Superior Vena Caval Occlusion in Acute Decompensated Heart Failure: First-in-Human Experience

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# Disclosures

#### Navin K. Kapur, MD:

Speaker/Consultant Honoraria: Abbott, Abiomed, Boston Scientific, Medtronic, LivaNova, MD Start, Precardia

Equity Interest: Precardia

Research Grants: Abiomed, Boston Scientific, MD Start, NIH RO1 HL139785, RO1H133215

Richard H. Karas, MD PhD:

Consultant Honoraria and Equity Interest: Precardia





## Increasing Prevalence of Heart Failure By 2030, 1:33 US individuals will have heart failure

Total US Healthcare Costs for HF Estimated at \$70 Billion



### **Increasing Prevalence of Heart Failure** Actual HF Burden Exceeds Projected Burden



Lam CS, Donal E, Kraigher-Krainer E et al. Eur J Heart Fail. 2011;13:18–28.

## **Congestion is an Important Target of Therapy** *Congestion is Associated with Poor Clinical Outcomes*

	Co	Congestion Score*											
	0	1	2	3-9									
HF hospitalization	26%	35%	35%	35%									
Death 🤇	19%	25%	25%	43%									
HF hosp. or Death	36%	46%	46%	60%									

\*Discharge/Day 7 Congestion score: Based on extent of orthopnea, JVD, edema (each on scale 0-3) N=2016, placebo arm only Median f/u: 9.9 months Ambrosy, Pang, Gheorghiade, EHJ, 2013

## **Congestion is an Important Target of Therapy** *Congestion not Just Cardiac Output in ADHF*



**Conclusion:** Final PCWP and final right atrial pressure were stronger predictors of postdischarge outcomes than CI in patients with advanced heart failure. The ability to lower filling pressures appears to be more prognostically important than improving CI in the management of patients with advanced heart failure.

Cooper and Rogers et al. J Card Fail. 2016 March; 22(3): 182–189.

## **Congestion is an Important Target of Therapy** *Hemodynamic Indices of Congestion Predict Mortality*



Right atrial pressure is independently associated with in-hospital mortality

Odds ratio 1.12 per 1mmHg increase in RA pressure (p<0.001)

D.M. Brinkley Jr. et al. / American Heart Journal 199 (2018) 31-36

## **Existing Decongestive Therapies are Limited** *There exists a need for more rapid and effective cardiac decongestion in patients with acute heart failure*

### Loop diuretics

- May worsen renal function
- Associated with worse clinical outcomes.
- 20-30% of patients develop diuretic resistance.

#### **Ultrafiltration**

• Lack of compelling results and limited adoption.

### <u>Vasodilators</u>

- Associated with hypotension in acute heart failure
- Associated with toxicity and tachyphylaxis

#### <u>Inotropes</u>

- Increase cardiac workload
- No improvement in clinical outcomes
- Associated with arrhythmias



**Reducing Ventricular Load Improves Outcomes** Load is the Product of Ventricular Pressure and Volume Unloading Technologies are Expensive and Complicated



Laplace's Law: Wall stress =	Pressure x Radius	Pressure x Volume
	2 x Wall Thickness	LV Mass

### The Disruptive Concept: Restricting Cardiac Preload No device therapy specifically reduces LV preload due

to concerns around reduced blood pressure



#### Preload:

The load imposed on the ventricle at the end of diastole. The most common measures of preload include end-diastolic volume (EDV), end-diastolic pressure (EDP).

The different loops are obtained with different levels of preload, but constant contractility.

## The Disruptive Concept: Restricting Cardiac Preload

The Superior (SVC) and Inferior Vena Cava (IVC) Contribute 30% and 70% of Cardiac Preload Respectively



## **Preclinical Testing Phase 1: SVC vs IVC**

In contrast to IVC occlusion, acute SVC occlusion reduced cardiac filling pressures without reducing systemic blood pressure or cardiac output



Kapur Lab AHA 2017

## **Preclinical Testing Phase 1: SVC vs IVC**

IVC

SVC

p=0.15

p=0.53

p=0.03

5

Occluded

86

Occluded

354

Occluded



# SVC Occlusion Provides Effective & Reproducible LV Unloading



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## **Preclinical Testing Phase 2: Chronic Animal Testing**

12-18 hours of intermittent SVC occlusion was well tolerated without adverse vascular or neurologic effects in a swine model of congestive heart failure

A	Hours																					
	-1	-2	-3	-4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LAD Occlusion																						
LAD Reperfusion																						
SVC Therapy *																						
Left Renal Artery Occlusion																						
<b>Right Renal Artery Occlusion</b>																						



\* SVC Therapy Duty Cycle : 5 mins occluded to 30 second patent

**Partially Filled** 

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# preCARDIA Pump Mechanics



Balloon Inflation (Non-dilating)



Balloon Deflation (Partial)

## **Preclinical Testing Phase 2: Chronic Animal Testing**



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# **SVC Occlusion in Acute Heart Failure**

Preclinical Conclusions and Lessons Learned:

- Compared to IVC occlusion, acute SVC occlusion provides a superior hemodynamic profile with reduced cardiac filling pressures and stable systemic pressure and cardiac output.
- 2. Intermittent SVC occlusion with a novel cathetermounted SVC balloon system is well tolerated with durable reduction in cardiac filling pressures without anatomic evidence of neurologic or vascular injury.

**Study Design:** Prospective, single-arm, proof-of-concept study investigating superior venocaval (SVC) occlusion as a therapeutic approach to improve heart function in human subjects with advanced heart failure.

**Primary Objective:** confirm safety of transient SVC occlusion including neurologic assessment before, during, and for 24 hours post-procedure

**Secondary Objective:** measure acute hemodynamic changes associated with transient SVC occlusion

**Study Population:** 18-75 year old patients admitted with acutely decompensated heart failure with reduced ejection fraction referred for cardiac catheterization

**IRB** Approved Protocol











Pre-Occlusion SVC Diameter SVC Occlusion

Post-Occlusion Non-injured SVC





## **Clinical Proof of Concept Study**





# **Clinical Proof of Concept Study**

No neurologic safety issues were identified during the acute phase of the study, at 7 days (n=8), or 30 days (n=5) of follow up.



Mini-Cognitive Testing Score (Range 0 to 5; 5 = normal)



# **SVC Occlusion in Acute Heart Failure**

Clinical Conclusions and Lessons Learned:

- 1. We now report the first-in-human experience with SVC occlusion as a potentially novel therapeutic approach to rapidly and significantly reduce cardiac filling pressures in acutely decompensated systolic heart failure.
- 2. SVC occlusion was well tolerated with stable mean arterial pressures and cardiac output, and without neurologic side effects.
- 3. Future studies are required to test the clinical utility of SVC therapy as an approach to reduce congestion and improve outcomes for patients with acute congestive heart failure.



Prospective, multicenter Early Feasibility and Safety Study to confirm the safety and feasibility of the preCARDIA System

FDA Approved EFS Study: March 2019

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## Thank You

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