Acute Decompensated Heart Failure: Inpatient Management

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Overview

- Epidemiology of ADHF
- Goals of acute management
- Pharmacologic Management:
  - Acute vasoactive therapy
  - Beta-blockers in the hospital
  - Emerging therapies
- Goals and strategies for discharge
Acute Decompensated Heart Failure
## Definitions of HFrEF and HFrEF

<table>
<thead>
<tr>
<th>Classification</th>
<th>EF (%)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Heart failure with reduced ejection fraction (HFrEF)</td>
<td>≤40</td>
<td>Also referred to as systolic HF. Randomized clinical trials have mainly enrolled patients with HFrEF, and it is only in these patients that efficacious therapies have been demonstrated to date.</td>
</tr>
<tr>
<td>II. Heart failure with preserved ejection fraction (HFrEF)</td>
<td>≥50</td>
<td>Also referred to as diastolic HF. Several different criteria have been used to further define HFrEF. The diagnosis of HFrEF is challenging because it is largely one of excluding other potential noncardiac causes of symptoms suggestive of HF. To date, efficacious therapies have not been identified.</td>
</tr>
<tr>
<td>a. HFrEF, borderline</td>
<td>41 to 49</td>
<td>These patients fall into a borderline or intermediate group. Their characteristics, treatment patterns, and outcomes appear similar to those of patients with HFrEF.</td>
</tr>
<tr>
<td>b. HFrEF, improved</td>
<td>&gt;40</td>
<td>It has been recognized that a subset of patients with HFrEF previously had HFrEF. These patients with improvement or recovery in EF may be clinically distinct from those with persistently preserved or reduced EF. Further research is needed to better characterize these patients.</td>
</tr>
</tbody>
</table>

EF indicates ejection fraction; HF, heart failure; HFrEF, heart failure with preserved ejection fraction; and HFrEF, heart failure with reduced ejection fraction.
## Epidemiology and Economic Burden of HF

**American Heart Association. Heart Disease and Stroke Statistics – 2014 Update.**

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2030 (est)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Incidence</strong></td>
<td>825,000/year</td>
<td></td>
</tr>
<tr>
<td><strong>Prevalence</strong></td>
<td>5.1 million (2.1%)</td>
<td>8 million</td>
</tr>
<tr>
<td><strong>Hospitalizations</strong></td>
<td>~1,000,000 per year</td>
<td></td>
</tr>
<tr>
<td><strong>Mortality</strong></td>
<td>57,757 (58% female)</td>
<td></td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$30.7 billion</td>
<td>$69.7 billion</td>
</tr>
</tbody>
</table>
From: Geographic Disparities in Heart Failure Hospitalization Rates Among Medicare Beneficiaries, Age $\geq$ 65 Years, 2000–2006: Total Population.

Estimated Direct/Indirect Costs of HF: $30.7 Billion

ESTIMATED COSTS OF HEART FAILURE

Lifetime Costs of Medical Care After Heart Failure Diagnosis. Circulation: Cardiovascular Quality and Outcomes. 2011; 4: 68-75.
What is a “Typical” Presentation of ADHF?

- Median age: 75
- HTN: 72%
- DM: 44%
- COPD: 31%
- CKD: 30%
- AF: 31%
- Reduced EF: ~50%

NYHA class at admission: (N=11,555)

- I: 2%
- II: 11%
- III: 40%
- IV: 47%

Systolic Blood Pressure at admission (N=104,573)

- <90 mmHg: 2%
- 90-140 mmHg: 48%
- >140 mmHg: 50%

ADHERE Registry: 10/01-1/04
FIRST ACUTE DECOMPENSATED HEART FAILURE
ANNUAL EVENT RATES PER 1000
(FROM ARIC COMMUNITY SURVEILLANCE 2005-2010)
ADHF Precipitating Factors: OPTIMIZE-HF Registry

**Precipitating Factors**

- **PNEUMONIA/ RESPIRATORY PROCESS**: 15.3%
- **ISCHEMIA/ ACS**: 14.7%
- **ARRHYTHMIA**: 13.5%
- **UNCONTROLLED HYPERTENSION**: 10.7%
- **NONADHERANCE TO MEDICATIONS**: 8.9%
- **WORSENING RENAL FUNCTION**: 6.8%
- **NONADHERANCE TO DIET**: 5.2%
- **OTHER**: 12.7%

