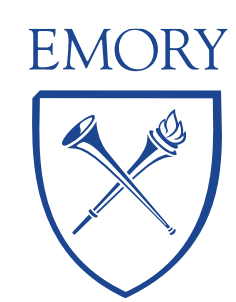


LVAD Outflow Graft Obstruction Causing Recurrent HF

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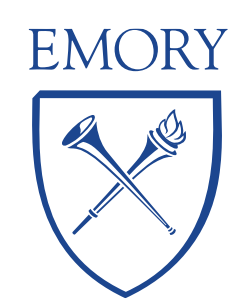
HF after LVAD Implant

LVAD use is increasing

- ~2% of HF patients have stage D disease¹
- 3552 transplants in 2019

BUT complications are high

- 1-year readmission ~75%²
- Recurrent HF is common:
 - Commonest causes:
 - RV failure ~0.08-0.12 EPPY
 - Pump thrombosis ~0.19-0.29 EPPY



HF after LVAD Implant

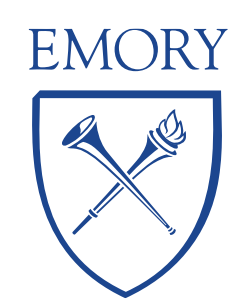
Table 1. Causes of Late Heart Failure After LVAD Implantation

	LV Failure	RV Failure
LVAD related	Pump thrombosis Inflow or outflow cannula obstruction Percutaneous lead or motor failure Pump speed too low	Cardiac tamponade Pump speed too high
Non–LVAD related	New/worsening aortic insufficiency Gastrointestinal bleeding with severe anemia	Intrinsic RV dysfunction Persistent pulmonary hypertension Pulmonary embolism New/worsening tricuspid regurgitation Ventricular arrhythmias

Outflow Cannula Obstruction

- Many case reports/series
 - All VAD types affected
 - Varying etiologies
 - Varying treatment strategies
- Incidence not defined
- No consensus on treatment

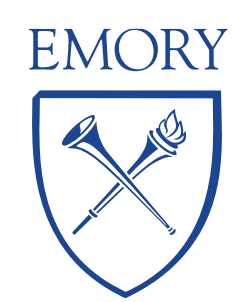
	N (%)
Clinical Presentation (N=58)	
Heart failure	44 (76)
Low LVAD pump flow	46 (79)
Both heart failure and low LVAD flow	38 (66)
LVAD details	
LVAD type (N=68)	
HMII	28 (41)
HVAD	34 (50)
HM3*	5 (7)
Jarvik 2000	1 (1)
Time Post LVAD implant (N=43)	28±17 months
Presentation <1-year post-implant (N=23)	8 (19)
Lesion Details	
Lesion type (N=61)	
Anastomosis site stenosis†	20 (33)
Kink	7 (11)
External compression of graft	29 (48)
Outflow graft thrombosis	5 (8)
Infectious mass obstructing flow	2 (3)
Treatment strategy (N=73)	
Balloon angioplasty	2 (3)
Stenting	46 (63)
Surgical repair of outflow graft lesion	16 (22)
No lesion-specific intervention	9 (12)
Geographic Region (N=34 publications)	
North America	21 (62)
South America	1 (3)
Europe	10 (29)
Asia	2 (6)



The Emory Experience

- Single Center, retrospective
- Jan 2012 – Apr 2020
 - N=286 LVADs
 - N=18 with hemodynamically significant LVAD outflow graft obstruction
- Incidence: 0.034 EPPY
 - Does not vary by LVAD type

N=18	
Clinical Parameters	
Age at presentation, years	49 (42-60)
Male	11 (61)
Body mass index, kg/m ²	31.3±6.4
Hypertension	11 (61)
Diabetes mellitus	8 (44)
Atrial fibrillation	7 (39)
Implantable cardioverter defibrillator	18 (100)
Cardiac resynchronization therapy	6 (33)
Ischemic cardiomyopathy	5 (28)
Medication on Admission	
Aspirin	16 (89)
Warfarin	18 (100)
INR	3.2±1.4
Beta-blocker	12 (67)
ACEi/ARB	10 (56)
Aldosterone antagonist	9 (50)
Loop diuretic	16 (89)
Calcium channel blocker	7 (39)
LVAD Details	
Implantation strategy	
Destination therapy	13 (72)
Bridge-to-transplantation	5 (28)
Device type	
HeartMate II	3 (17)
HeartWare	12 (67)
HeartMate 3	3 (17)



