Maintaining the Circulatory System when in a Critical State: ICU management for the Failing Circulation

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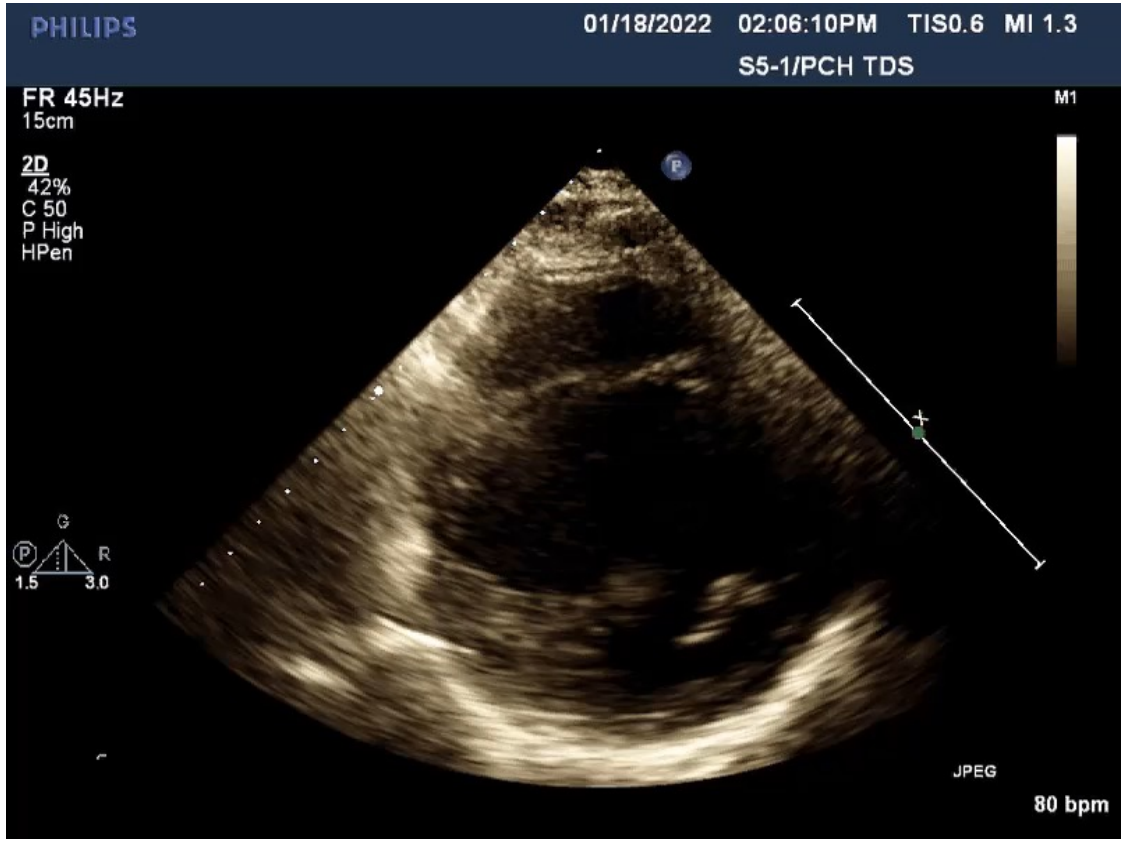
No conflicts of interest

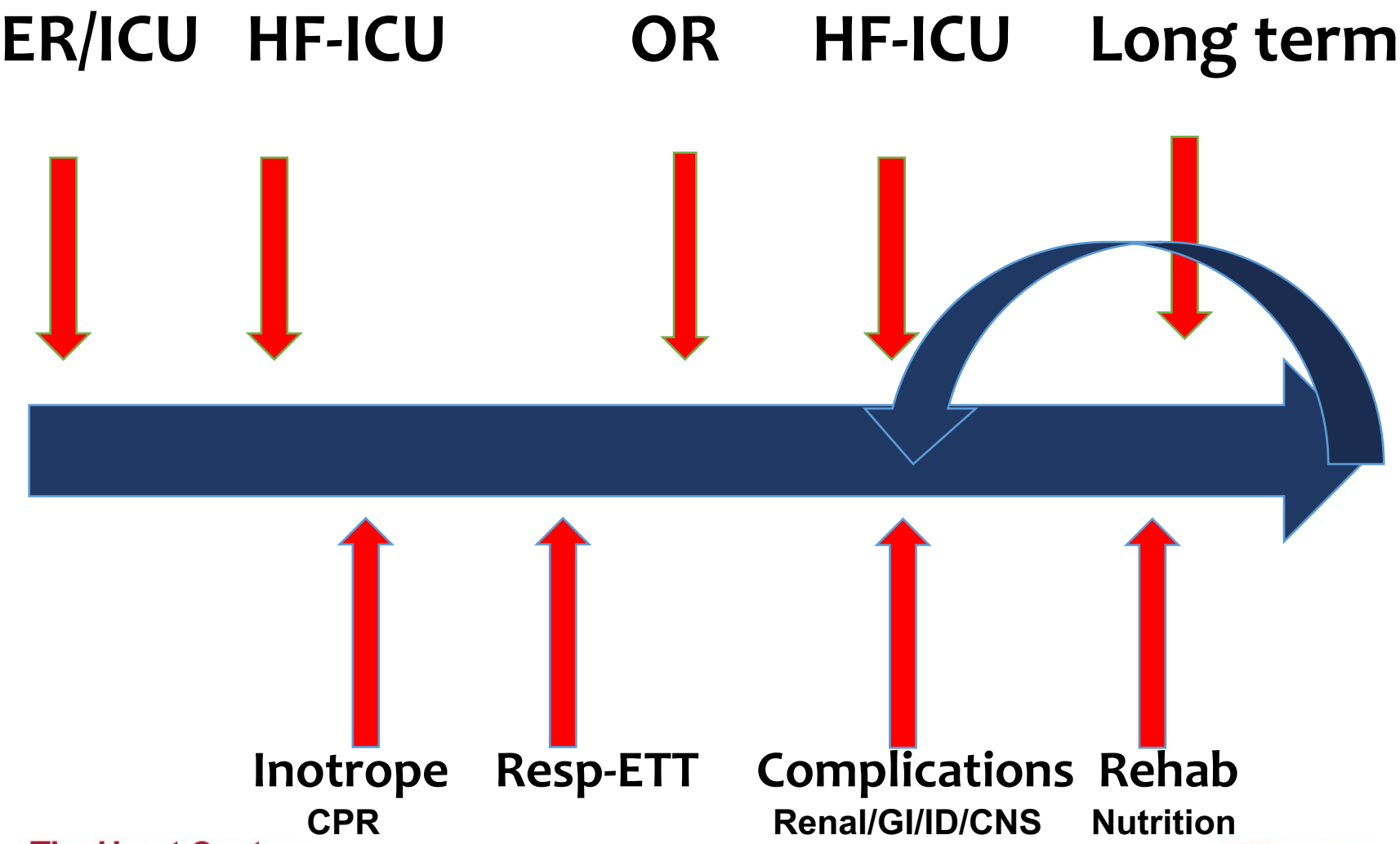
Objectives

- Describe strategies to maintain the circulation
- Describe potential opportunities for and threats to optimal management
- Leverage adult data (and some pediatric) to improve understanding of potential therapeutic optimization

