Right Ventricular Failure: Prediction, Prevention and Treatment

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and Cardiac Surgeons
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Disclosures: None

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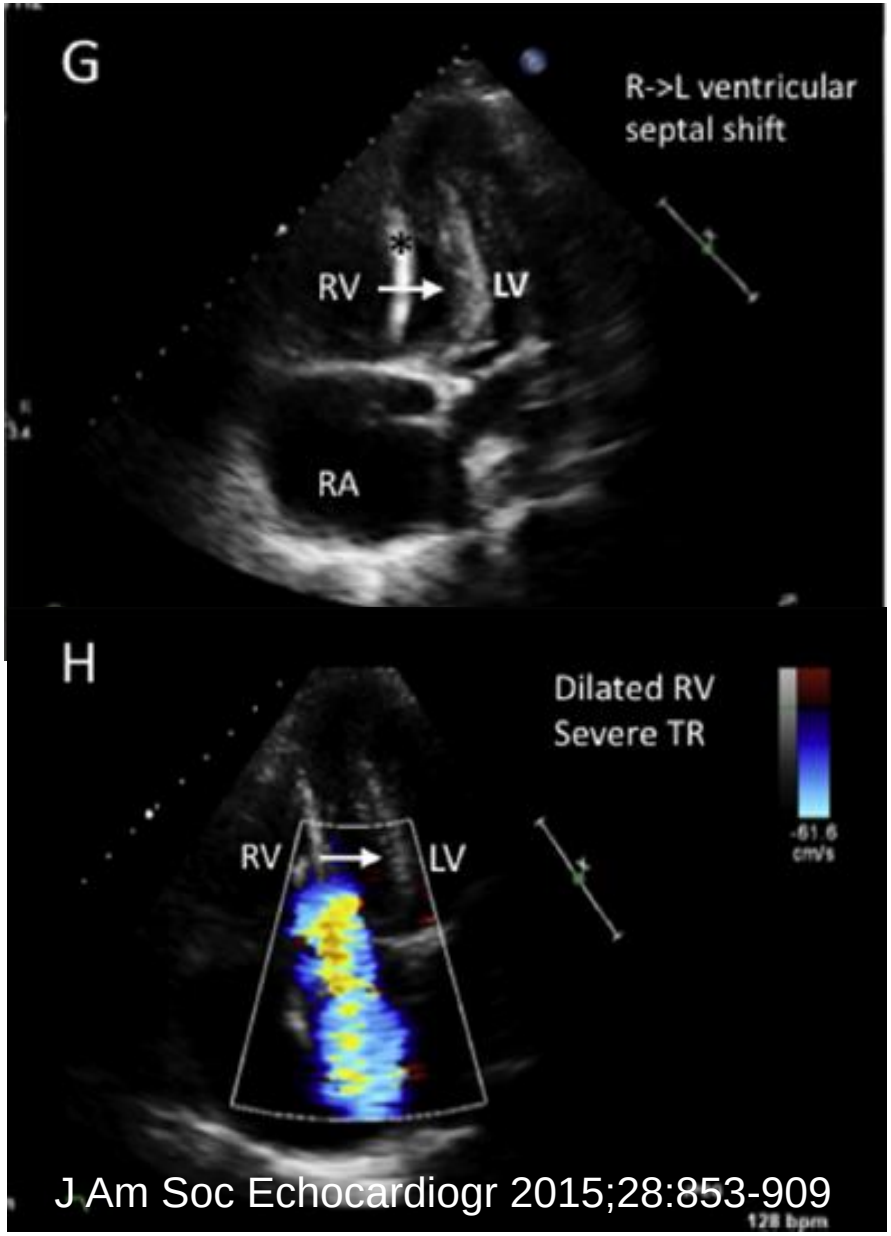
RV Failure Following LVAD

- Pre-implant diagnosis is challenging
- Definition
  - Need for inotropic support > 14 days
  - Need for RVAD
- Limits device function by reducing pre-load
- Associated with end-organ dysfunction and prolonged LOS
- Important cause of post-implant morbidity and mortality
- New description of “late” RV failure, etiology unknown

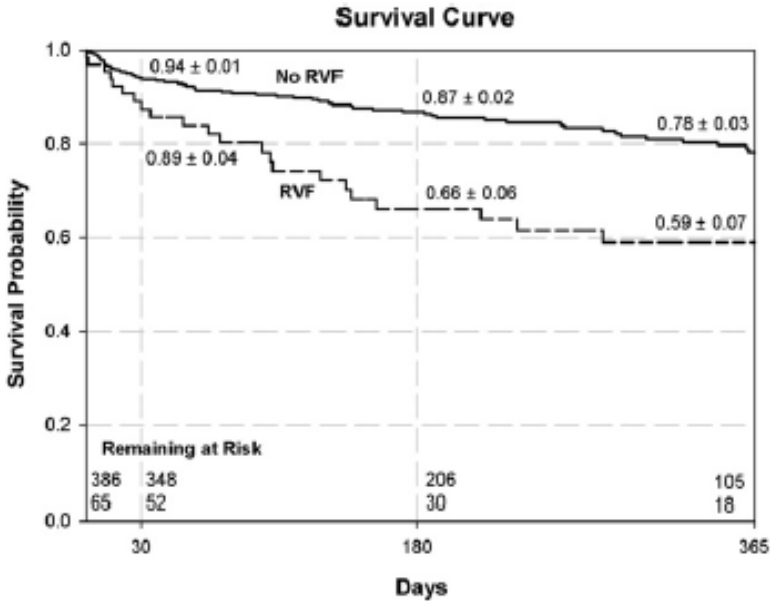


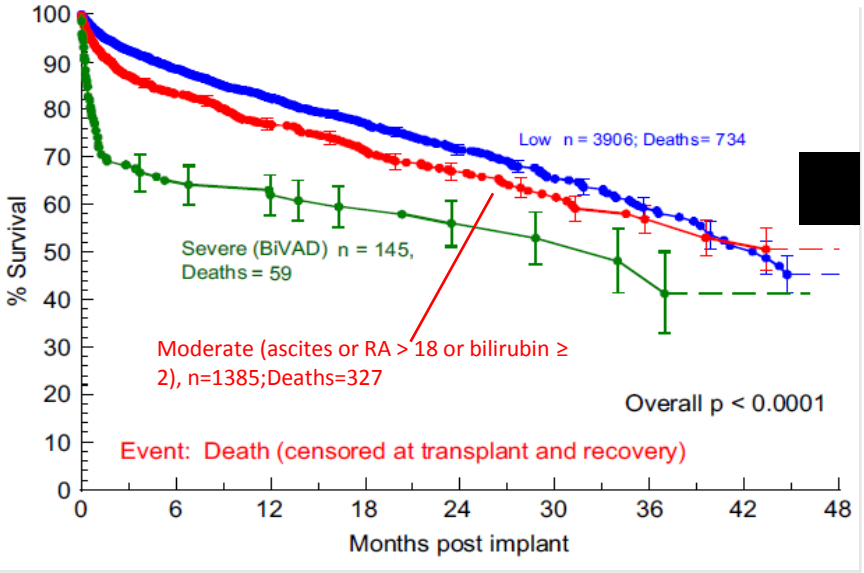
Adverse event	Continuous (n = 5,358) Events	Rate
Device malfunction	660	1.60
Bleeding	3895	9.45
Cardiac/vascular		
Right heart failure	737	1.79
Myocardial infarction	30	0.07
Cardiac arrhythmia	1919	4.66
Pericardial drainage	251	0.61
Hypertension[b]	351	0.85
Arterial non-CNS thrombosis	74	0.18
Venous thrombotic event	289	0.70
Hemolysis	299	0.73
Infection	3302	8.01
Neurological dysfunction	754	1.83
Renal dysfunction	582	1.41
Hepatic dysfunction	247	0.60
Respiratory failure	1038	2.52
Wound dehiscence	74	0.18
Psychiatric episode	425	1.03
Total burden	14927	36.22

