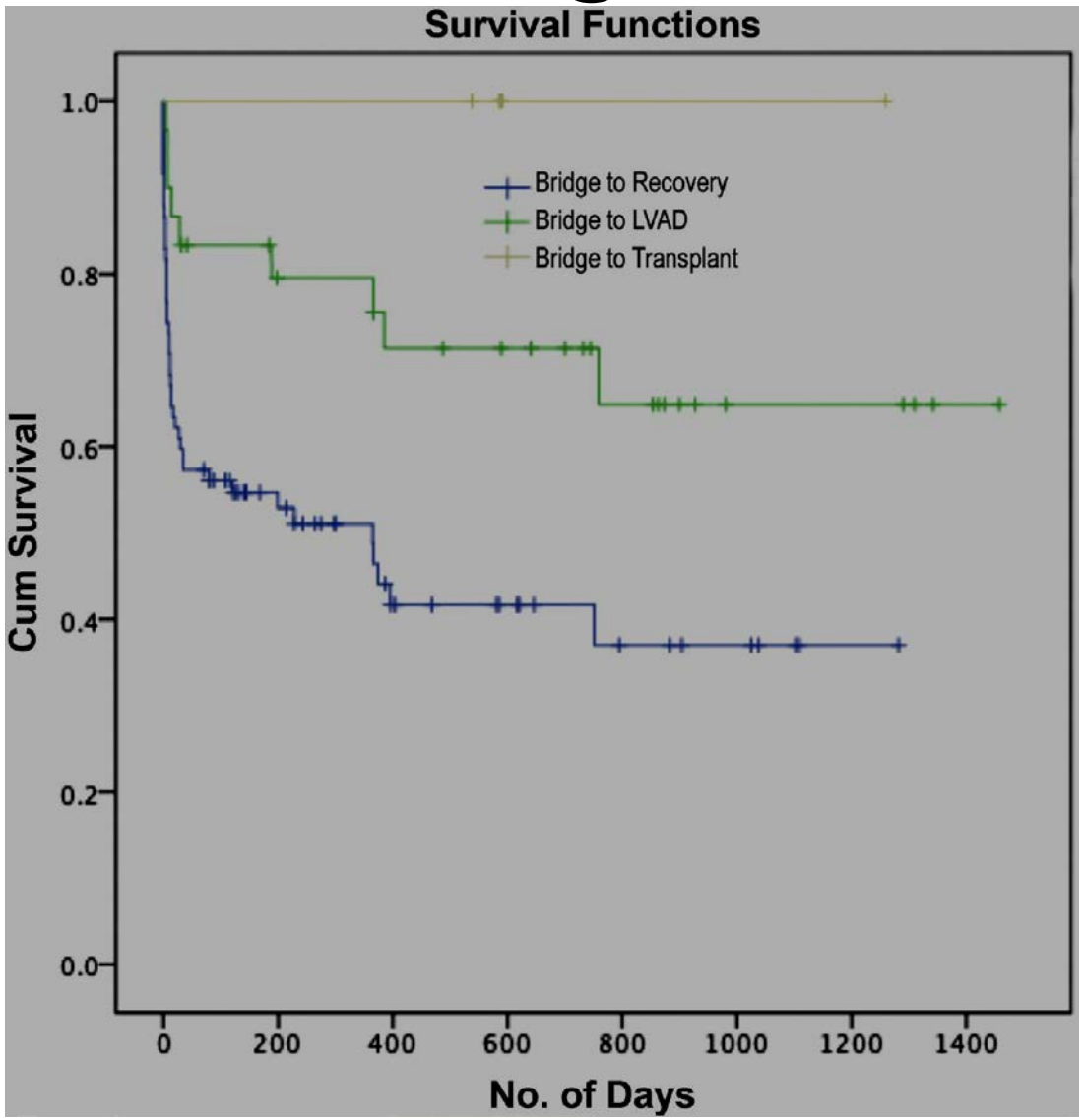


21 F inflow (venous)
15 F or 17 F outflow (artery)





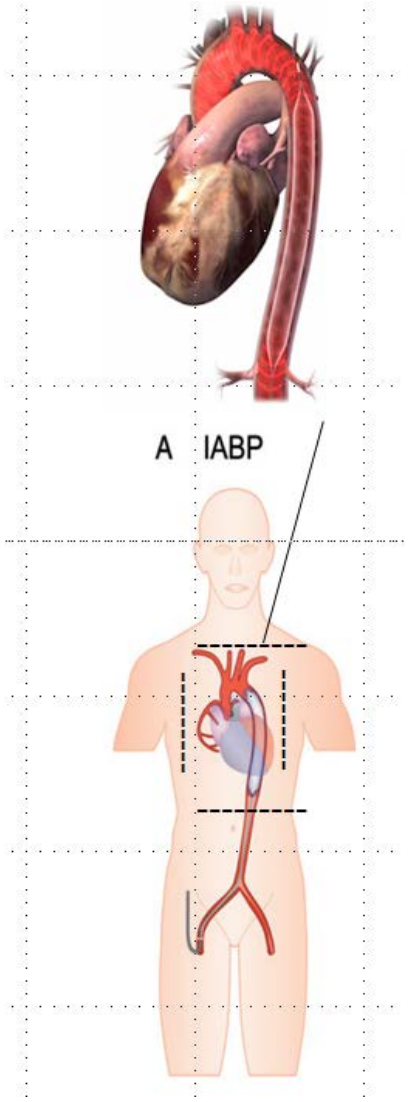
Tandem Bridge Strategy



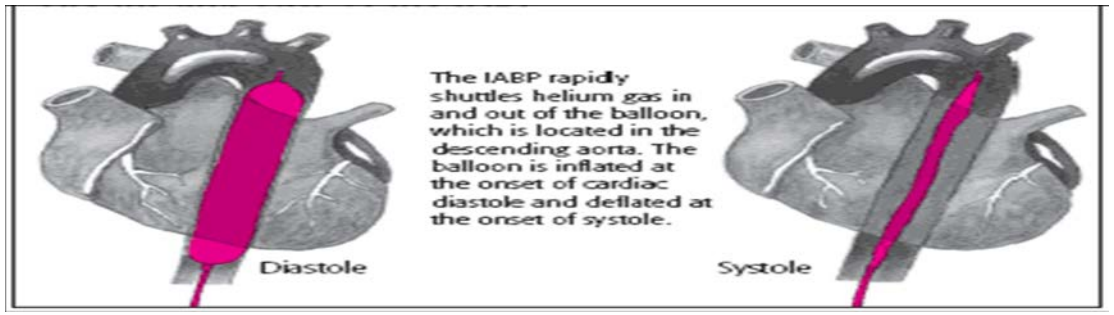
TANDEM Support in Severe, Refractory Cardiogenic Shock (N=117)

Kar et. al JACC 2010

Iabp favorable features



- Widely available and can be placed at the bed side
- Very encouraging safety profile[2]