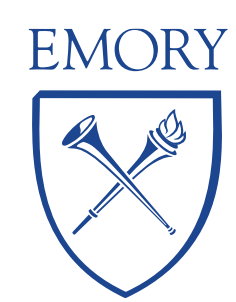
Clinical Presentation

Initial Findings

- 94% → low LVAD pump flow relative to baseline
- 89% → symptomatic HF
- 83% presented with both HF and low LVAD flow

Natural History

- Typically insidious
 - LVAD log file review
 - Slow decline in flow for months
- But can be abrupt
 - 4 of 18 within days



Clinical Presentation

Labs

- LDH remains normal/baseline
 - 271 ± 74 (normal : 140-271)
 - None $>1.5x$ upper limit
- Other labs unremarkable

Echo

- Prospective: LVAD outflow graft visualized in $>90\%^1$
- 11 of 17 adequately imaged in our study
- Good screening tool
- Negative findings should NOT eliminate outflow graft obstruction

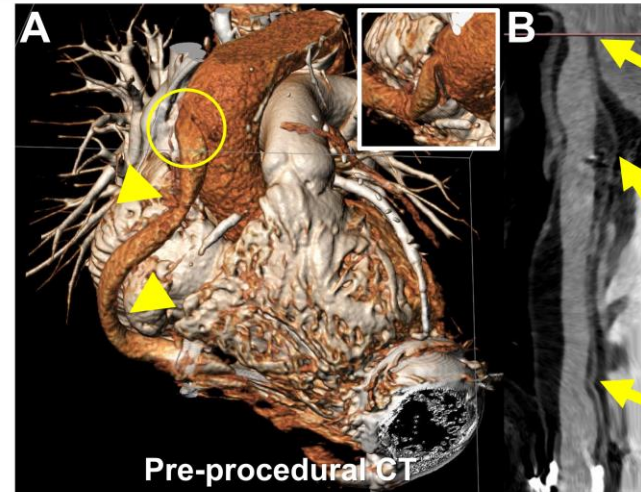
Cardiac CTA is Essential

CTA

- Define anatomic location
- Identify etiology
- Assess entire graft

Lesions

- External graft compression (76%)
- Stenosis of the aortic anastomosis (41%)
- Kinking (35%)
- Multiple lesions (53%)