Two images are worth > 1000 words…



Course of the child with ADHF



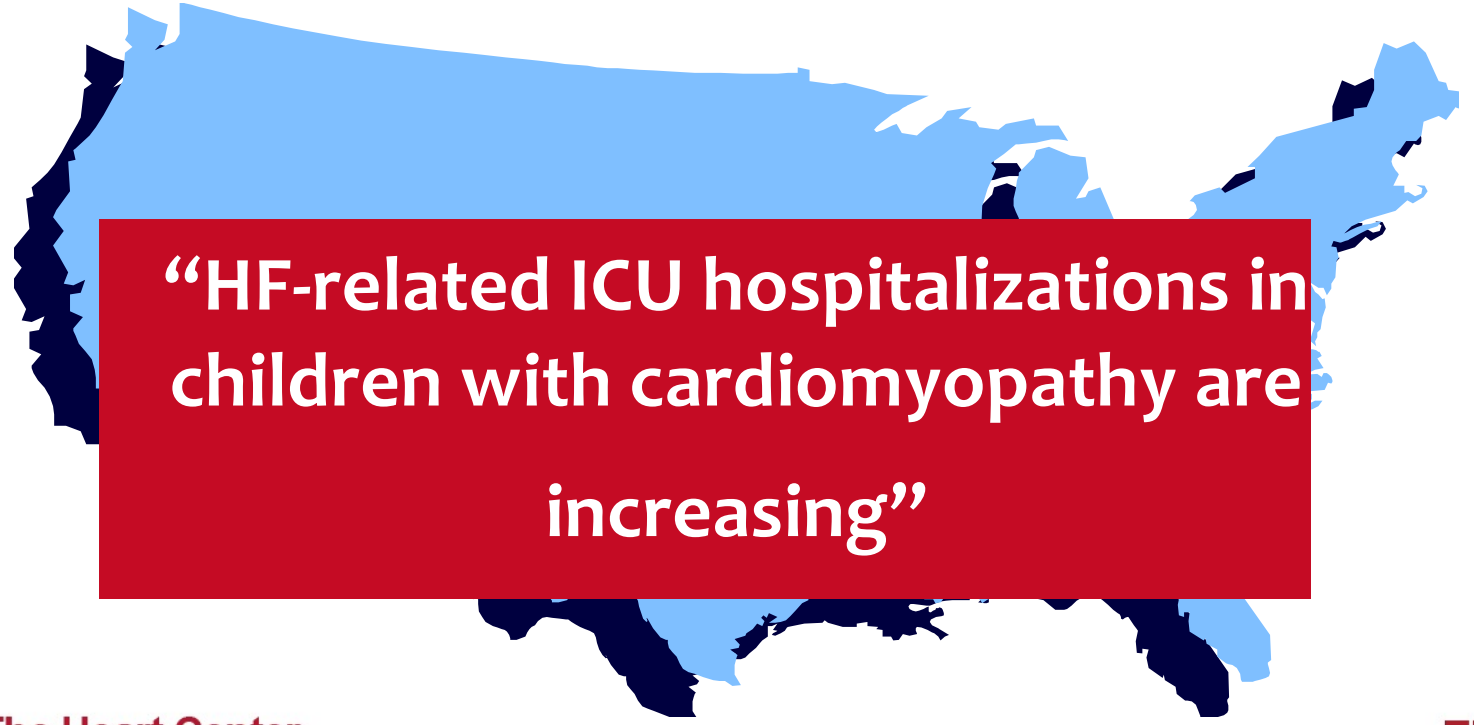
The Bottom Line

- The main objectives of maintenance is:
  - Stabilization of organ function
  - Balance perfusion and congestion
  - Anticipation of complications
  - Preparation of mechanical support when needed

  - **It is getting the patient to be weaned of vasoactives into oral therapies or to be healthy enough to be an appropriate organ recipient**

2,058 Hospitalizations in 1,599 Pts

- Overall in hospital mortality = 11%
- Cardiac Tx occurred in 20% of hospitalizations
- MCS used in 13% of hospitalizations



"HF-related ICU hospitalizations in children with cardiomyopathy are increasing"

Shamszad P et al., J Cardiac Fail 2013;19:672e677

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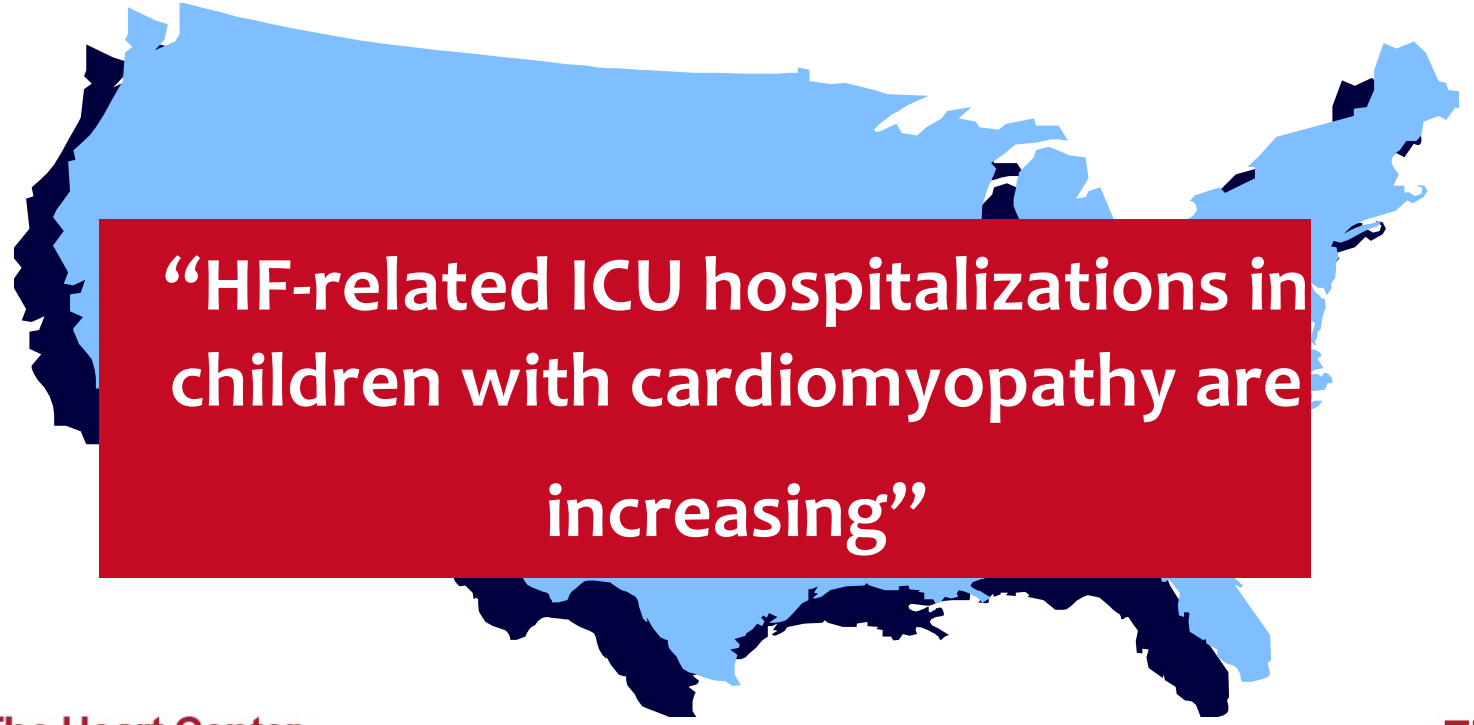