  - Major limb ischemia 0-5%
  - Bleeding 1.8-9% ; access site bleeding < 5%
- Counter-pulsation platform is simple

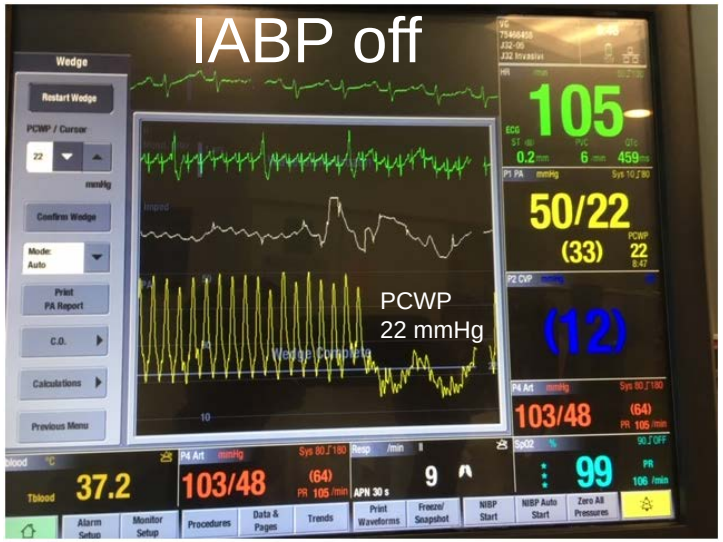


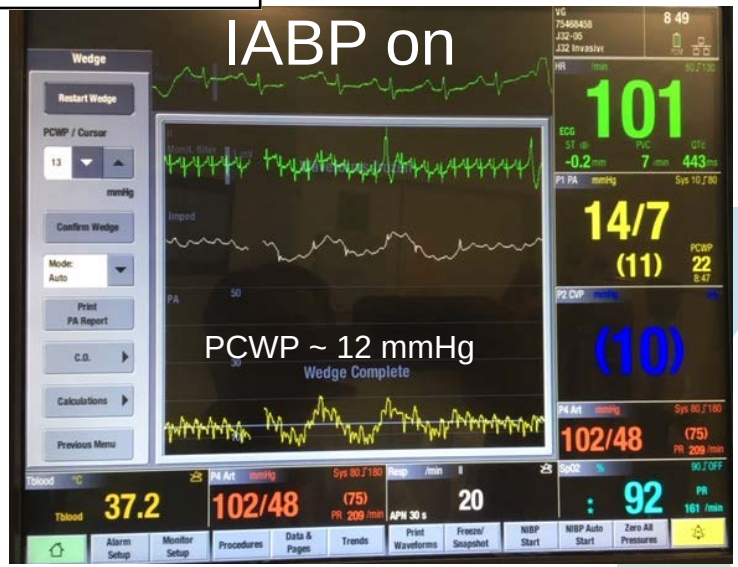
1-Annamalai et al. Journal of Cardiac Failure 2017
2-Trost J, Hillis D. Intraaortic balloon counterpulsation. *Am J Cardiol.* 2006;97(9):1391-1398. Epub 2006 Mar 202-

We Know a Favorable IABP Response When We see It !