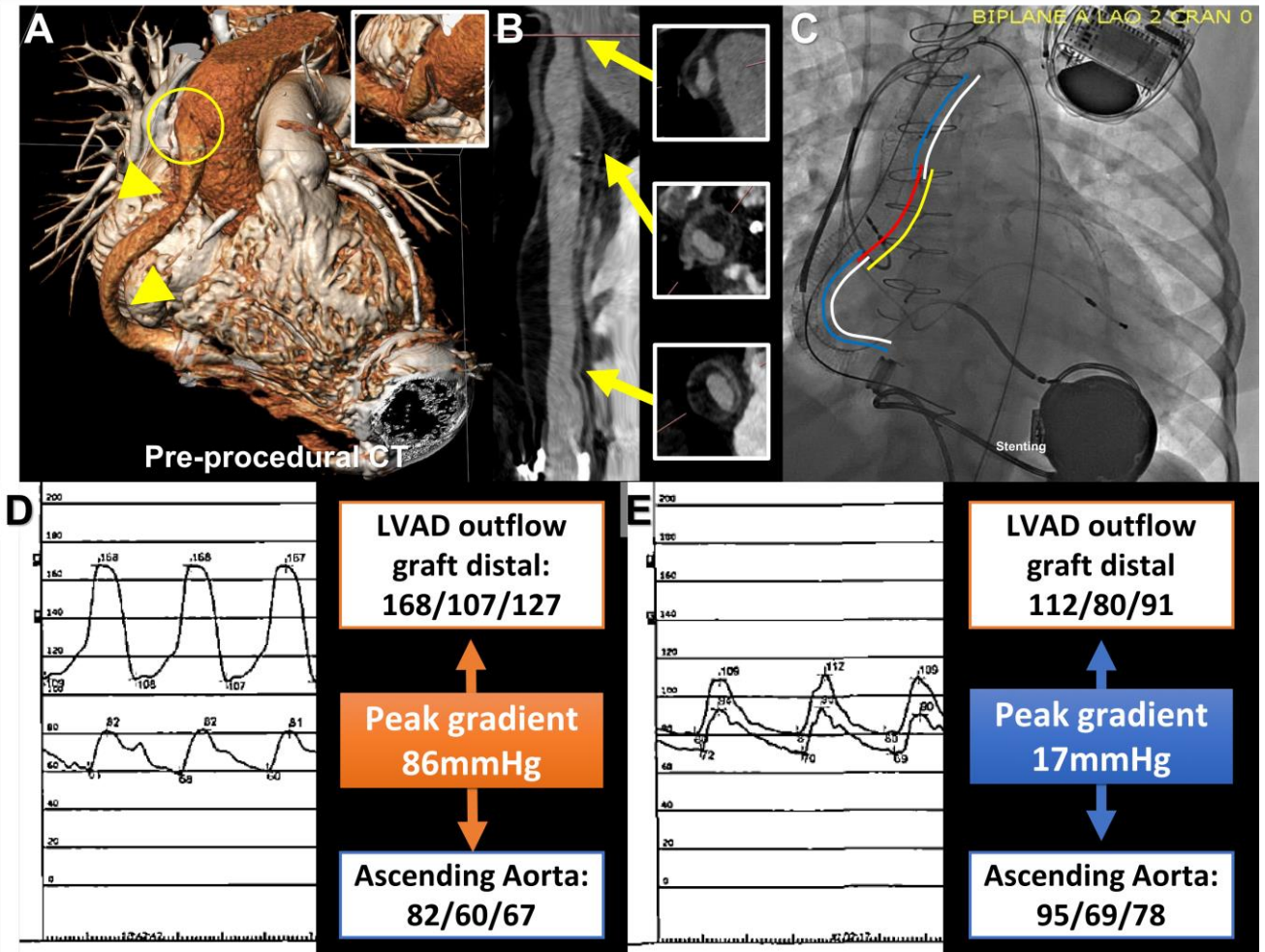
Stenting is Safe and Durable

Efficacy:

- 1 repeat procedure in 18 patients
- Follow-up: 13 ± 8 months