“HF-related ICU hospitalizations in children with cardiomyopathy are increasing”

~80% Medical Management

Shamszad P et al., J Cardiac Fail 2013;19:672e677

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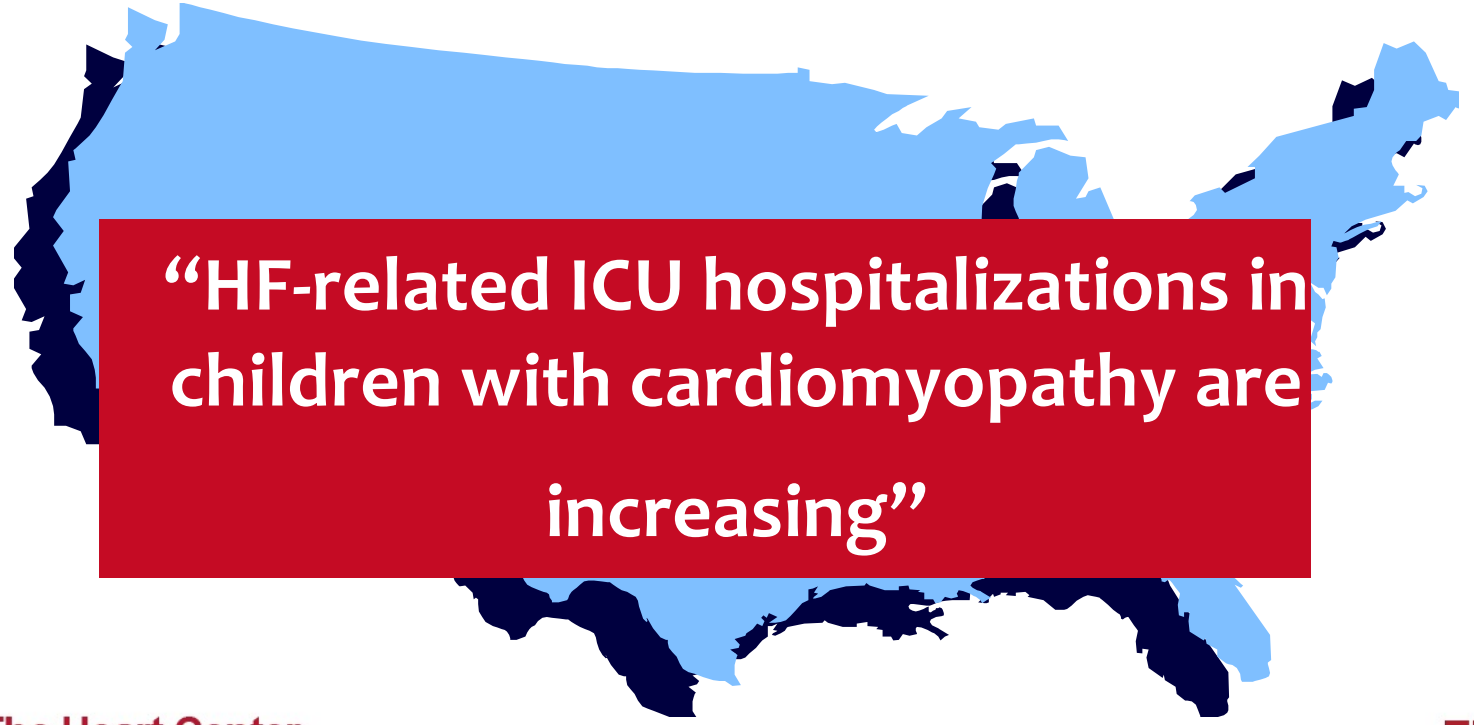


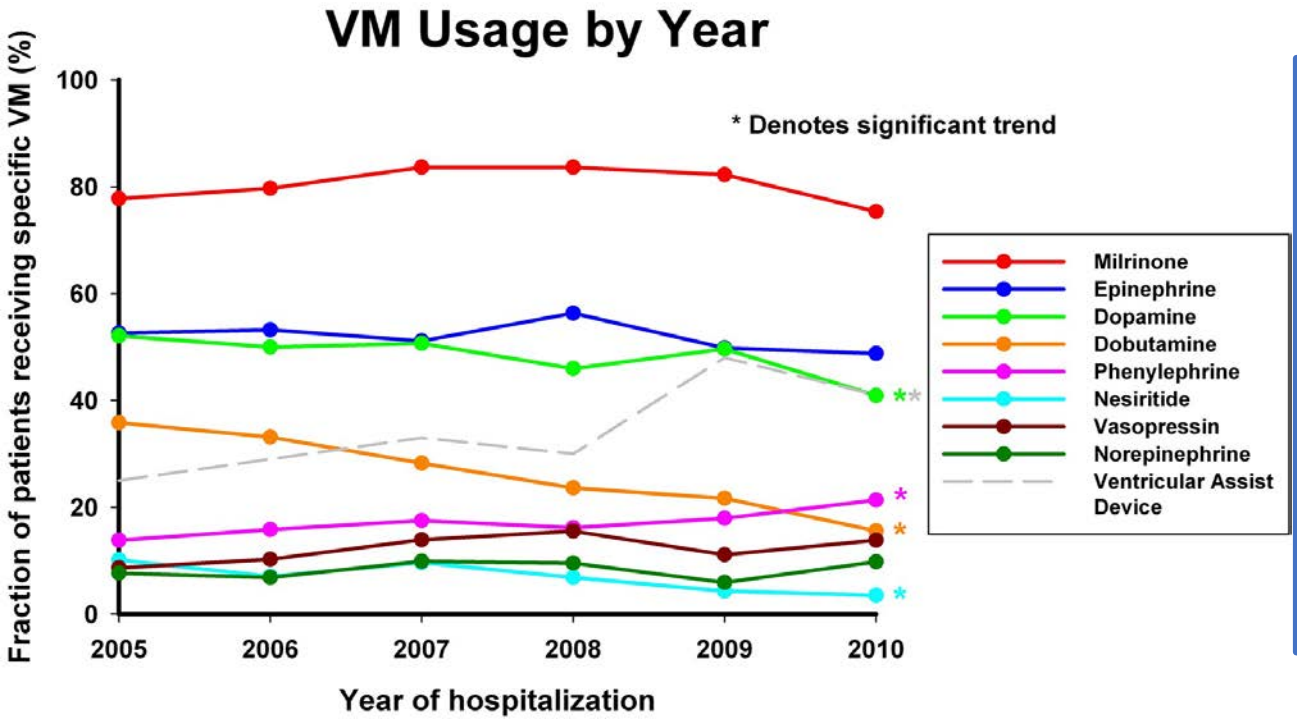
"HF-related ICU hospitalizations in children with cardiomyopathy are increasing"