Patient example

Non –AMI cardiogenic shock complicating acute on chronic HF





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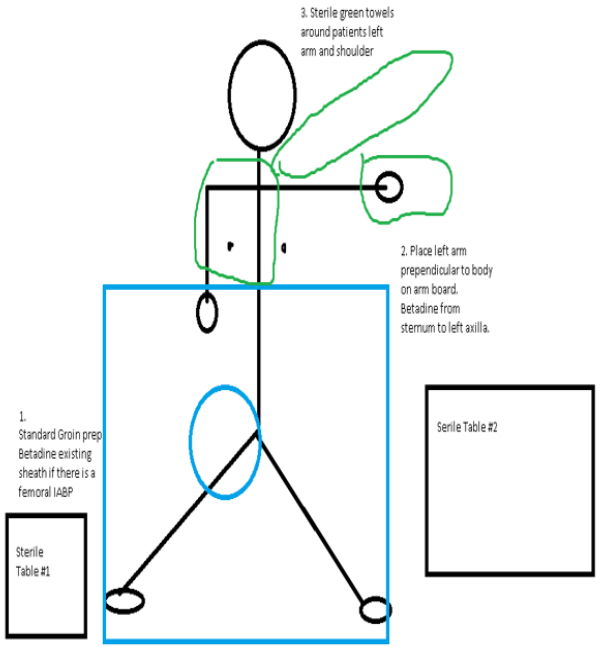
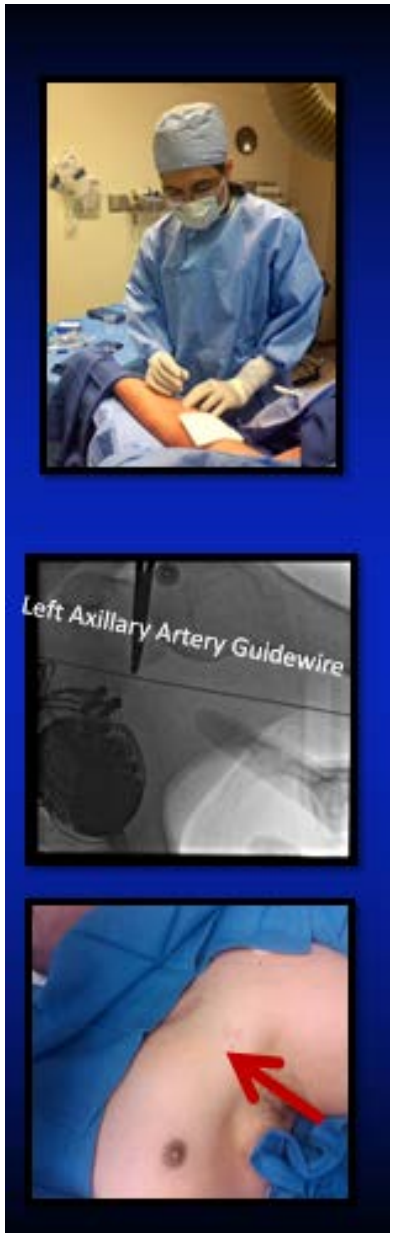
MINI FOCUS ISSUE: ADVANCED HEART FAILURE

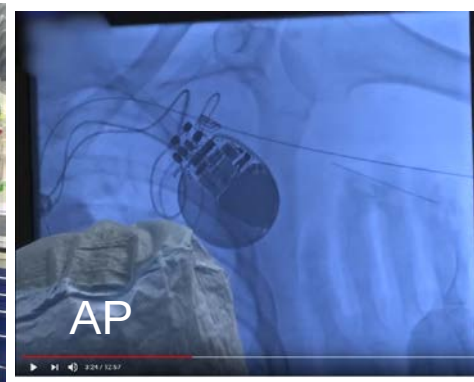
Percutaneous Placement of an IABP in the Left Axillary/Subclavian Position Provides Safe, Ambulatory Long-term Support as Bridge to Heart Transplantation

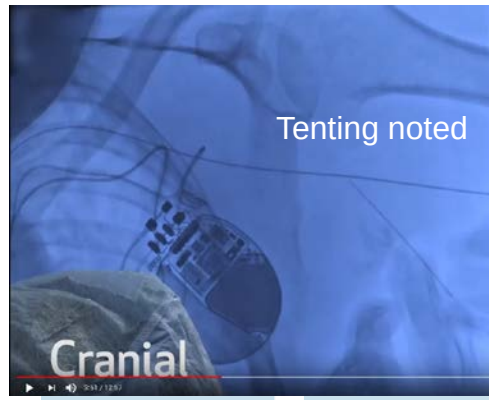
Jerry D. Estep, MD,* Andrea M. Cordero-Reyes, MD,* Arvind Bhimaraj, MD,*
Barry Trachtenberg, MD,* Nashwa Khalil, BS,* Matthias Loebe, MD, PhD,† Brian Bruckner, MD,†
Carlos M. Orrego, MD,* Jean Bismuth, MD,† Neal S. Kleiman, MD,*
Guillermo Torre-Amione, MD, PhD*‡
Houston, Texas; and Monterrey, Mexico