**Number of Precipitating Factors**

- 0: 38.7%
- 1: 42.2%
- 2: 13.6%
- 3: 4.2%
- ≥4: 1.4%
Mortality After 1st Hospitalization for Heart Failure:

- In-hospital: 3%
- 30-day: 10.4%
- One year: 22%
- Five years: 40-60%

5 Year Mortality by Stage:

- Stage A: 3%
- Stage B: 4%
- Stage C: 25%
- Stage D: 80%

*50% 6 month readmission rate!!

Am J Cardiol 2008;101:1016–22.
Circulation 2007;115:1563–70.
Incidence of ADHF is skyrocketing. Huge strain on hospitals and health care financing

Patients are extremely sick

There are not enough cardiologists to manage ADHF

Generalists will need to become expert in managing all but the sickest patients with ADHF
Acute Decompensated Heart Failure

INITIAL EVALUATION
Initial Evaluation

1. Determine adequacy of systemic perfusion
   - Extremities warm versus cool/cold
   - Urine output
   - Mental status

2. Determine volume status
   - Exam
     - JVP (best single indicator)
     - Edema (pretibial, presacral)
     - Lung exam
   - CVP
   - IVC appearance on echo (dilated, collapsible?)
   - CXR, BNP

<table>
<thead>
<tr>
<th>IVC Diameter</th>
<th>Collapse w/ inspiration</th>
<th>Estimated RA Pressure (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.1cm</td>
<td>&gt;50%</td>
<td>0-5</td>
</tr>
<tr>
<td>&lt;2.1cm</td>
<td>&lt;50%</td>
<td>5-10</td>
</tr>
<tr>
<td>&gt;2.1cm</td>
<td>&gt;50%</td>
<td>5-10</td>
</tr>
<tr>
<td>&gt;2.1cm</td>
<td>&lt;50%</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>
3. Determine the contribution of precipitating factors or co-morbidities
   - acute coronary syndromes/coronary ischemia
   - severe hypertension
   - atrial and ventricular arrhythmias
   - Infections
   - pulmonary emboli
   - renal failure
   - medical or dietary noncompliance

4. Determine the ejection fraction (preserved or reduced)
EKG

- Important to look for underlying
  - Ischemia
  - Arrhythmias
Figure 1.
A bedside assessment allows for definition of a patient’s hemodynamic profile, integrating signs and symptoms of both perfusion and congestion.

**Evidence for Congestion**
*(Elevated Filling Pressure)*
- Orthopnea
- High Jugular Venous Pressure
- Increasing Sa
- Loud P
- Edema
- Ascites
- Rales (Uncommon)
- Abdominopelvic Reflux
- Valsalva Square Wave

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**Evidence for Low Perfusion**
- Narrow Pulse Pressure
- Pulsus Alternans
- Cool Forearms and Legs
- May Be Sleepy, Obtunded
- ACE Inhibitor-Related
- Symptomatic Hypotension
- Declining Serum Sodium Level
- Worsening Renal Function

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**Congestion at Rest?**

<table>
<thead>
<tr>
<th>PCWP:</th>
<th>CI:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18</td>
<td>&gt;2.2L/min/m²</td>
</tr>
<tr>
<td>&gt;18</td>
<td>&lt;2.2L/min/m²</td>
</tr>
</tbody>
</table>

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Acute Decompensated Heart Failure

PHARMACOLOGIC MANAGEMENT
Goals of Acute Management

- Rapidly improve symptoms while preserving end organ function
- Restore function to pre-morbid levels/ Improve quality of life
- Educate patient and family
- Initiate therapies/interventions shown to reduce long-term mortality
- Reduce the risk of rehospitalization
- Control costs
Basic Treatment Strategies