~80% Medical Management

~86% had A Vasoactive Agent

Shamszad P et al., J Cardiac Fail 2013;19:672e677

Vasoactive Medications Use



P Shamszad , SCCM, 2013

Circulation: Heart Failure

ORIGINAL ARTICLE

Epidemiology and Outcomes of Acute Decompensated Heart Failure in Children

Javier J. Lasa, MD; Michael Gaies, MD, MPH, MSc; Lauren Bush, MD; Wenying Zhang, MS; Mousumi Banerjee, PhD; Jeffrey A. Alten, MD; Ryan J. Butts, MD; Antonio G. Cabrera; Paul A. Checchia, MD; Justin Elhoff, MD; Angela Lorts, MD; Joseph W. Rossano, MD; Kurt Schumacher, MD; Lara S. Shekerdemian, MD; Jack F. Price, MD;
for the Pediatric Cardiac Critical Care Consortium (PC[4])

BP= CO x SVR

CO=SV x HR

- SV= depends on preload, afterload and contractility

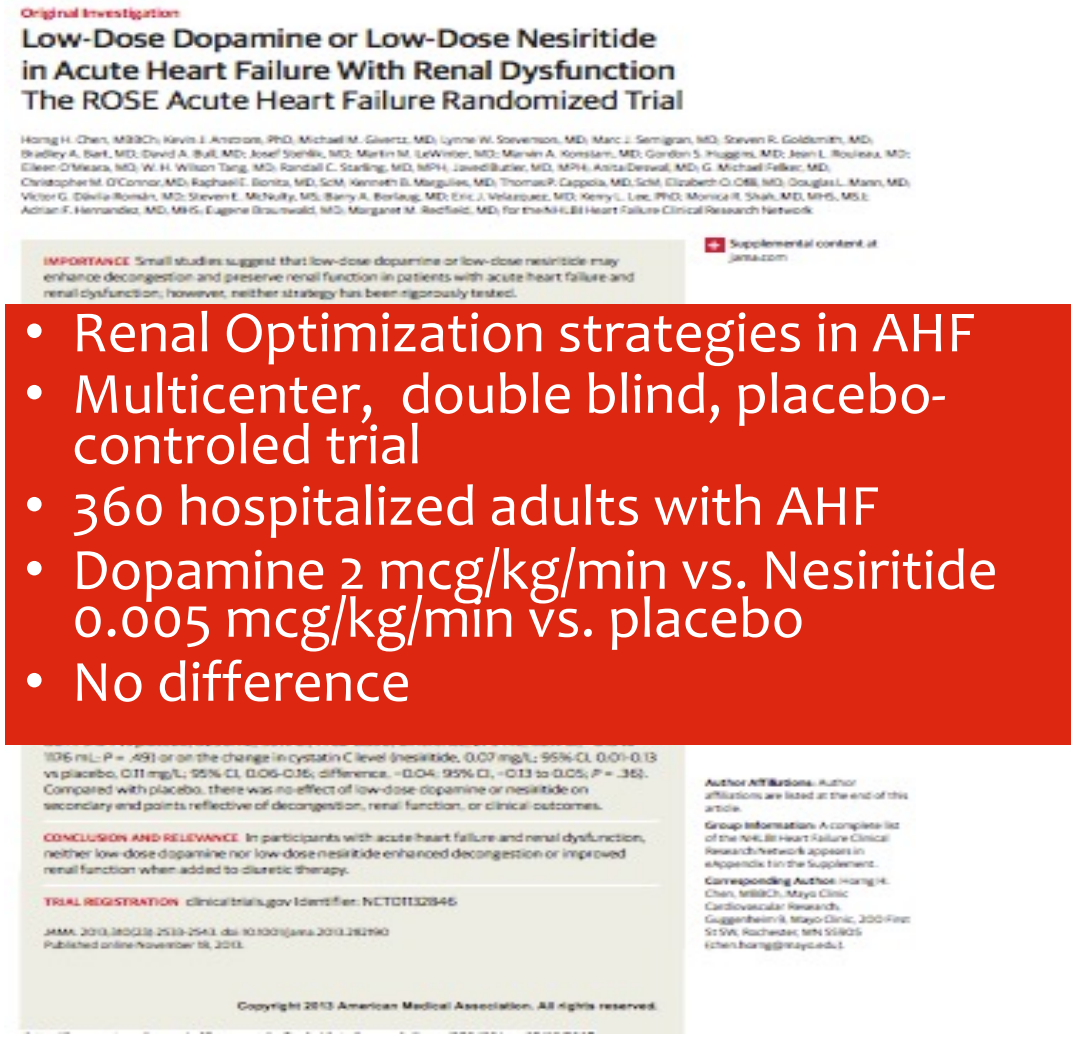
Potential scenarios for normal BP

Low CO and high SVR

Low SVR and high CO

Vasoactive Agents

- **Dopamine:**
  - Synthetic precursor of NE. Effective treating hypotension in non-cardiac neonates
  - Price (JCARD FAIL): children with advanced CHF . Use of Dopamine 2-3 mcg/kg/min alone or in combination with milrinone was well tolerated, increased EF, decrease HF symptoms and reduced readmissions after starting therapy



Original Investigation

Low-Dose Dopamine or Low-Dose Nesiritide in Acute Heart Failure With Renal Dysfunction
The ROSE Acute Heart Failure Randomized Trial

- Renal Optimization strategies in AHF
- Multicenter, double blind, placebo-controled trial
- 360 hospitalized adults with AHF
- Dopamine 2 mcg/kg/min vs. Nesiritide 0.005 mcg/kg/min vs. placebo
- No difference