Events/100 pt-month in first 12 months follow-up

J Heart Lung Transplant 2013;32:141-56

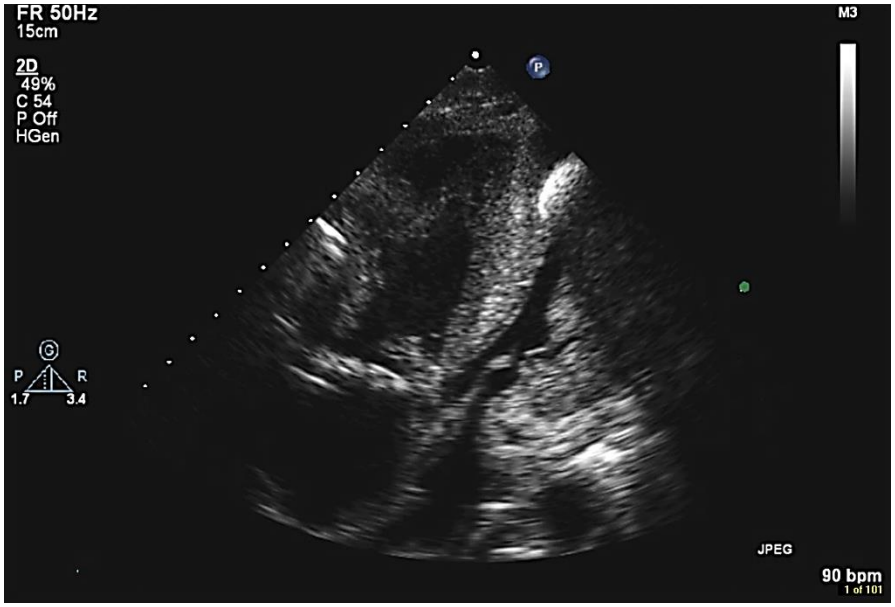
J Thorac Cardiovasc Surg 2010;139: 1316-24





Predictors of Post-LVAD RV Failure

- Clinical
  - Pre-implant mechanical ventilation
  - Pre-implant renal or hepatic dysfunction
  - Need for vasopressors
- Hemodynamic
  - High RA, low PA
  - CVP:PCWP pressure > 0.63
  - RVSWI < 300 mmHgxSV/m^2
- Echocardiographic
  - RV size and function
  - Tricuspid insufficiency
  - TAPSE
  - RV Strain



Predictors of RV Failure during LVAD Support

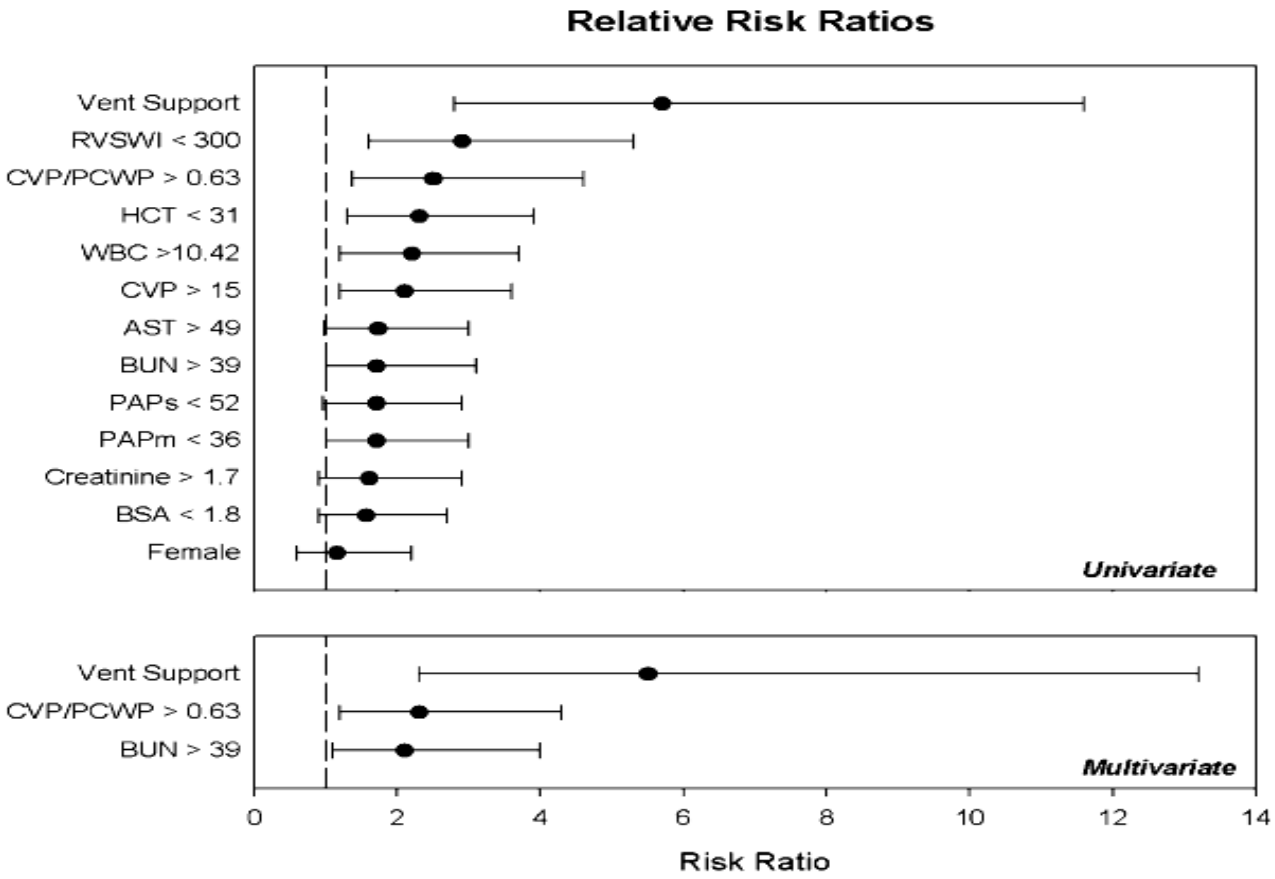


FIGURE 2. Relative risk ratios of univariate and multivariate predictors of RVF during LVAD support.