- **PCWP:**
  - < 18
  - > 18

- **CI:**
  - > 2.2L/min/m²
  - < 2.2L/min/m²

**Basic Treatment Strategies**

- **Inotropes**
- **IV Fluids**
- **Diuretics**
- **Vasodilators**

**Continue PO Outpt Treatment (GDMT)**

**Inotropes +/- IV Fluids**

**Diuretics**

**Vasodilators**

**Diuretics Inotropes**
Parenteral Drugs for ADHF

- **Traditional Drugs:**
  - Diuretics
  - Vasodilators: nitroglycerin, nesiritide, nitroprusside
  - Inotropes: dobutamine, milrinone, dopamine, digoxin

- **Novel Agents/therapies:**
  - Novel inotropes
  - Arginine vasopressin analog (tolvaptan)
  - Serelaxin
  - Ultrafiltration
  - Others
Clinical Vignette #1

- 64 y/o M with h/o non-ischemic dilated cardiomyopathy, EF=25-30%
- Returned from vacation 2 days ago
  - Previously able to walk 2 miles, currently cannot walk more than 10 feet before developing dyspnea
  - PND 3 times per night, 4 pillow orthopnea, increasing lower extremity edema, 10# weight gain
  - Exam: alert and oriented, JVP=17cm H2O, bibasilar rales, 2+ pitting edema, warm extremities, BP=115/78, P=82
  - Creat=1.6 (baseline=1.2), BNP=2,048 ng/L, troponin i=0.10 (ULN=0.04)
  - Home cardiac medications=carvedilol, lisinopril, eplerenone, digoxin
What is the best initial therapy?

A. Stop beta blocker and ACE inhibitor

B. Start IV furosemide at 1-2.5x the home oral equivalent dose

C. Start nesiritide drip

D. Instruct the patient to not take anymore vacations

Correct answer= B
Basic Treatment Strategies

PCWP: <18 or >18
CI: >2.2 L/min/m² or <2.2 L/min/m²

- Inotropes +/− IV Fluids
- Diuretics
- Vasodilators

Continue PO Outpt Treatment (GDMT)

Low Perfusion at Rest?
Congestion at Rest?

Warm and Dry
Cold and Dry
Warm and Wet
Cold and Wet
DIURETICS

Take only the prescribed dose.
Diuresis

- IV loop diuretics
  - Institute **early** in the ER
  - Dose should equal or exceed PO dose
  - For ineffective diuresis:
    - Increase dose/ frequency
    - Add second diuretic (metolazone, aldactone, chlorothiazide, chlorthalidone, etc)
    - Continuous infusion of a loop diuretic

- To enhance diuretic effectiveness:
  - Limit sodium intake (?)
  - Multiple dosings of the diuretic (limit rebound resorption of sodium)

- If all diuretic strategies are unsuccessful:
  - Ultrafiltration is reasonable (class 2b)
  - Low dose dopamine (class 2b)
Diuretic Pearls

- **Loop Diuretics**
  - Torsemide and bumetanide more reliably absorbed in oral doses, most notably in patients with edema of GI tract (R heart failure)
    - Furosemide: renally excreted, ~50% orally absorbed
      - Variable absorption: 10-100% in various patients
    - Torsemide/ Bumetanide hepatically metabolized, 80-100% orally absorbed
  - Patients on torsemide have less hospitalization and a better QOL than patients treated w/ furosemide

- **Diuretic Tolerance**
  - “Braking”: decreased response after 1st dose
  - Long term: increased distal reabsorption of sodium
    - Counteracted by concomitant use of thiazide diuretics

- If a sulfa allergy exists, ethacrynic acid may be used—no sulfa moiety

NEJM 1998; 339: 387-395
J Gen Int Med 1998; 13 supp 18: abstract
Diuretic Pearls

- May use thiazide with a loop — synergistic response
- Absorption of metolazone is slower and less predictable than other thiazides; therefore, other thiazides may be preferable to metolazone when in conjunction with loop diuretic
- Chlorothiazide if IV thiazide needed
- K+ sparing diuretics may work synergistically with loop diuretics; response can be predicted by measuring urine electrolytes
  - If urine Na+ and K+ are both low, then the amount of Na+ delivered to the distal nephron is not sufficient for the diuretic to take effect.
  - If urine Na+ is low and urine K+ is high, then Na+ is being exchanged for K+ distally, and the K+ sparing diuretic will have an effect.