PATIENT PREP

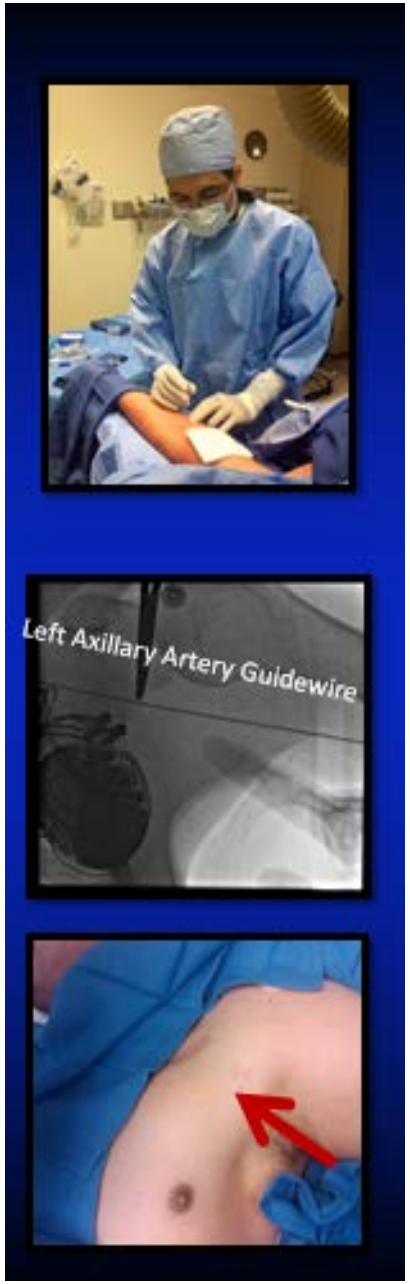








You tube training video “Percutaneous Axillary IABP Placement “



Patient Example Kaufman Heart Failure Recovery Unit

Initial Experience with Axillary IABP Support

- ~80% of patients had stabilization with axillary IABP support and underwent heart or heart-multi-organ transplant
- ~20% had progressive HF requiring escalation of therapy
- Current Practice at CCF
  - Femoral IABP for INTERMACS 1-2 patients
  - If favorable clinical response and extended support needed, then change to axillary position
  - 20 patients bridged to heart transplant under the new Heart allocation policy

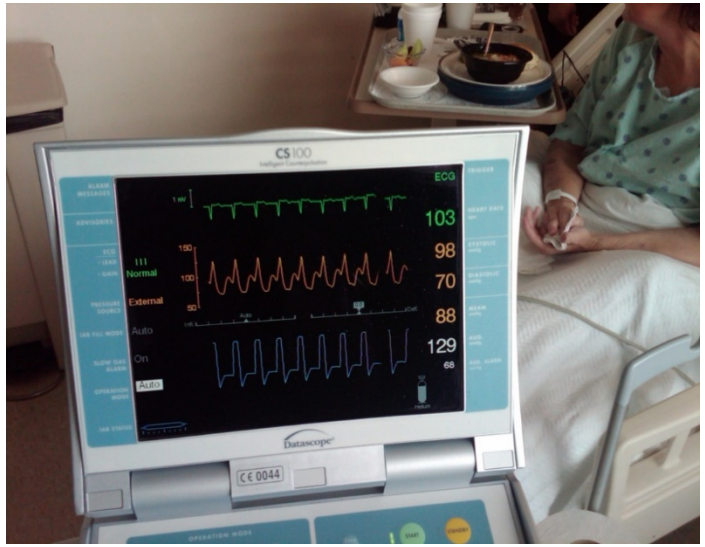


Table 2 Comparison of Pertinent Hemodynamic and Laboratory Values Before and After Extended Axillary IABP Support (N = 42)

	Before Implantation*	After Implantation†‡	p Value
RAP (mm Hg)	13 ± 5.8	10 ± 6	0.09
mPAP (mm Hg)	34 ± 10.9	27 ± 9	0.006
WBCs (k/μl)	8.0 ± 3.1	8.2 ± 2.7	0.8
Creatinine (mg/dl)	1.7 ± 1.0	1.5 ± 0.8	0.01
BUN (mg/dl)	36.1 ± 24	28.9 ± 17	0.01
Hemoglobin (g/dl)	11.6 ± 2.1	10.8 ± 1.9	0.001
Platelets (k/μl)	189 ± 75	162 ± 53	0.01
AST (U/l)	62.7 ± 117	46.8 ± 52	0.2
ALT (U/l)	50 ± 78.9	36.7 ± 20.3	0.2
Total bilirubin (mg/dl)	1.1 ± 0.6	0.8 ± 0.5	0.003
PT (s)	17.7 ± 5.4	16.4 ± 4.3	0.6
INR	1.5 ± 0.6	1.4 ± 0.5	0.5