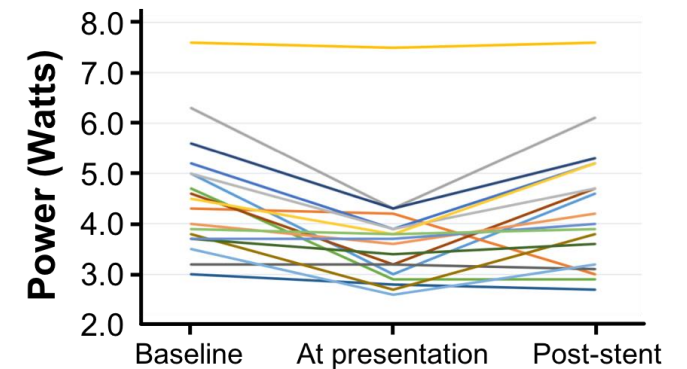
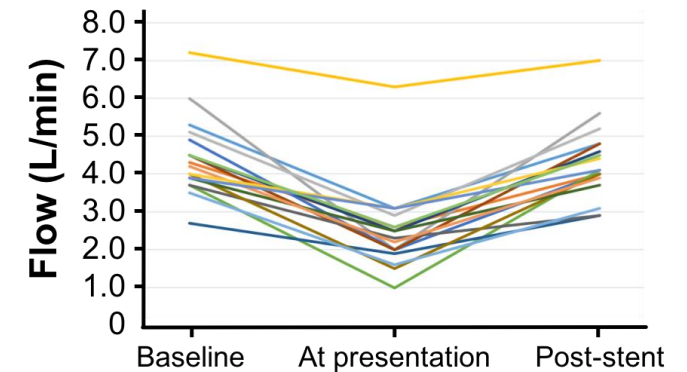
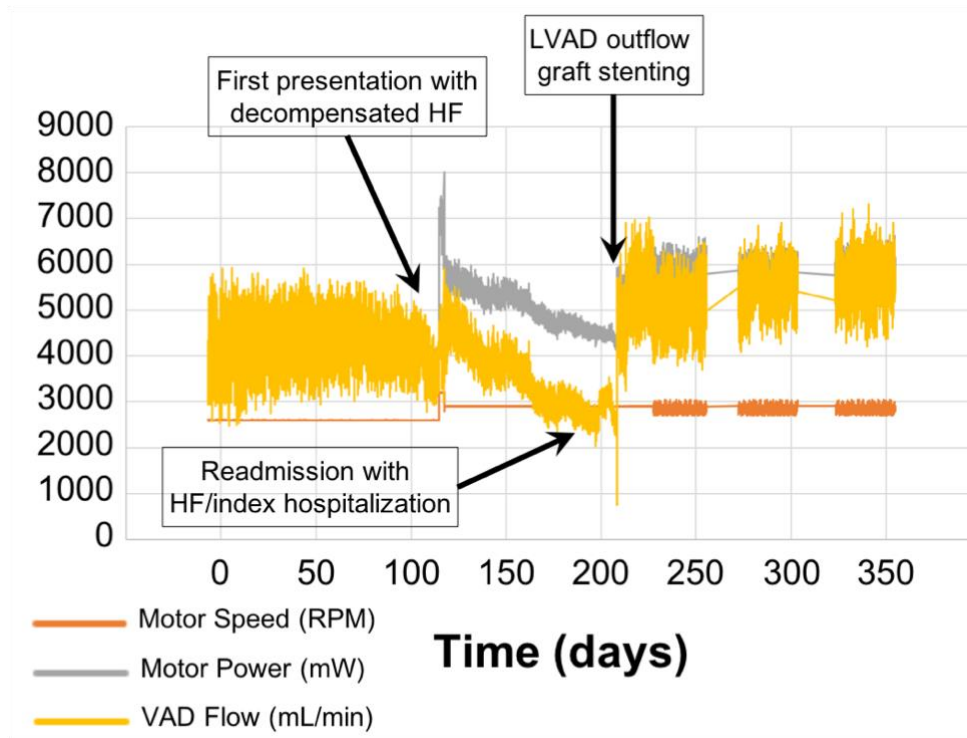
Safety:

- 3 with minor blood loss anemia
- 1 stroke (1st case)



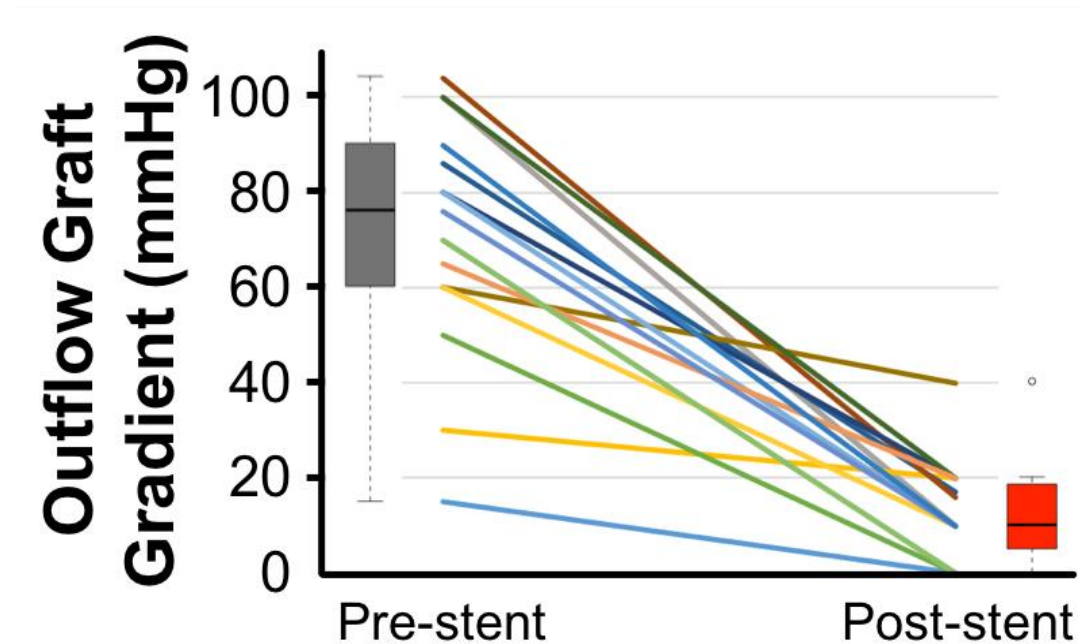
Stenting is Safe and Durable

- LVAD flow immediately returns to normal



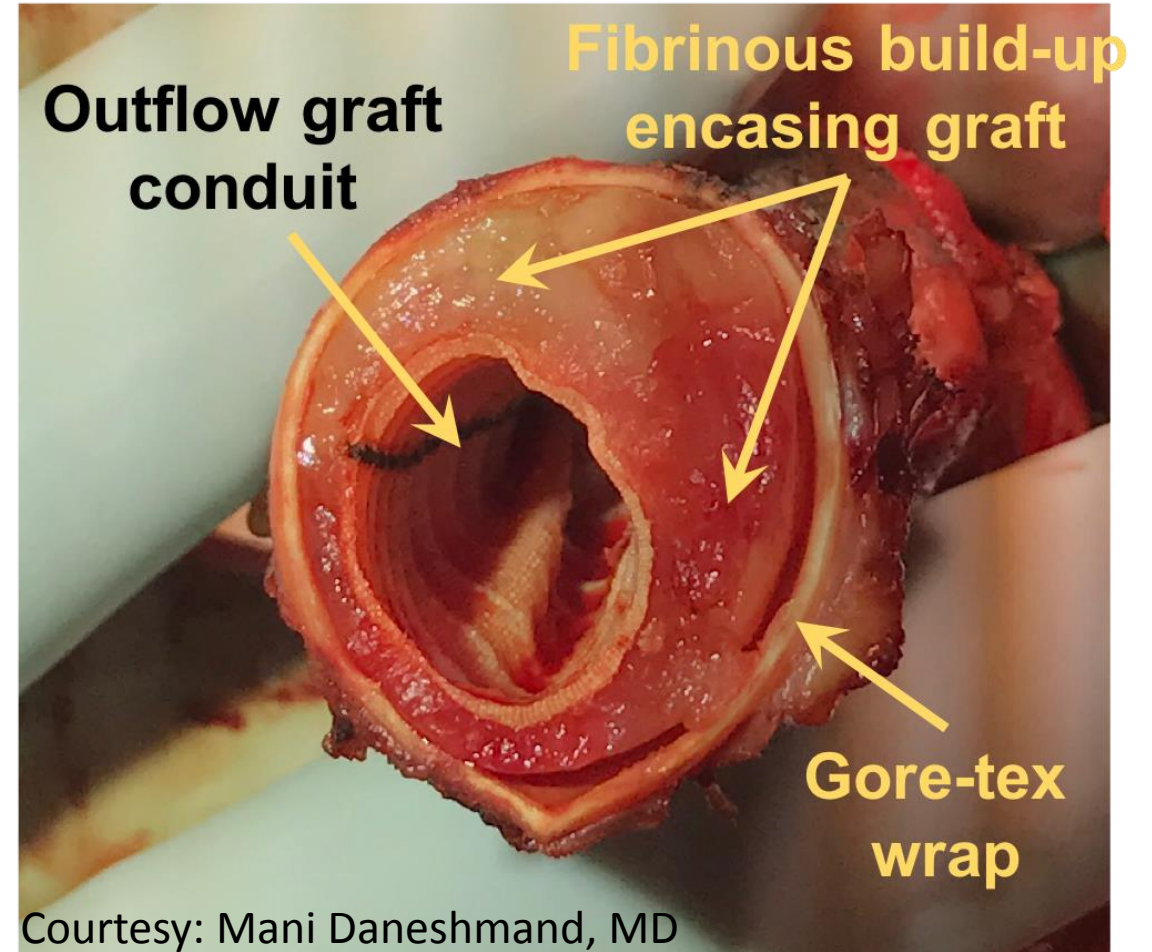
Stenting is Safe and Durable

- Marked hemodynamic improvement



External Compression

- Build-up in the Gore-tex wrap used to protect the outflow graft
- Commonest in our series (76%) and literature (48%)
- Can be confused for thrombus **within** the outflow graft on CT
- Acellular fibrinous matrix¹⁻⁴

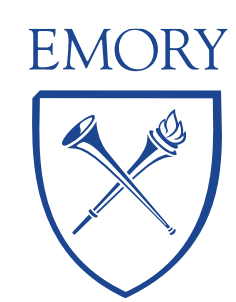


1 – Bhamidipati *et al.* Ann Thorac Surg. 2017;103:e101.