J Thorac Cardiovasc Surg 2010;139:1316-24

Multivariable Models

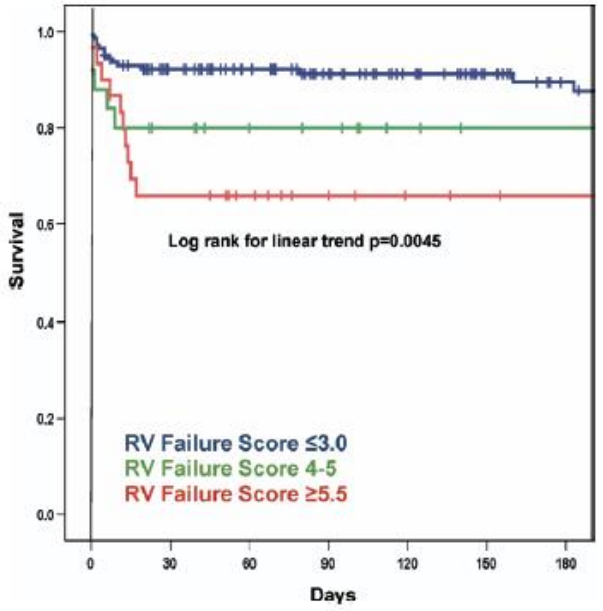
	OR (95% CI)	Points
Vasopressor Requirement	3.9 (1.5-9.8)	4
AST ≥ 80 IU/L	2.1 (0.96-4.5)	2
Bilirubin ≥ 2.0 mg/dL	2.4 (1.1-5.2)	2.5
Cr ≥ 2.3 mg/dL	2.9 (1.1-7.7)	3

J Am Coll Cardiol 2008; 51:2163-72

Table 6 Right Ventricular Failure Risk Score and Likelihood of RV Failure by Score Strata

Risk Score	n	RV Failure (n)	No RV Failure (n)	Likelihood Ratio (95% CI)
≤3.0	142	29	113	0.49 (0.37–0.64)
4.0–5.0	25	15	10	2.8 (1.4–5.9)
≥5.5	30	24	6	7.6 (3.4–17.1)

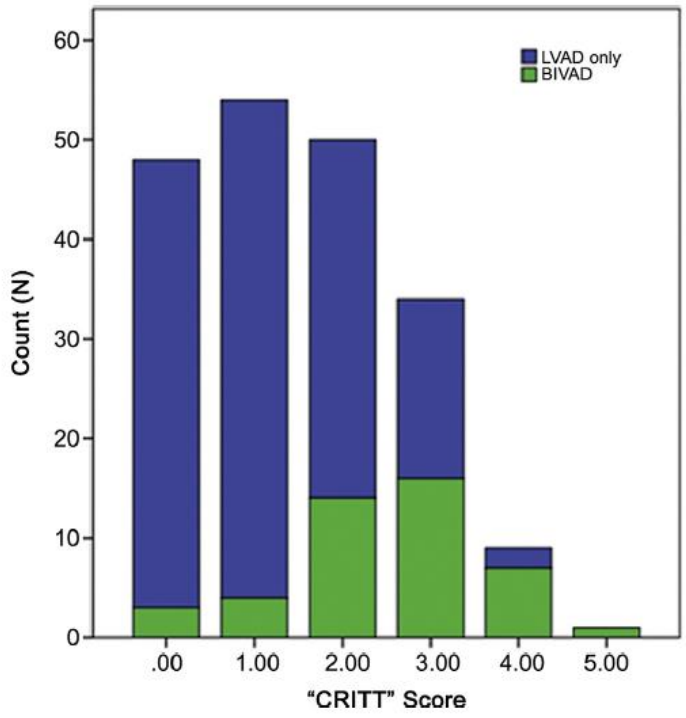
Risk Score is derived by summing points awarded for the presence of a vasopressor requirement (4 points), AST ≥80 IU/l (2 points), bilirubin ≥2.0 mg/dl (2.5 points), and creatinine ≥2.3 mg/dl (3 points).



Predicting Right Ventricular Failure in the Modern, Continuous Flow Left Ventricular Assist Device Era

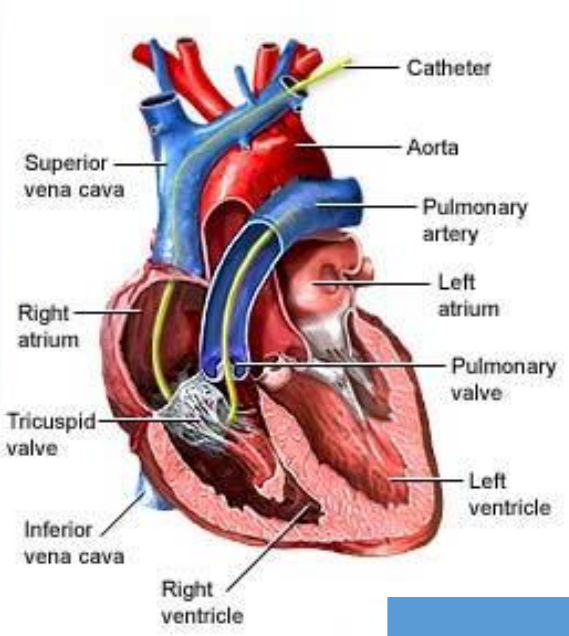
Pavan Atluri, MD, Andrew B. Goldstone, MD, Alex S. Fairman, BA, John W. MacArthur, MD, Yasuhiro Shudo, MD, Jeffrey E. Cohen, MD, Alexandra L. Acker, William Hiesinger, MD, Jessica L. Howard, BS, Michael A. Acker, MD, and Y. Joseph Woo, MD

Variable	Odds Ratio	95% CI	*p* Value
Severe right ventricular dysfunction	3.7	1.7 – 8.1	0.001
Severe tricuspid regurgitation	4.1	1.4 – 12.4	0.011
Preoperative mechanical ventilation	4.3	1.9 – 9.6	<0.001
Central venous pressure >15 mm Hg	2.0	0.9 – 4.2	0.089
Heart rate >100 beats/min	2.0	0.9 – 4.3	0.086
Constant	0.04		



Ann Thorac Surg 2013;96:857-64

Hemodynamic Predictors of RV Failure during LVAD support



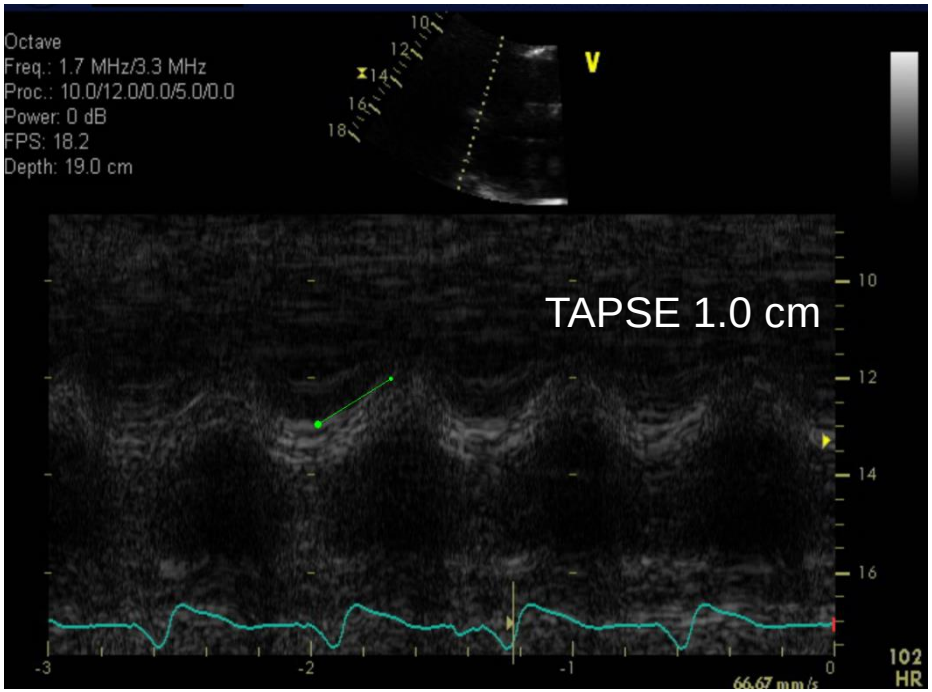
Parameter	Desirable Value
RVSWI (mPA-mCVP) x SV/BSA	< 300 mmHg × mL/m^2
CVP	>15 mmHg
PVR and TPG	PVR >4 Woods Units and TPG >15 mmHg