Estep et al. JACC: HF Vol. 1, No. 5, 2013

RCM and HCM Patients

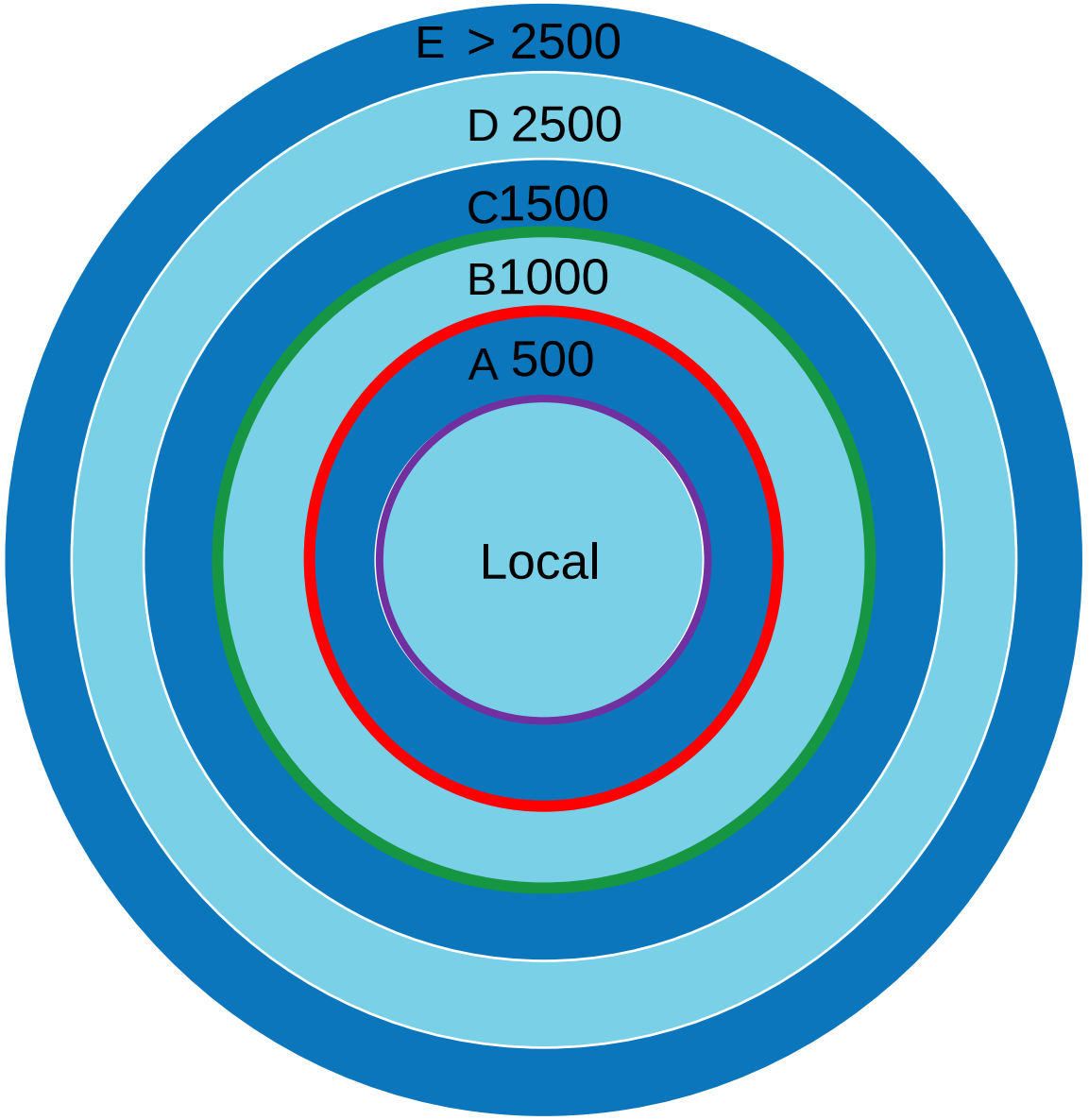
Status 2 exception:

1. Admitted with continuous Swan Ganz catheter monitoring
2. Within 24 hours reached maximally tolerated doses of inotropes and demonstrates at least **2 hemodynamic** and **1 end organ parameters:**
   - Systolic BP <90mmHg
   - LAP, RAP, LVEDP, RVEDP, or PCWP > 20mmHg
   - Low index ≤ 2.2 L/min/m^2
   - SVO2 <50%
   - TPG ≥15mmHg
   - PVR ≥ 2.5 WU

End organ dysfunction indicators:

- Elevated arterial lactate to 2.5 mmol/L
- Increase in serum creatinine > 50% above baseline
- Increase in total bilirubin > 50% above baseline
- AST or ALT > 2x upper limit of normal