Rossano JW, Cabrera AG, et al. PCCM 2016
JAMA. 2013;310(23):2533-2543

Vasoactive Agents

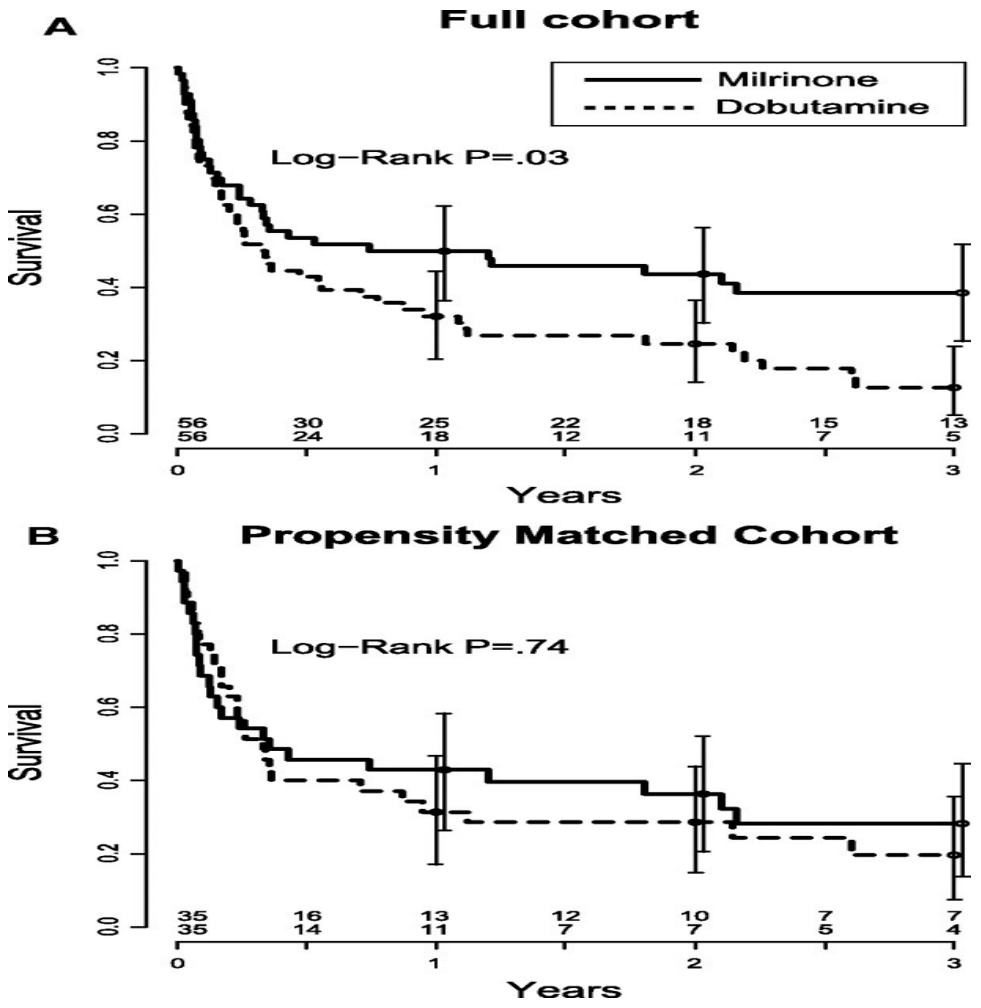
- Epinephrine
  - At low doses (~0.01-0.03 mcg/kg/min) can be used as a first or second agent when hypotension is present
- Dobutamine
  - Effective in treating hypotension in non-cardiac neonates
  - B-1 and B2 agonist
  - Tachyphilaxis after 2 weeks

Rossano JW, Cabrera AG, et al. PCCM 2016

Vasoactive Agents: Milrinone

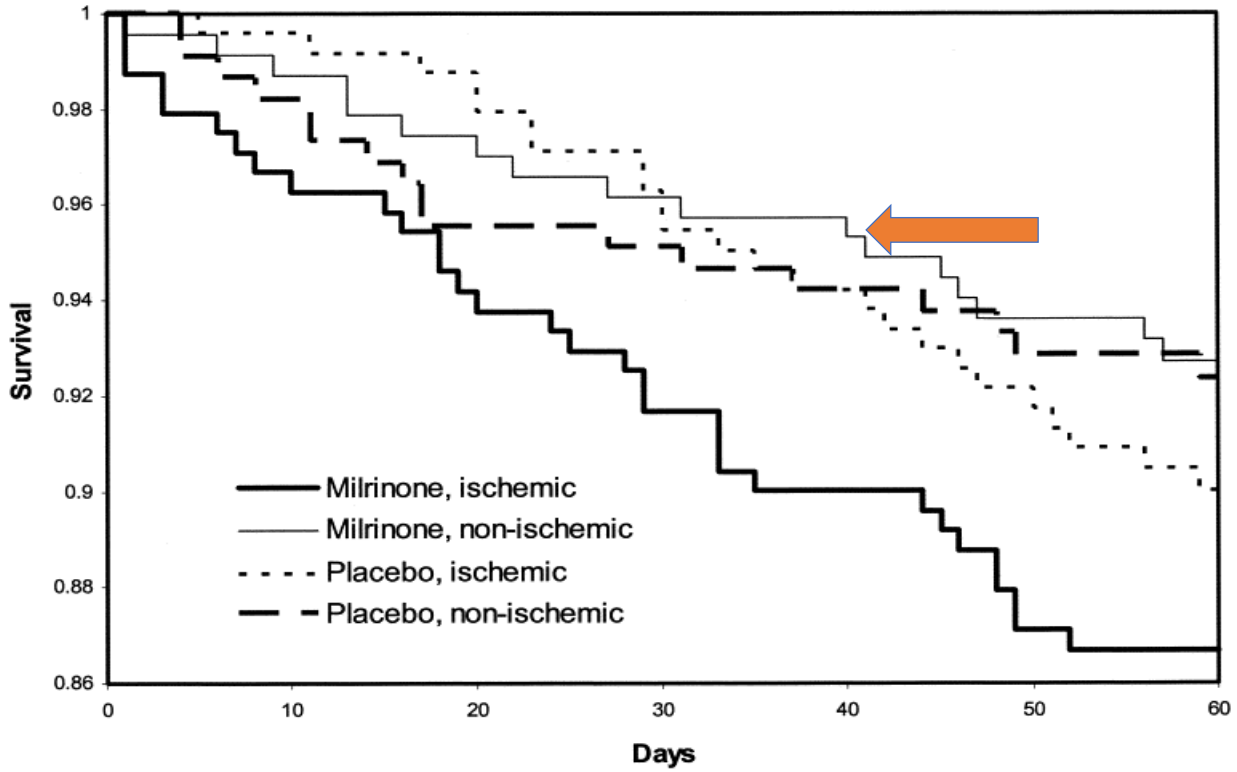
- Onset of action: 5-15 min
- T1/2 =2.5 hours (prolonged if renal failure or CVVHD)