NEJM 1998; 339: 387-395
In administration of loop diuretics in ADHF, which statement is correct?

A. Bolus dosing results in less diuresis and less clinical improvement than continuous infusion.

B. Continuous infusion results in worsened renal function compared to bolus dosing.

C. Higher dose of diuretic results in faster weight loss and a shorter hospital stay than a lower dose of diuretic.

D. None of the above

D is correct
Prospective, double blind, randomized trial

308 patients with ADHF- 2x2 design
  - Bolus every 12 hours versus continuous infusion
  - Low dose (equivalent to patient’s previous oral dose) versus high dose (2.5x the previous oral dose)

Primary endpoints:
  - Patients’ global assessment of symptoms
  - Change in serum creatinine over 72h

Baseline characteristics evenly matched

DOSE: Primary Outcomes

Figure 1. Patients' Global Assessment of Symptoms during the 72-Hour Study-Treatment Period.

Patients' global assessment of symptoms was measured with the use of a visual-analogue scale and quantified as the area under the curve (AUC) of serial assessments from baseline to 72 hours. Mean (±SD) AUCs are shown for the group that received boluses every 12 hours as compared with the group that received a continuous infusion (Panel A) and for the group that received a low dose of the diuretic (equivalent to the patients' previous oral dose) as compared with the group that received a high dose (2.5 times the previous oral dose) (Panel B). Plus–minus values are means ±SD.

**DOSE: Secondary Outcomes**

<table>
<thead>
<tr>
<th>End Point</th>
<th>Bolus Every 12 Hr (N=156)</th>
<th>Continuous Infusion (N=152)</th>
<th>P Value</th>
<th>Low Dose (N=151)</th>
<th>High Dose (N=157)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUC for dyspnea at 72 hr</td>
<td>4456±1468</td>
<td>4699±1573</td>
<td>0.36</td>
<td>4478±1550</td>
<td>4668±1496</td>
<td>0.04</td>
</tr>
<tr>
<td>Freedom from congestion at 72 hr — no./total no. (%)</td>
<td>22/153 (14)</td>
<td>22/144 (15)</td>
<td>0.78</td>
<td>16/143 (11)</td>
<td>28/154 (18)</td>
<td>0.09</td>
</tr>
<tr>
<td>Change in weight at 72 hr — lb</td>
<td>−6.8±7.8</td>
<td>−8.1±10.3</td>
<td>0.20</td>
<td>−6.1±9.5</td>
<td>−8.7±8.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Net fluid loss at 72 hr — ml</td>
<td>4237±3208</td>
<td>4249±3104</td>
<td>0.89</td>
<td>3575±2635</td>
<td>4899±3479</td>
<td>0.001</td>
</tr>
<tr>
<td>Change in NT-proBNP at 72 hr — pg/ml</td>
<td>−1316±4364</td>
<td>−1773±3828</td>
<td>0.44</td>
<td>−1194±4094</td>
<td>−1882±4105</td>
<td>0.06</td>
</tr>
<tr>
<td>Worsening or persistent heart failure — no./total no. (%)</td>
<td>38/154 (25)</td>
<td>34/145 (23)</td>
<td>0.78</td>
<td>38/145 (26)</td>
<td>34/154 (22)</td>
<td>0.40</td>
</tr>
<tr>
<td>Treatment failure — no./total no. (%)†</td>
<td>59/155 (38)</td>
<td>57/147 (39)</td>
<td>0.88</td>
<td>54/147 (37)</td>
<td>62/155 (40)</td>
<td>0.56</td>
</tr>
<tr>
<td>Increase in creatinine of &gt;0.3 mg/dl within 72 hr — no./total no. (%)</td>
<td>27/155 (17)</td>
<td>28/146 (19)</td>
<td>0.64</td>
<td>20/147 (14)</td>
<td>35/154 (23)</td>
<td>0.04</td>
</tr>
<tr>
<td>Length of stay in hospital — days</td>
<td></td>
<td></td>
<td>0.97</td>
<td></td>
<td></td>
<td>0.55</td>
</tr>
<tr>
<td>Median</td>
<td>5</td>
<td>5</td>
<td></td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Interquartile range</td>
<td>3–9</td>
<td>3–8</td>
<td></td>
<td>4–9</td>
<td>3–8</td>
<td></td>
</tr>
<tr>
<td>Alive and out of hospital — days</td>
<td></td>
<td></td>
<td>0.36</td>
<td></td>
<td></td>
<td>0.42</td>
</tr>
<tr>
<td>Median</td>
<td>51</td>
<td>51</td>
<td></td>
<td>50</td>
<td>52</td>
<td></td>
</tr>
</tbody>
</table>