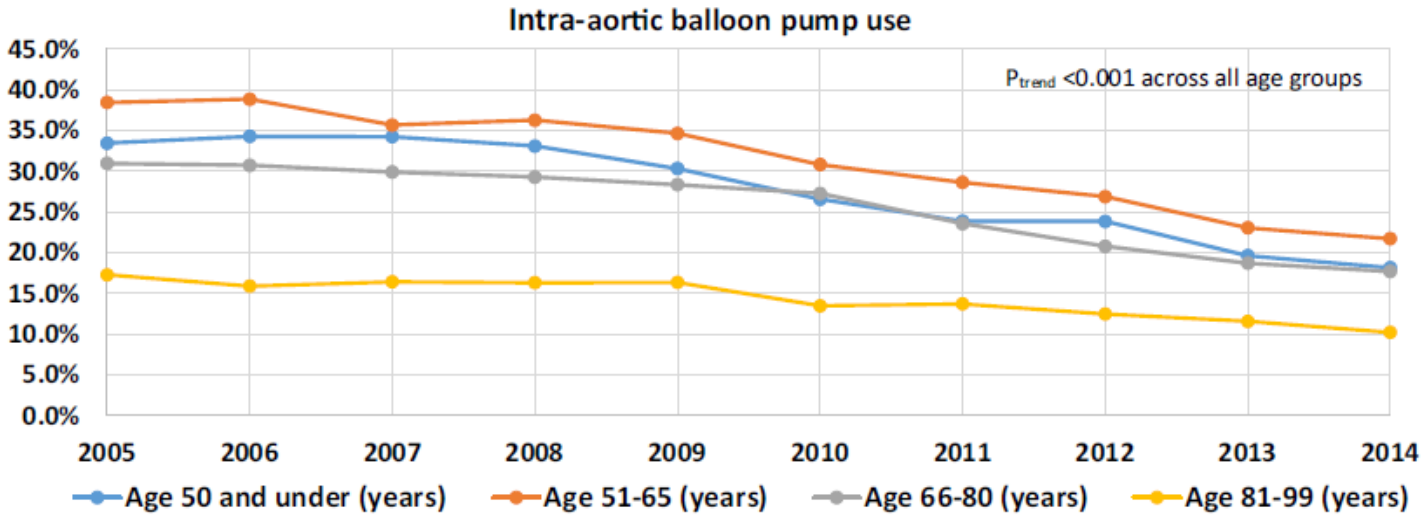
Heart Geographic Distribution

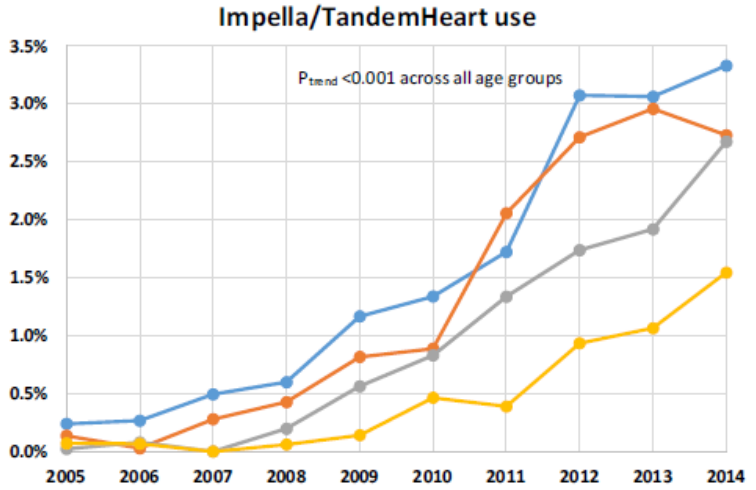


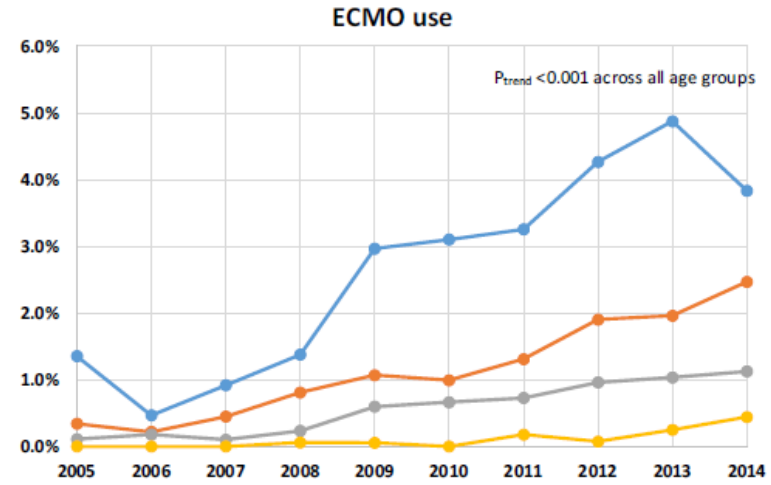
Local OPO AND zone A for Status 1 then Status 2 patients.

Then status 3 in local DSA. Then status 1 and 2 in zone B.