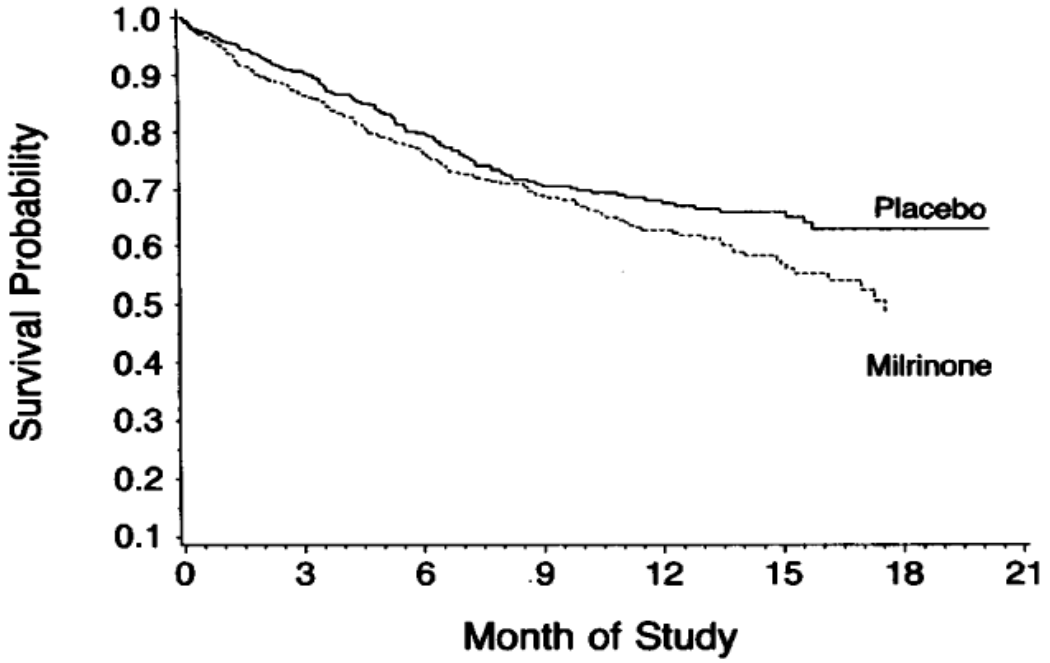
- ADHERE trial: higher mortality in adults with ADHF who received milrinone or dobutamine vs. nesiritide or nitroglycerine



Rossano JW, Cabrera AG, et al. PCCM 2016
Gorodeski E Z et al. Circ Heart Fail. 2009;2:320-324

Milrinone and Cardiomyopathy





Milrinone may have a neutral to positive effect in patients with non ischemic cardiomyopathy

OPTIME-HF trial Investigators, JACC 2003

PROMISE Study Packer M, et al. NEJM. 1991

Impact of Early Vasoactive Therapies

ADHERE Registry (n=35,700)

- All patients tx with IV vasoactive therapy (<6 hrs vs >6 hrs)
- Within 48 hrs of admission
- **In-hospital mortality significantly lower in early tx group:**
  - (OR 0.87, CI 0.79-0.96, p=0.006)

Variable	< 6 hours n=22,788	> 6 hours n=12,912	P-value
Mortality	1166 (5.1)	847 (6.6)	<0.001
Time in ED (hr)	4.5 (3.1-6.5)	5.4 (3.8-7.6)	<0.001
LOS (days)	4.7 (3-7.6)	5.8 (3.8-9)	<0.001
ICU time (days)	2.4 (1.3-4)	3 (1.9-5.4)	<0.001
Asymptomatic at DC	10,016 (51.9)	5012 (46.7)	<0.001

Peacock, et al, Congest Heart Fail 2009;15:256

Macicek SM et al. Acute Heart Failure Syndromes in the ED

- 57 patient visits from 51 pts
- New onset symptoms: 25 (44%)
- Exacerbation of preexisting disease: 32 (56%)
- IV inotropes in the ED = 21% of all cases
- Time to initiation of inotropes:
  - ED= 7 hours vs ICU 11 hours

Opportunities

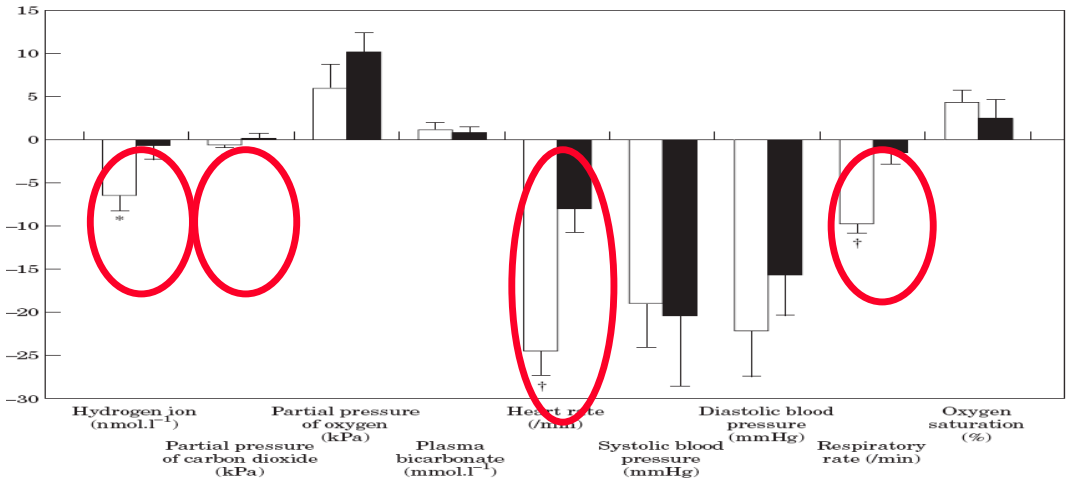
- Early vasoactives possible better than late
- Vasoactive initiation should not be delayed based on location. Should be considered before arrival to the ICU
- Milrinone is not benign and has increased incidence of atrial and ventricular arrhythmias + worse outcomes. Have to make sure patient has symptomatic heart failure indication
- There is tachyphylaxis with Dobutamine but is not inferior to milrinone

Non-invasive Ventilation In Acute Cardiogenic Pulmonary Edema- 3CPO

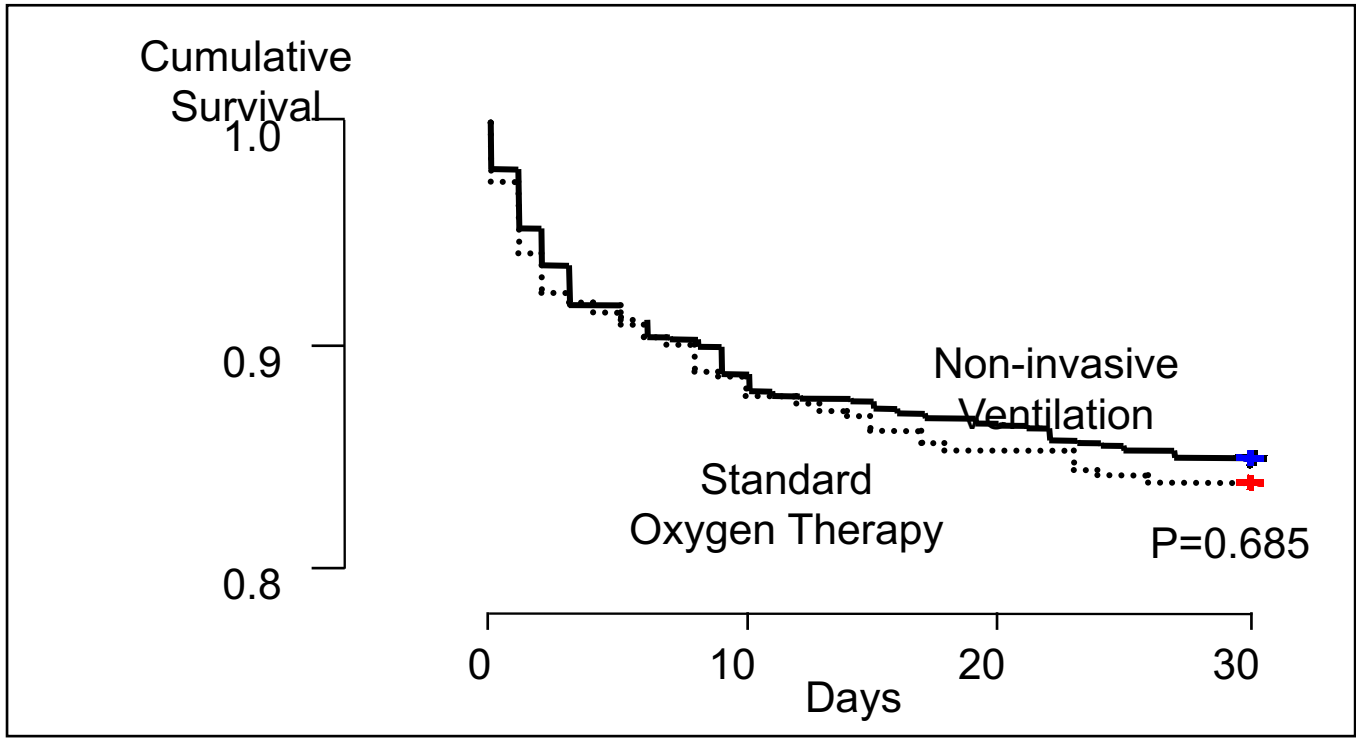
- Multicenter randomized controlled trial
- Setting: Emergency Department
- Prospective 'open-label' trial
- Three treatment interventions in a 1:1:1 randomization:
  - 'Standard' oxygen therapy
  - CPAP
  - NIPPV