J Heart Lung Transplant 2010;29:S1-39

Tricuspid Annular Motion as a Predictor of Severe Right Ventricular Failure After Left Ventricular Assist Device Implantation

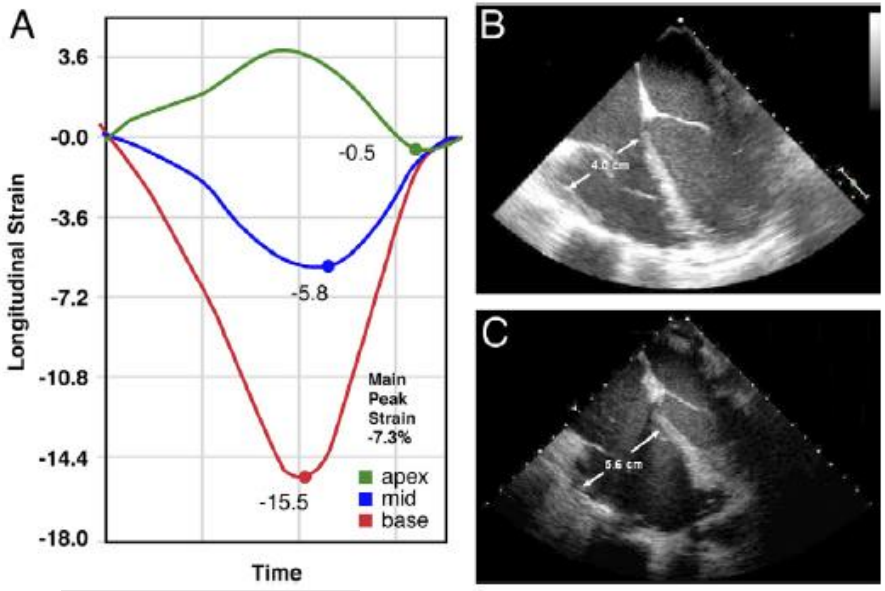
Sarinya Puwanant, MD,[a] Karen K. Hamilton, MD,[a] Charles T. Klodell, MD,[b] James A. Hill, MD, MS,[a] Richard S. Schofield, MD,[a] Timothy S. Cleeton, ARNP,[a] Daniel F. Pauly, MD, PhD,[a] and Juan M. Aranda Jr, MD[a]

- Retrospective of 33 patients
  – 11 patients with RV failure
- TAPSE < 0.75 cm significant predictor

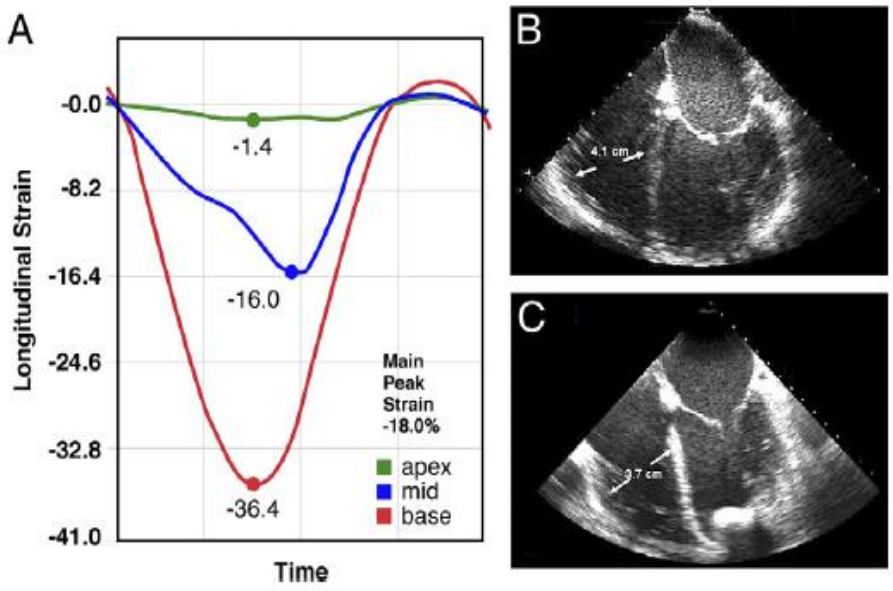


J Heart Lung Transplant 2008;27:1102-7

Addition of Strain Imaging to Risk Prediction



With RV Failure



Without RV Failure

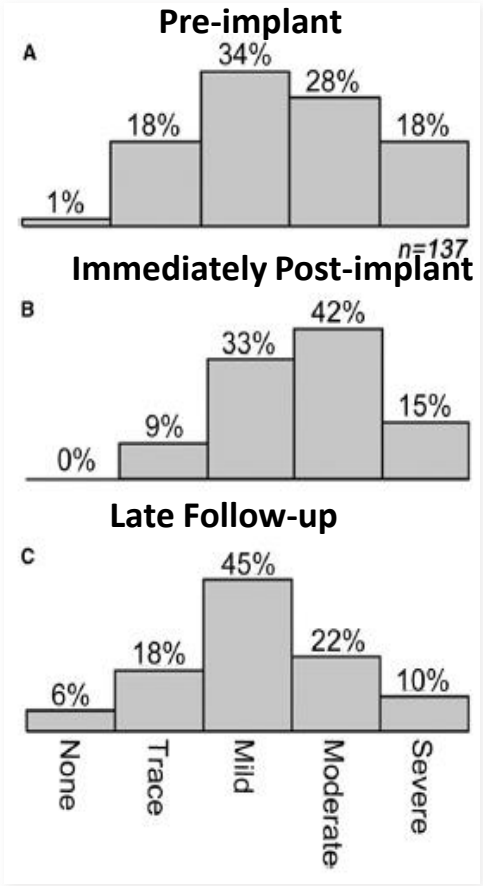
Grant, et al. *JACC* 2012; 60:521-528.