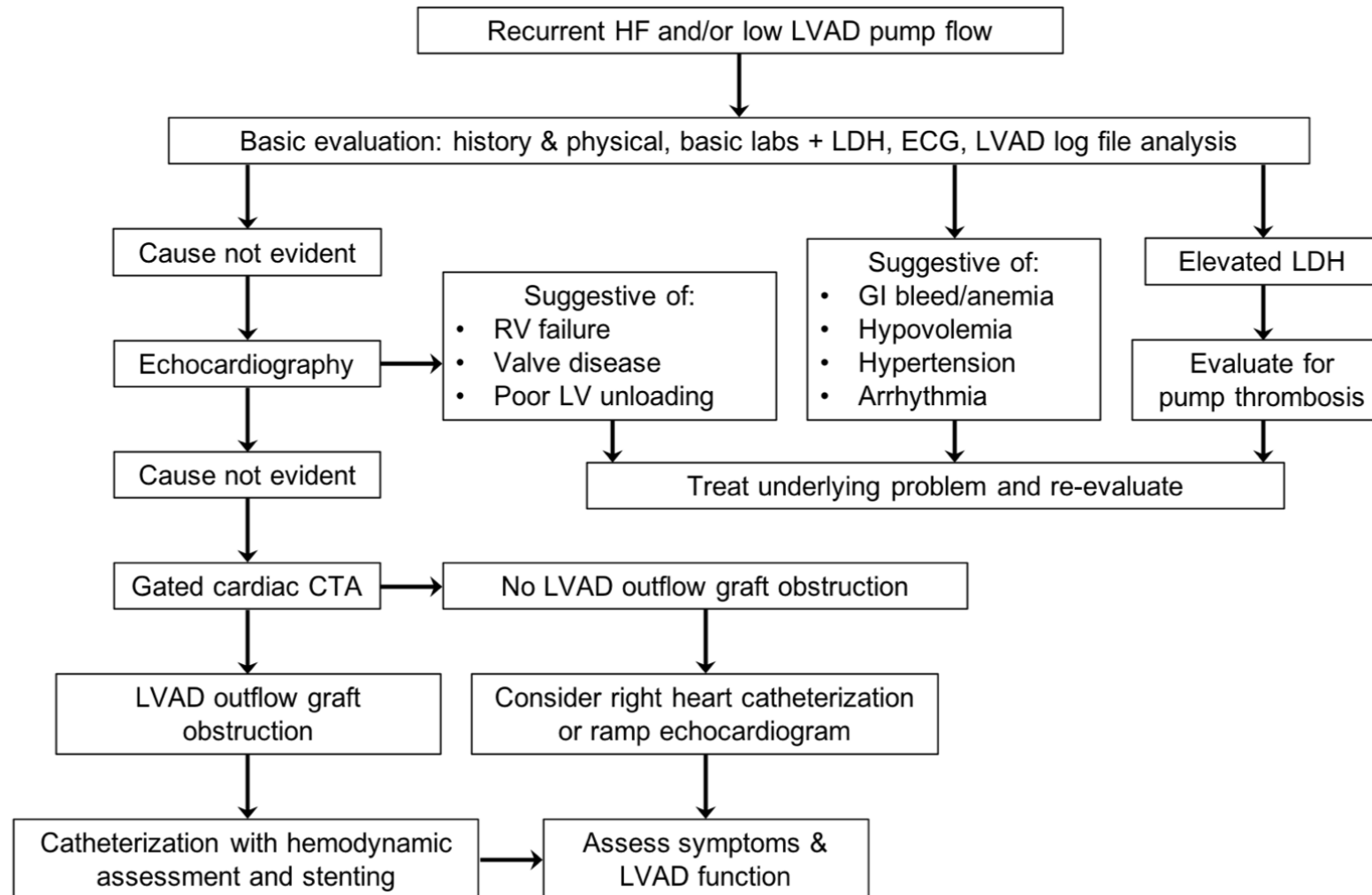
2 – Duero Posada *et al.* Circ Heart Fail. 2017;10:e004275.

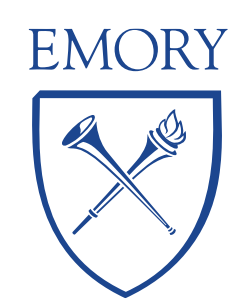
3 – Rajagopal *et al.* J Heart Lung Transplant. 2019;38:472.

4 – Barac *et al.* Heart Lung Circ. 2020;29:e25.



Suggested Management Algorithm





Summary: LVAD Outflow Graft Obstruction

Major Findings

- Incidence: 0.03EPPY
 - Less common than other VAD complications
 - May be an underestimate
 - Likely underrecognized
 - Present with HF &/or low flow
- Stenting: safe/durable
 - Follow-up free of outflow graft problem: 13 ± 8 mo
 - Complications: blood loss, stroke (<20%)

Management Tips

- LDH normal/baseline
- Normal or low power
- Use LVAD log files!!
- Negative echo does NOT exclude
- Cardiac CTA is essential
- Consider leaving protective wrap open posteriorly upon initial VAD implant surgery