Gray A et al, N Engl J Med. 2008 Jul 10;359

Physiological Improvement with CPAP in Patients with ACPO (Oedema)



Reduced acidosis, respiratory rate and heart rate



No change in mortality

Gray A et al, N Engl J Med. 2008 Jul 10;359

The Ugly word: “Tracheostomy”

Hospital outcomes for pediatric heart transplant recipients undergoing tracheostomy: A multi-institutional analysis

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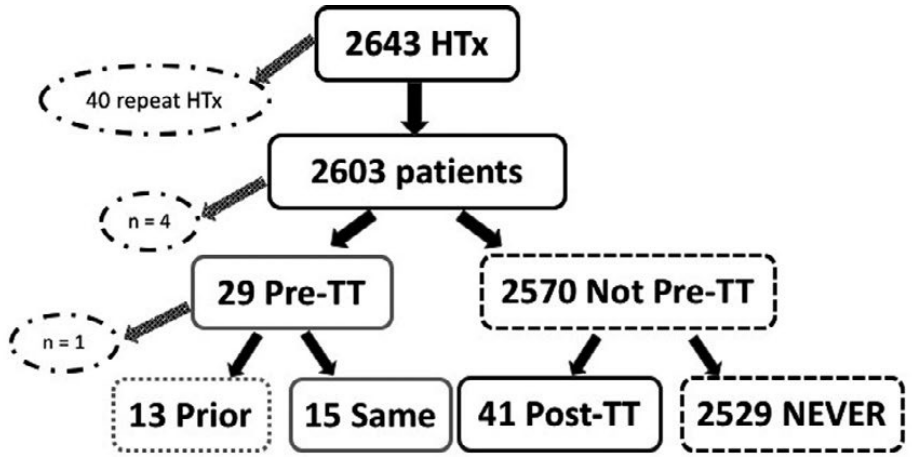
Abstract

Tracheostomy is associated with increased mortality and resource utilization in children with CHD. However, the prevalence and hospital outcomes of tracheostomy in children with HTx are not known. We describe the prevalence and compare the post-HTx hospital outcomes of pediatric patients with Pre-TT and Post-TT to those without tracheostomy. A multi-institutional retrospective cohort study was performed using the Pediatric Health Information System database. Hospital mortality, mediastinitis, LOS, and costs were compared among patients with Pre-TT, Post-TT, and no tracheostomy. Pre-TT was identified in 29 (1.1%) and Post-TT was identified in 41 (1.6%) of 2603 index HTx hospitalizations. Patients with Pre-TT were younger and more likely to have CHD, a non-cardiac birth defect, or an airway anomaly compared to those without Pre-TT. Pre-TT was not independently associated with increased post-HTx in-hospital mortality. Age at HTx < 1 year, CHD, and Post-TT were associated with increased in-hospital mortality. Pre-TT that occurred during the HTx hospitalization and Post-TT were associated with increased resource utilization. Tracheostomy was not associated with mediastinitis.

KEYWORDS
outcome, pediatric heart transplant, tracheostomy



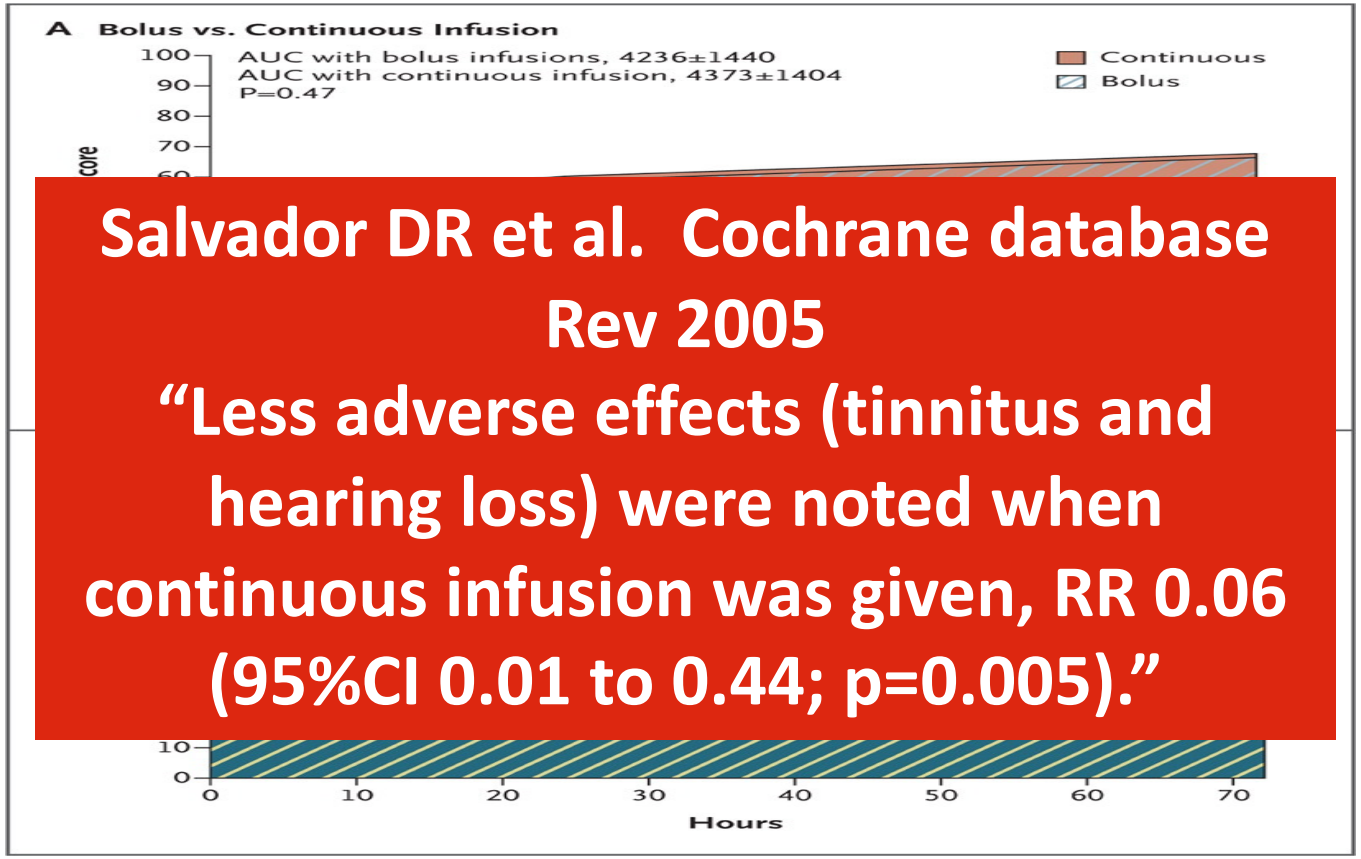
HTx: Heart Transplant; Pre-TT: Pre-transplant tracheostomy; Post-TT: Post-transplant tracheostomy