RV Management Pre-VAD

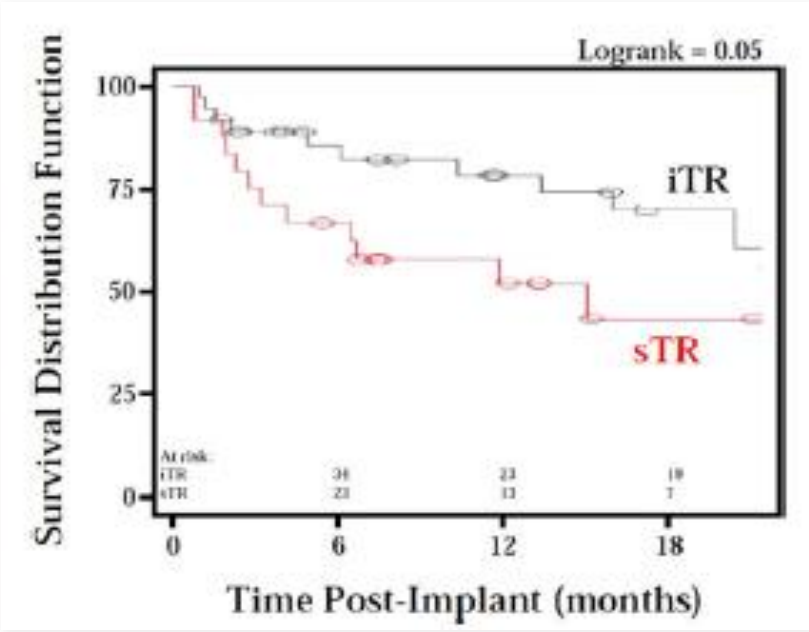
- Know the hemodynamics
- Critical to get CVP below 20 mmHg
- Treat pulmonary hypertension and RV failure:
    - Nitroprusside
    - Milrinone
    - Ultrafiltration
- 24 hrs pre-op an elective IABP *may* reduce need for RVAD
    - LV unloading
    - Less ischemia
    - Improved pulsatility

MCS with Concomitant Tricuspid Valve Repair

137/176 CF VAD patients with complete pre- and post-implant echo data



	iTR	sTR	*p* Value
RVAD implantation, %	0	9.7	0.003
Post-LVAD inotropic infusion, median days	5	8.5	0.02
Post-LVAD hospital stay, median days	20	27	0.03

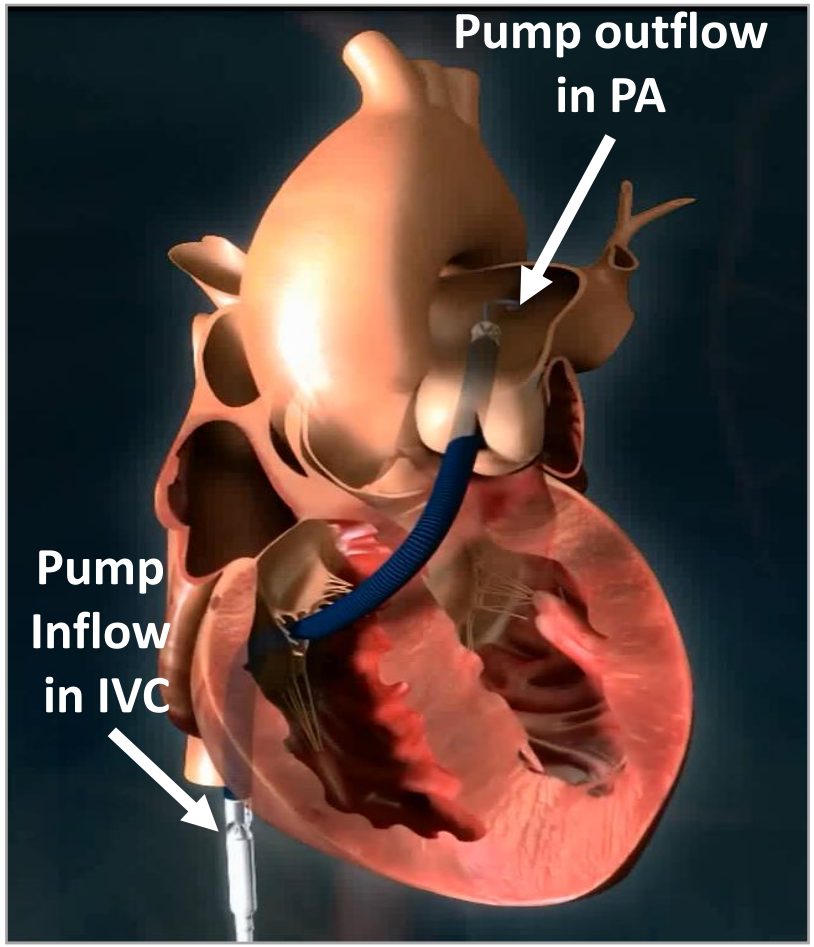


Ann Thorac Surg 2011;91:1342-7

Managing RV Failure After LVAD

- Inotropes
  - PDE inhibitors
- Pulmonary vasodilators
  - NO
  - Prostacycline
  - PO phosphodiesterase inhibitors
- Careful volume management
- Avoid “over pumping”

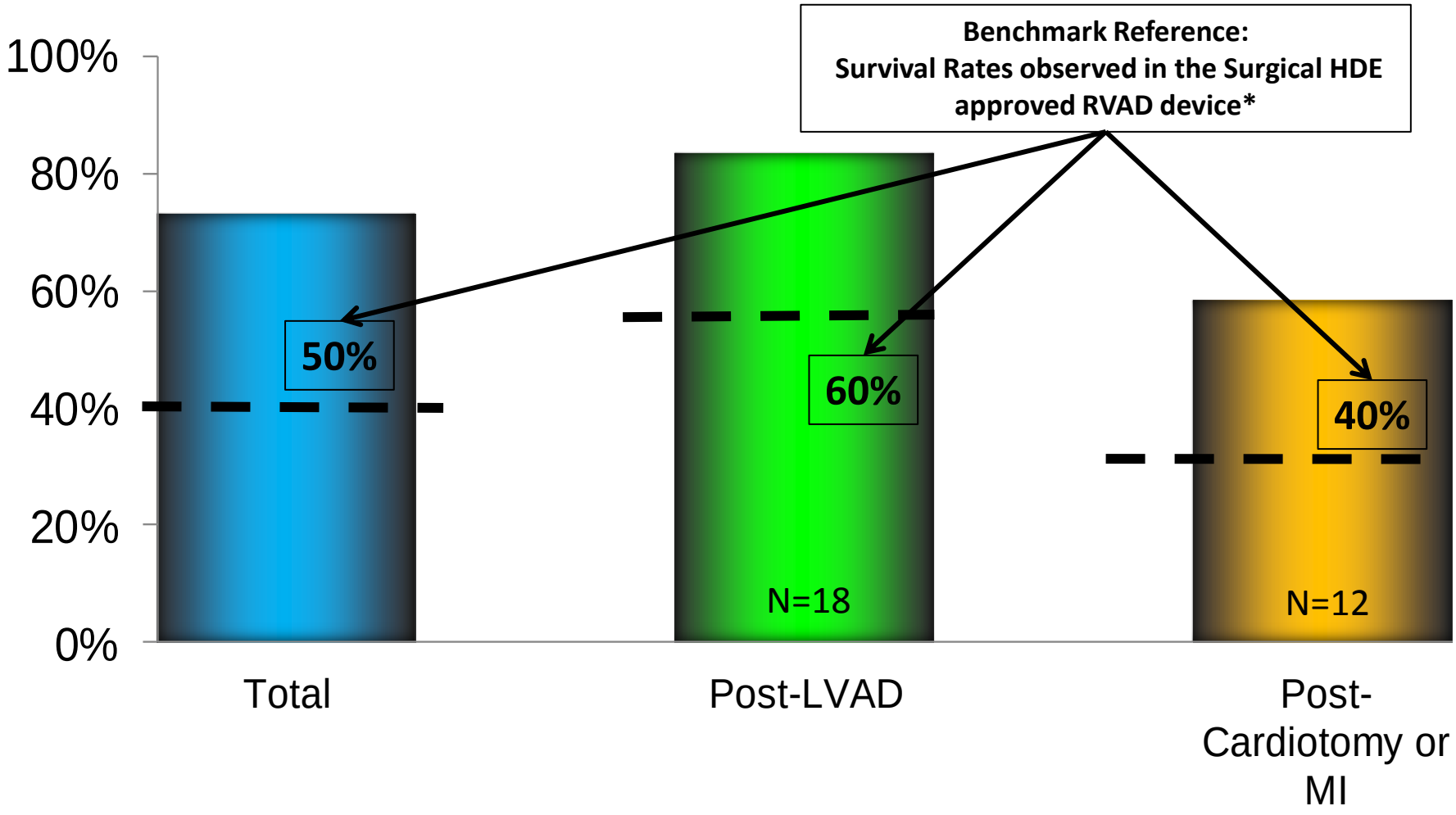
Impella RP: Percutaneous Right Ventricular Assist Device (RVAD)