Trends in IABP use in the United States



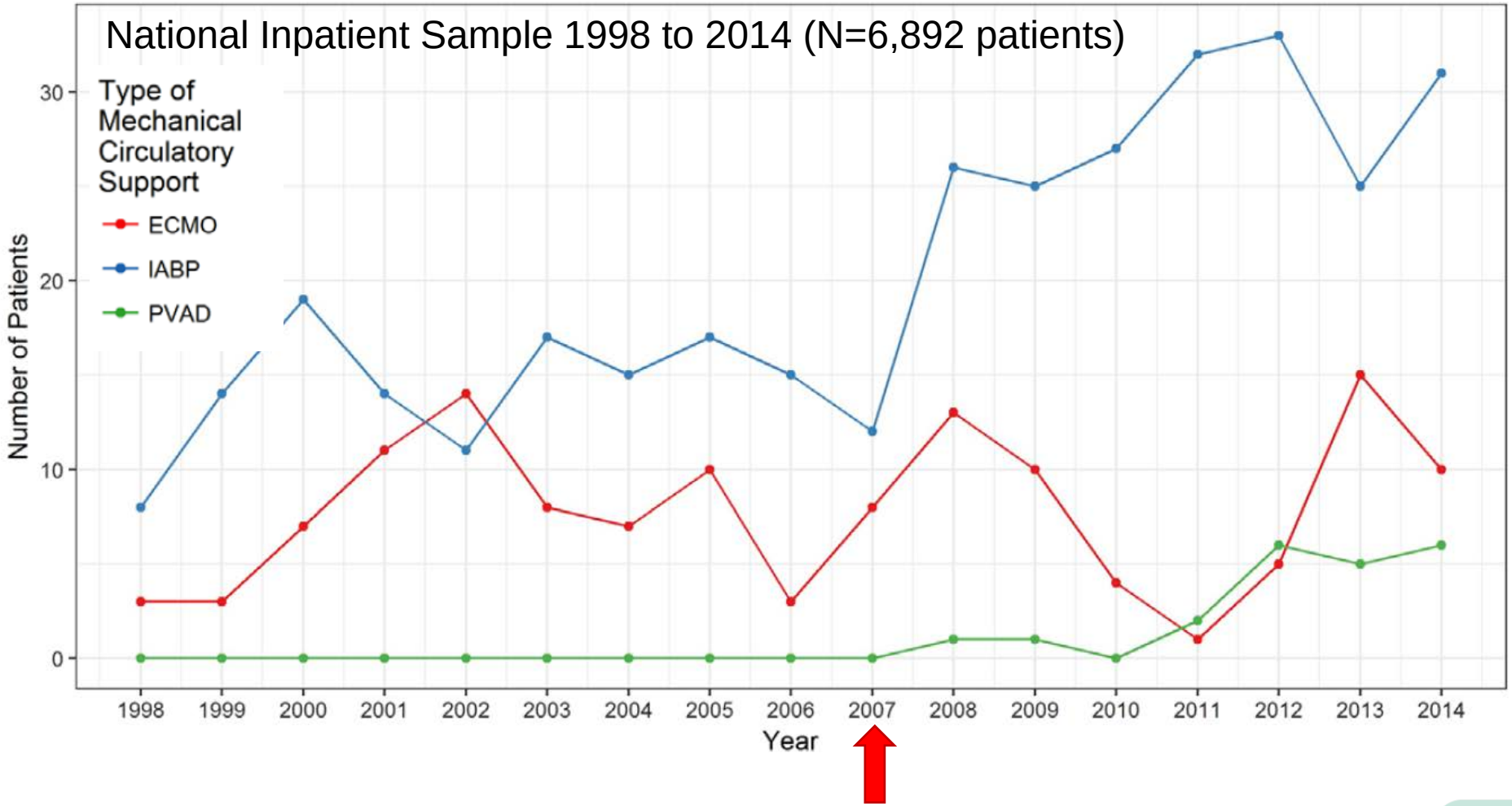




-144,254 cases of CS (55% AMI and 45% non-AMI).
- Overall decline in IABP use
  (**29.8–17.7%; ptrend < 0.01**)

Shah M. et al. Clin Res Cardiol (2018) 107:287–303

Temporary MCS Use Pre Heart Transplantation



David Ouyang et al. JHLT 2018;37:1060–1066

Short Term Devices Considerations

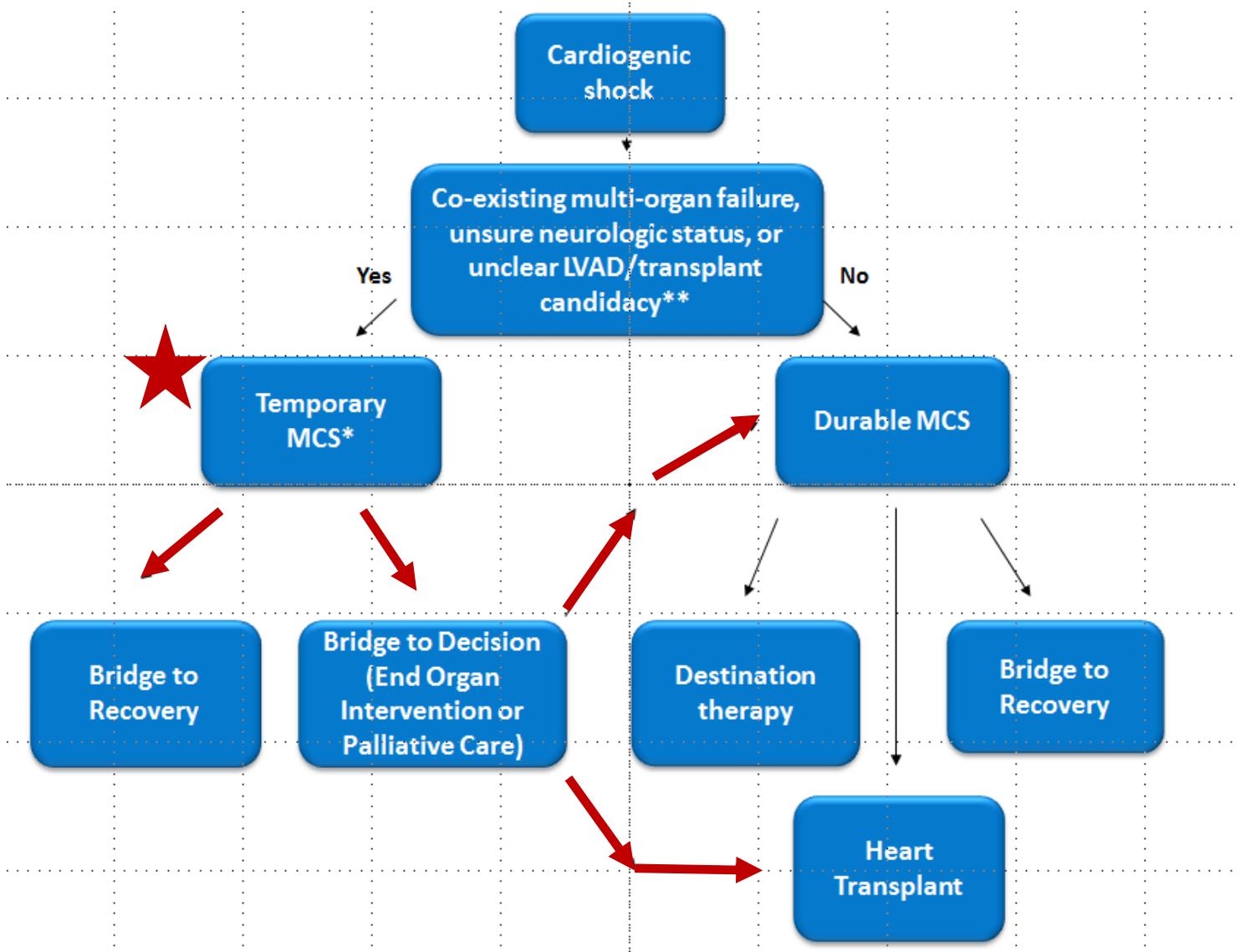
	IABP	Impella 2.5	TandemHeart	Peripheral ECMO
Insertion Time	~ 6-22 mins[1]	~ 11-41 mins[1,7]	~ 15 -65 mins[9]	~15 to 60 mins
Theoretical Flow/ Reported PCWP reduction MAP increase	Minimial (up to 6%) [1]	2.5/(2.2 ± 0.3 l/min)[2] -7 mmHg +20-30 mmHg	4.5 l/min (3.29 ± 0.7 l/min)[9] -14 mmHg +36 mmHg	5.0 l/min (4.0 l/min)
Duration of support (FDA/clinical experience)	6 hrs/ several weeks	6 hrs/several days	6 hrs/several days	6hrs/several days
★ Leg Ischemic Risk	0.9 %[11]	0 to 3.9%	3.4[9] to 33%[2]	18.8%[12]
★ Bleeding Requiring transfusion	0.8%[11]	13%[10]	Up to 59.8%[9]	18%[12]