Pre-HTx tracheostomy was present in 1.1% of children who underwent a first-time HTx, and it was not an independent risk factor for increased mortality

Opportunities

- Use of some sort of positive pressure will reduce the work of breathing and may stabilize the patient prior intubation or even at times prevent intubation
- Work of breathing does not improve unless pulmonary edema improves, be mindful about weaning because “the patient does not need it”
- Tracheostomy could be a potential alternative if VAD is not a good option (size, anatomy or parental preference)

Decongestion-myths and legends



Salvador DR et al. Cochrane database Rev 2005

"Less adverse effects (tinnitus and hearing loss) were noted when continuous infusion was given, RR 0.06 (95%CI 0.01 to 0.44; p=0.005)."

Cardiac Failure

Loop Diuretic Administration

Negative Sodium Balance

RAAS

Sec-Hyperaldosteronism → **Distal Sodium Delivery**

Hypertrophy of Distal Nephron; Increased Expression of NaCl Transporter

Loop Diuretic Resistance

Low Urinary Sodium
High Urinary Potassium
High BUN
High RA pressure

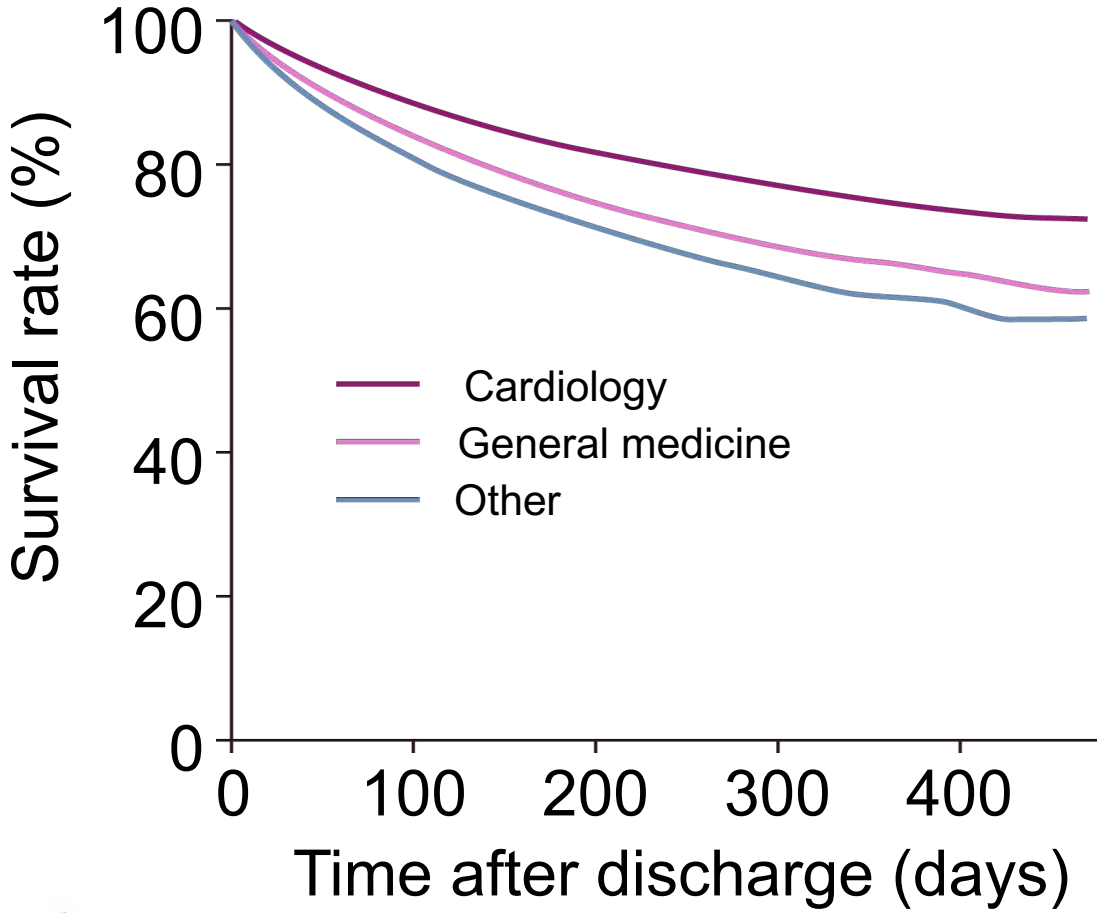
Felker GM et al. N Engl J Med 2011;364:797-805.

Bansal S,. Circ Heart Fail. 2009; 2:370-376

Other Systems cautionary tales/Threats

- **GI-** feeds could be the kiss of death. Feeding tolerance is a frequent issue. Patient becomes snacker+vomiting=check RV congestion Sometimes TPN and some feeds is better than NEC or no feeds. The true value and risk of trophic feeds on this population needs to be carefully studied
- **ID-** the Achilles heel of maintaining/waiting. Many patients lymphopenic but without discernible immunodeficiency. Fevers with negative blood cultures potentially mean partially treated CVL infections
- **HEME:** anticipation of potential thrombus or management of stroke risk
- **CNS:** agitation≠delirium→ could be changes in cardiac output

Care in specialist units reduces the likelihood of death in hospital or soon after discharge



- Teamwork between cardiologists and other physicians and nurses is essential
  - Emergency department
  - Internal medicine
  - Intensive care
  - Outside hospital
- Patients and public alike can recognize ‘good care’

The Bottom Line

- The main objectives of maintenance are:
  - Stabilization of organ function
  - Balance perfusion and congestion
  - Anticipation of complications
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  - **It is getting the patient to be weaned of vasoactives into oral therapies or to be healthy enough to be an organ recipient**

Thank YOU