* Plus–minus values are means ±SD. To convert pounds to kilograms, divide by 2.2. AUC denotes area under the curve, and NT-proBNP N-terminal pro-brain natriuretic peptide.
† Treatment failure was defined as the development of any one of the following during the 72 hours after randomization: increase in serum creatinine level of more than 0.3 mg per deciliter (26.5 µmol per liter), worsening or persistent heart failure, clinical evidence of excessive diuresis requiring intervention (e.g., administration of intravenous fluids), or death.
Benefits of outpatient sodium restriction in heart failure is well substantiated; benefits/lack thereof not known for inpatients

Adult inpatients with ADHF, LVEF<45%

- Exclusions: creatinine clearance <30mL/min/m2; shock; etc

Intervention:

- Group 1 (n=38): fluid restricted to 800mL/day; sodium restricted to 800mg/day
- Group 2 (n=37): standard hospital diet (fluid at least 2.5L/day; sodium 3-5g/day)
30 days:

- Hospital readmission and ER visits (p=0.41)
  - 800mg/d group: 29%
  - 3-5g/ day group: 19%

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**Table 4. CCS at the End of the Study and at 30-Day Follow-up and the Difference Between These Periods in the IG and CG**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>800mg/d</th>
<th>Mean (SD)</th>
<th>3-5g/d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IG</td>
<td></td>
<td>CG</td>
</tr>
<tr>
<td>CCS at study end</td>
<td>6.4 (3.0), n = 38</td>
<td>7.1 (2.6), n = 37</td>
<td></td>
</tr>
<tr>
<td>CCS at 30-d follow-up</td>
<td>7.9 (3.8), n = 37</td>
<td>6.0 (3.0), n = 34</td>
<td></td>
</tr>
<tr>
<td>ΔCCS_{D30-End}^a</td>
<td>1.5 (3.6)</td>
<td>-1.2 (3.3)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CCS, clinical congestion score; CG, control group; ΔCCS_{D30-End}, difference in CCS between 30-day follow-up and the end of the study; IG, intervention group.

^a Difference significant at P = .002; adjusted covariance matrix for correction of different CCS at hospital day 7.
28 y/o F previously in normal health, no medications

4 day history of increasing dyspnea, orthopnea, PND, dizziness. 2 syncopal episodes in last 24 hours. Had a viral URI last week.

Physical Exam: mildly confused, cold extremities, BP=80/45, P=128, JVD to angle of jaw, bibasilar rales

Echocardiogram shows EF=10-15%
A. Start on esmolol drip
B. Myocardial biopsy
C. Give 500cc NS bolus
D. Start milrinone +/- norepinephrine

Answer=D
INOTROPES
Inotropes

Evidence for Low Perfusion
- Narrow Pulse Pressure
- Pulsus Alternans
- Cool Forearms and Legs
- May Be Sleepy, Obtunded
- ACE Inhibitor-Related
- Symptomatic Hypotension
- Declining Serum Sodium Level
- Worsening Renal Function

Low Perfusion at Rest?
- NO
- YES

Congestion at Rest?
- NO
- YES

PCWP:
- <18
- >18

CI:
- >2.2L/min/m^2
- <2.2L/min/m^2

Cold and Dry
Cold and Wet
Warm and Dry
Warm and Wet


- 2013 ACC/AHA Heart Failure Guidelines:
  “In patients with clinical evidence of hypotension associated with hypoperfusion and obvious evidence of elevated cardiac filling pressures (e.g., elevated jugular venous pressure; elevated pulmonary artery wedge pressure), intravenous inotropic or vasopressor drugs should be administered to maintain systemic perfusion and preserve end-organ performance while more definitive therapy is considered.”
## Inotropes in ADHF