1. Seyfarth et al. JACC 2008; 2. Burzotta et al., Dixon et al. (PROTECT I); 3. Burkhoff Am H J 2006; 4. Tex Heart Inst J. 2006; 33(2):111-115 (HR PCI); 5. Tex Heart Inst J. 2006; 33(2):111-115 (AMI CS); 6. Journal of Invasive Cardiology. 2008 Jun; 20(6): 319-322; 7. Ann Thorac Surg. 2007 Dec; 84(6):1993-9; 8. *Henriques (Sjauw, MACH II, JACC 2008)-Impella 2.5; 9. Kar et al JACC 2011; 10. USImpella TCT 2010 data; 11 Ferguson JACC 2001.*

CONTRAINDICATIONS

- IABP
  - Greater than Mild AI
  - Severe PVD or aortic disease
- Impella CP/5.0
  - Mechanical AV
  - Greater than Moderate AI
  - AV stenosis (Area < 1.5 cm2)
  - Severe PVD (for the CP)
  - Mobile LV thrombus
- Tandem
  - Severe PVD
  - Right or left atrial thrombus

Role of Temporary MCS and Patient and Programmatic Considerations



J. Brown and JD. Estep Heart Failure Clinics 2016

Adult congenital Heart Disease Patients

- “Measurements of hemodynamics among patients with CHD can be complicated by altered anatomy and rendered meaningless”
- ACHD patients may not be ideal candidates for inotropic or mechanical support
- 2% OHT population (but growing)
- Distinction between single and dual ventricle physiology (exemption criteria for higher listing status exists)

Exceptions Still Exist

- Regional review board can review cases when

“1. A candidate is admitted to transplant hospital that registered the candidate on the wait list and

2. Transplant physician believes, using acceptable medical criteria, that a heart candidate has an urgency and potential for benefit comparable to that of other candidates at requested status.”

- Sensitized patient may gain higher priority within a listing status if all transplant programs within the OPO and donor service area (DSA) agree

Implications

- Since sickest patients are prioritized and the 2018 allocation system places emphasis on MSCD support, especially of non-dischargeable supports, this may encourage the use of temporarily support devices such as IABP and Impella over inotropes

- Bridge to transplant LVAD patients without complications are assigned a lower allocation status given recent improvements in LVAD technology and event-free survival

- Allowance for more equitable sharing of organs within a 500 mile radius prioritizing the sickest patients first, in accordance with the “Final Rule”

Take Home Points

- New LVAD technology is associated with improved outcome (less morbidity) with current 2 year survival post LVAD ~ 80 %.
- Over 3,000 cardiac transplantations occur in United States annually, however, the demand for organs exceeds the supply.
- The 2018 UNOS organ allocation system was an effort to make organ allocation more equitable in the modern era of MCSD and durable LVADs.
- The 2018 UNOS criteria created more tiers with stronger emphasis on hemodynamic metrics for listing criteria.
- The use of MCSD, especially percutaneous support devices is expected to increase.
- Wait list time and mortality and post heart transplant outcome will be monitored.

Cleveland Clinic

Every life deserves world class care.