- Transfemoral venous insertion
- 3D shaped cannula
- 22 Fr motor housing
- Pump mounted on a 11Fr catheter
- Flow: 4 L/min @ 33,000 rpm
- Anticoagulation: ACT ~ 160-180 sec

Primary Endpoint

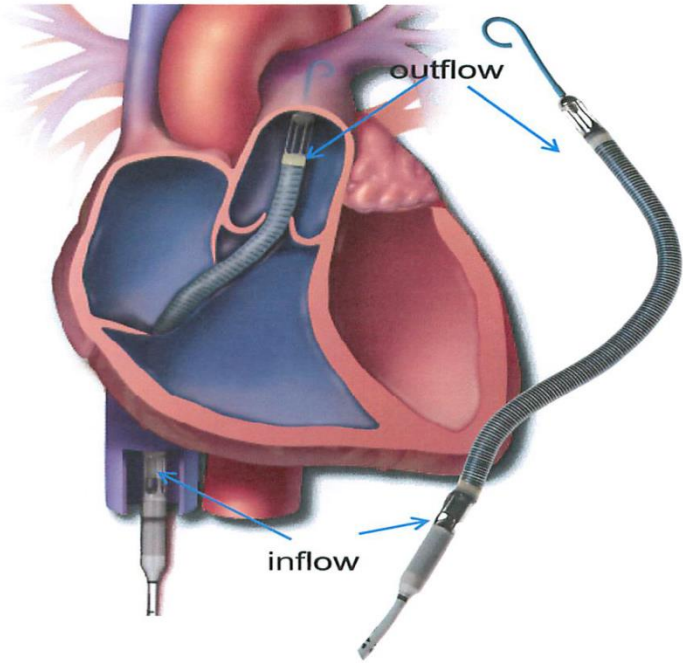
Survival to 30 Day, Discharge or Next Therapy

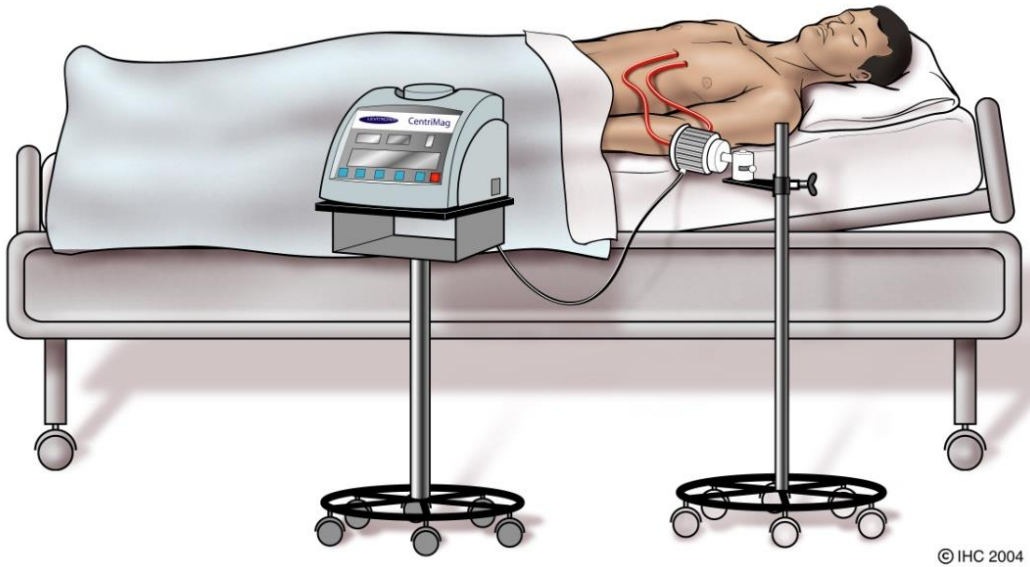


Mechanical Right Heart Support

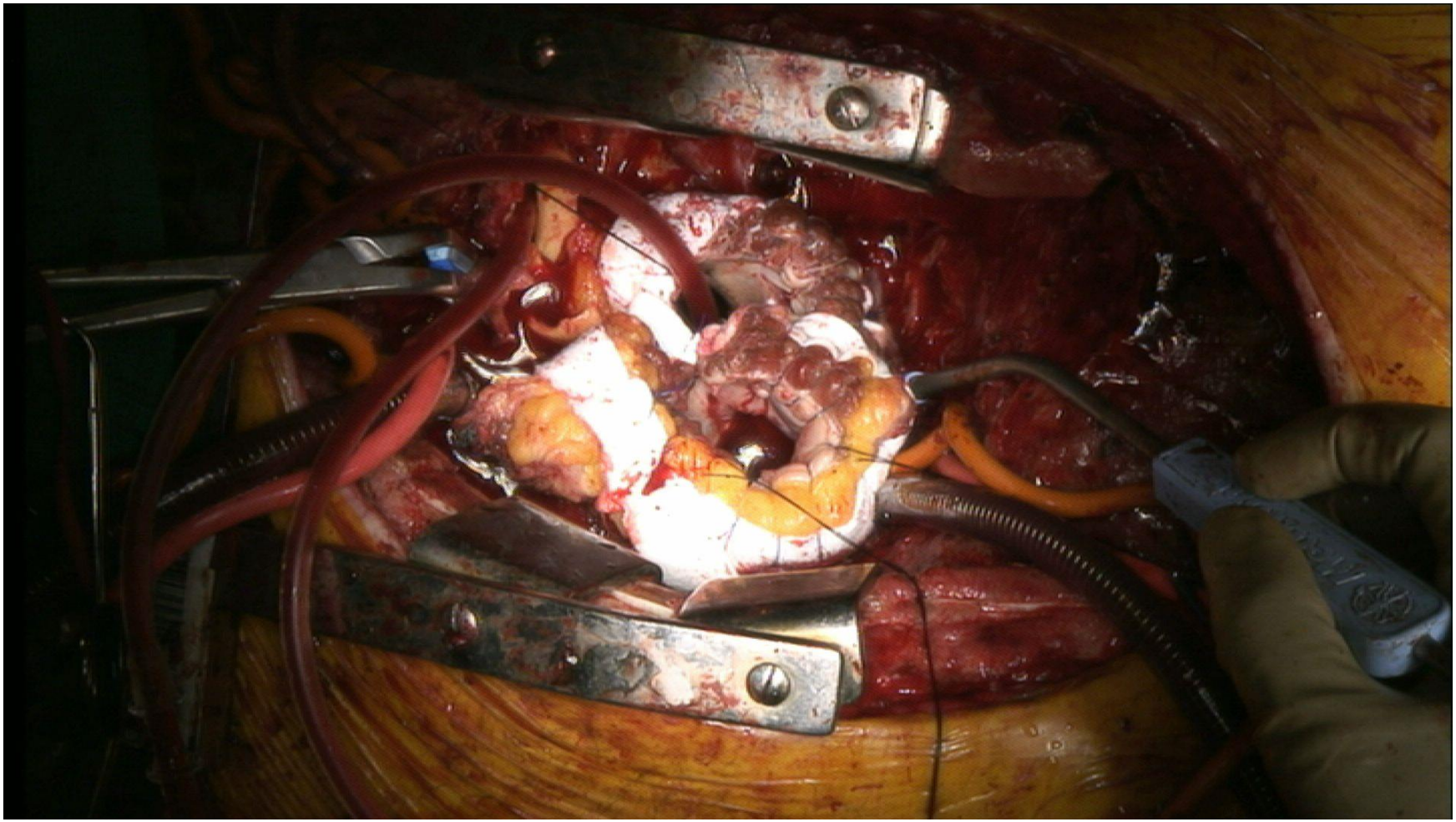
RECOVER RIGHT
The use of Impella RP Support System in Patients with Right Heart Failure:

A Clinical Safety and Probable Benefit Study

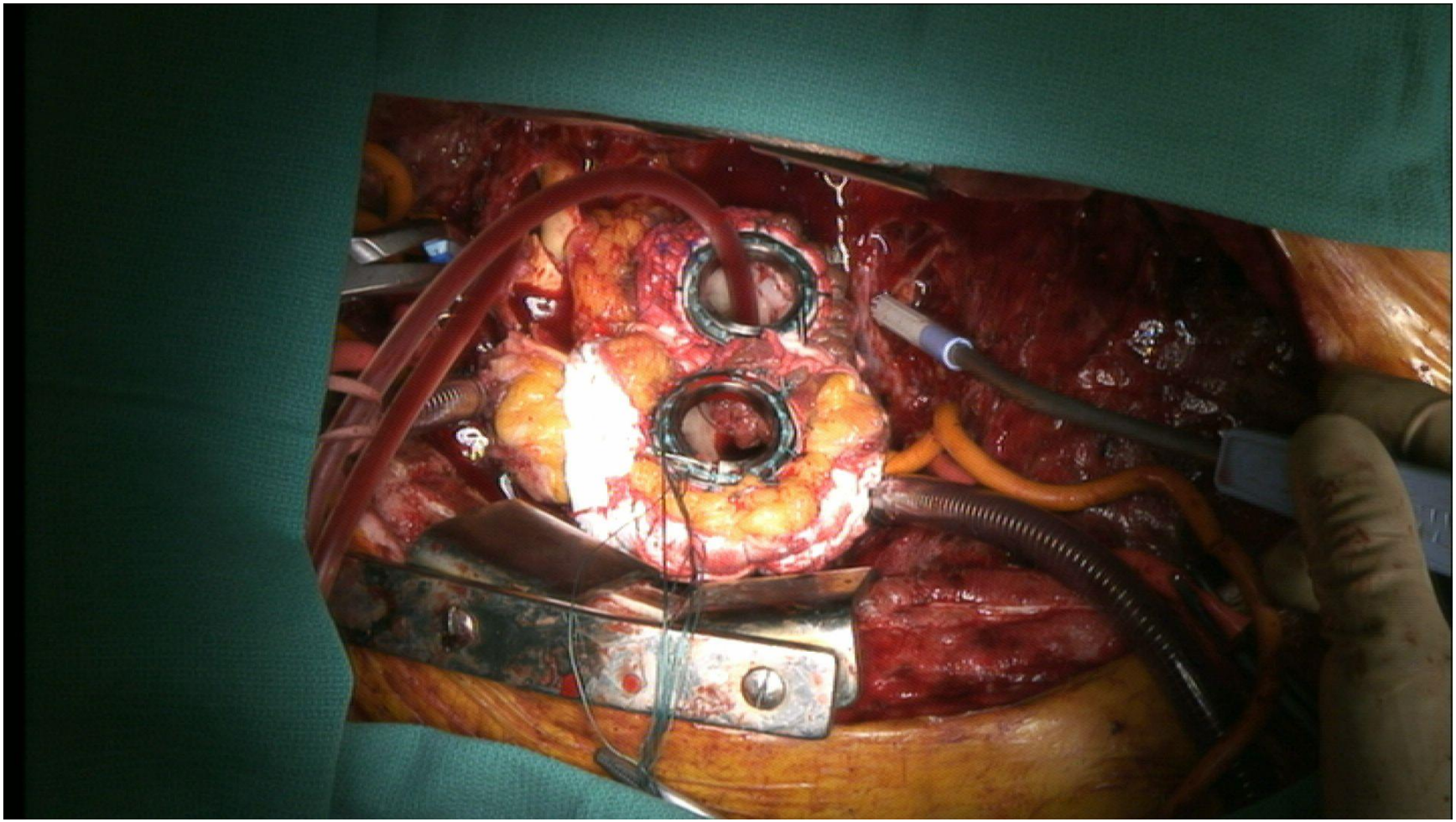




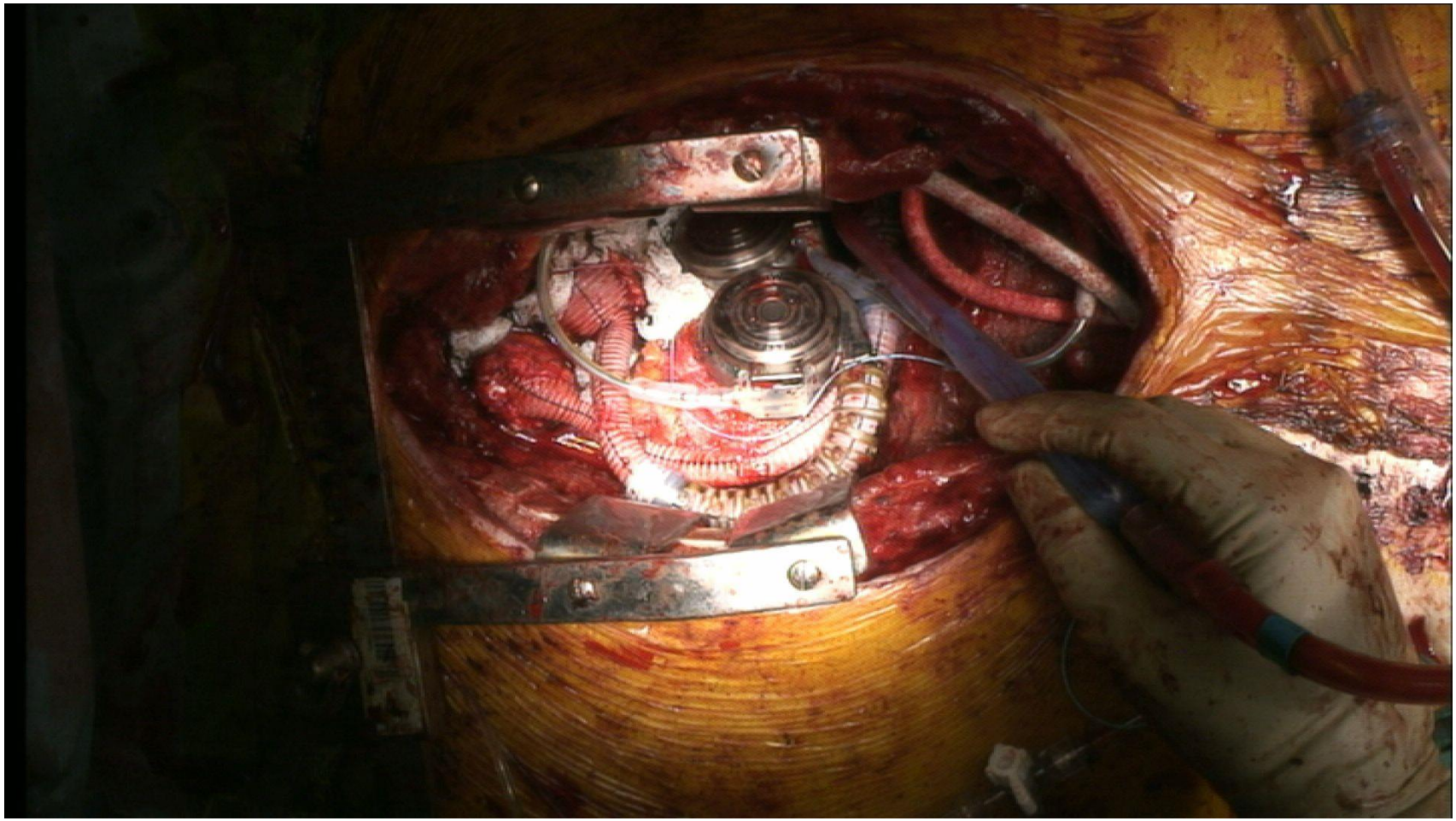
HVAD TAH



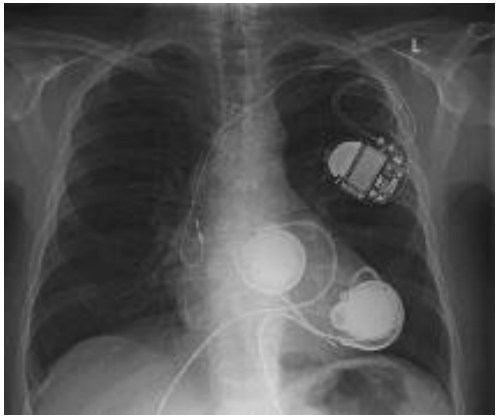
HVAD TAH



HVAD TAH



Strategies for Biventricular Support

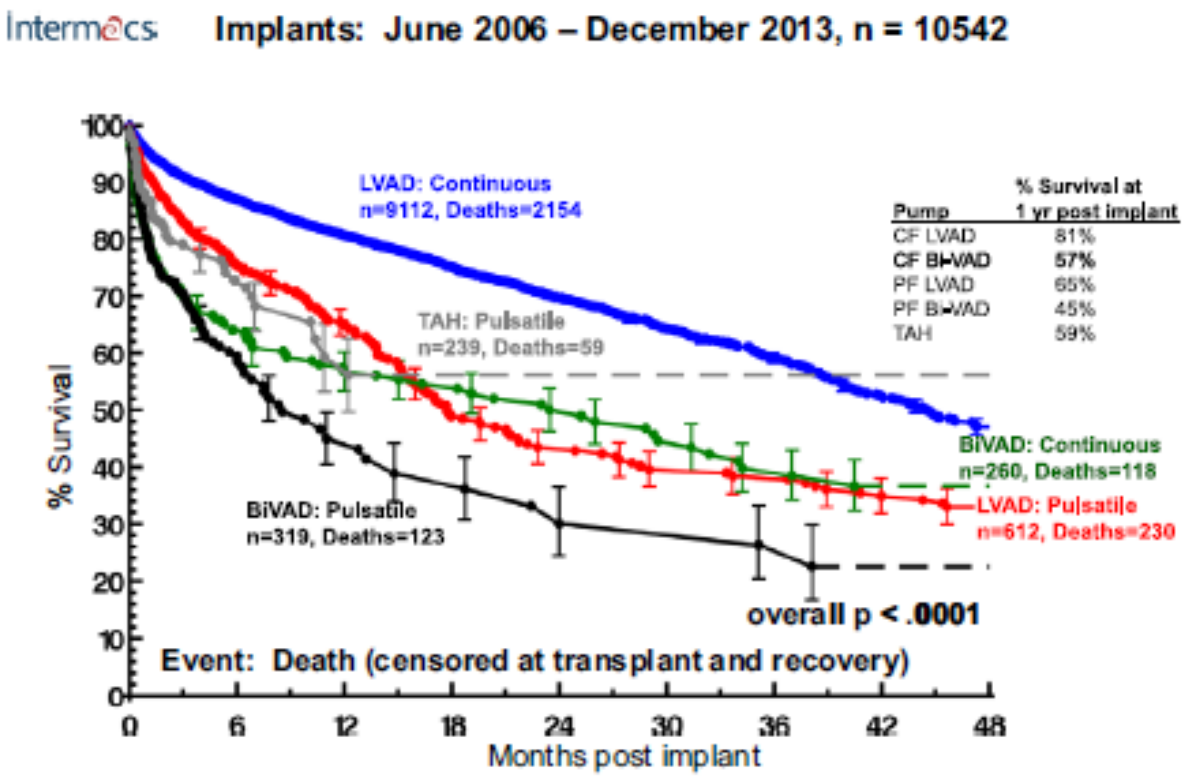


30-day survival 82%

Patient	Site of RVAD Implantation	On Ventilator, d	ICU Stay, d	Postoperative Complications	Hospital Discharge at POD	Support Period, d	Outcome
1	Anterior RV wall	4	24	Bleeding*	38	440	At home on BVAD
2	Anterior RV wall	6	14	None	27	420†	At home on LVAD
3	Anterior RV wall	4	11	None	21	375	Deceased after driveline injury
4	Anterior RV wall	9	9	None	...	9	Deceased (multiorgan failure)
5	Anterior RV wall	11	11	Bleeding	...	58	Deceased (multiorgan failure)
6	Anterior RV wall	5	18	Bleeding	28	350	Alive, at home
7	Anterior RV wall	25	38	Gastrointestinal bleeding	50	336	Alive, at home
8	Anterior RV wall	40	60	None	90	340	Alive, at home
9	Right atrium‡	13	29	None	53	280	Alive, transplanted
10	Anterior RV wall	2	19	None	38	46	Deceased (ICB)
11	Anterior RV wall	120	120	None	...	120§	Deceased (sepsis)
12	Anterior RV wall	25	25	Bleeding	...	25	Deceased, (endobronchial bleeding, lung failure)
13	Anterior RV wall	78	78	Bleeding, gastrointestinal bleeding, pneumonia	...	78	Deceased, (multiorgan failure)
14	Anterior RV wall	23	23	Mediastinitis	...	23	Deceased, (sepsis)
15	Anterior RV wall	1	6	None	24	75	Alive, at home
16	Anterior RV wall	5	5	Bleeding	...	5	Deceased (multiorgan failure)
17	Anterior RV wall	1	4	None	25	25	Alive, at home
Mean±SD		21.9±32.0	29.0±30.8			170±163	

Circulation 2011; 124 (suppl1):s179-s186

The Prognostic Implications of RV Failure



J Heart Lung Transplant 2014;33:555-64

Summary and Conclusions

- RV failure prior to LVAD is very difficult to predict
  - Integrate multiple data elements
- RV failure after LVAD will happen – be prepared
- Treatment typically relies on a combination of inotropes and vasodilators
- VAD management plays an important role in RV geometry and function
- Right sided MCS may be required. Don’t wait too long to implement.