- **Traditional Inotropes**: dobutamine, milrinone or dopamine

- **New Inotropes (not approved by FDA)**
  - Levosimendan: calcium sensitizer
  - Omecamtiv Mecarbil: cardiac myosin activator
  - Istaroxime: Na/K-ATPase inhibitor

<table>
<thead>
<tr>
<th></th>
<th>CO</th>
<th>PCWP</th>
<th>SVR</th>
<th>MAP</th>
<th>HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dobutamine</td>
<td>↑↑↑↑</td>
<td>↓/↔</td>
<td>↓</td>
<td>↓/↔↔</td>
<td>↑/↔↔</td>
</tr>
<tr>
<td>Dopamine- moderate</td>
<td>↑↑</td>
<td>↑/↔</td>
<td>↑/↔</td>
<td>↑↑</td>
<td>↑</td>
</tr>
<tr>
<td>Dopamine- high</td>
<td>↑</td>
<td>↑</td>
<td>↑↑↑↑</td>
<td>↑↑</td>
<td>↑↑</td>
</tr>
<tr>
<td>Milrinone</td>
<td>↑↑</td>
<td>↓</td>
<td>↓↓</td>
<td>↓/↔↔</td>
<td>↑/↔↔</td>
</tr>
<tr>
<td>Levosimendan</td>
<td>↑↑↑↑</td>
<td>↓↓</td>
<td>↓↓</td>
<td>↓</td>
<td>↑</td>
</tr>
</tbody>
</table>
Traditional Inotropes: Robbing Peter to Pay Paul?

- Pro-arrhythmic
- Probably increase mortality in ischemic patients
- Ischemic/injured myocardium may “hibernate” as a protective mechanism
  - Inotropes recruit hibernating myocytes and may hasten cell injury or apoptosis
- Short-term gains appear to be offset by higher mid and long-term mortality
Levosimendan

- Sensitizes myofilaments to calcium by binding to troponin C
  - Increased troponin C - Ca++ binding
  - Increased actin-myosin affinity = ↑ contractility
- Vasodilatory and anti-ischemic properties
- Hemodynamic effects:
  - increases CO
  - reduces PCWP
  - reduces symptoms
- ?? reduces risk of death and hospitalizations??
  - Yes: LIDO trial (compared with dobutamine); RUSSLAN; meta-analysis
  - No: REVIVE I-II (numerically HIGHER number of deaths, not statistically significant); SURVIVE

Omecamtiv Mecarbil

- Enhances contractility
  - Binds to myosin ATPase
  - Increases strength of actin-myosin cross-bridge
  - Speeds up phosphate release by myosin

- End Result
  - Increased systolic ejection duration
  - Increased stroke volume/ EF
  - Decreased heart rate
  - Improvement in cardiac efficiency
    - ATP energy and O2 consumption not increased
    - Intracellular calcium levels not altered

- Clinical trials ongoing

Istaroxime

- Inhibits $\text{Na}^+/\text{K}^+$-ATPase
  - Increased $\text{Na}^+$ in the cell decreases driving force for $\text{Ca}^{++}$ to leave cell
  - Increased intracellular $\text{Ca}^{++}$ increases contractility
  - Also improves relaxation by improving $\text{Ca}^{++}$ sequestration in diastole

- Advantages to digoxin:
  - Less pro-arrhythmic
  - Improved contractility
  - Improved safety ratio
    - Istaroxime=20, digoxin=3

- Studies ongoing (phase 2 trials)
Clinical Vignette #3

- 58 y/o M with longstanding hypertensive cardiomyopathy, last EF=55-60%, grade 2 diastolic dysfunction, h/o ischemic stroke. Recently stopped CPAP due to mask intolerance
- 2 days of increasing dyspnea, orthopnea, headache
- Physical exam: BP=190/110, P=64, warm extremities, rales halfway up both lung fields, JVP=14cm H2O, trace pretibial edema, hypertensive retinal changes
- Labs: normal CBC/TSH, creatinine=1.9 (baseline=1.4), proteinuria, troponin i=0.18 (ULN=0.04)
- ECG: no ischemia
What is the best initial step?

A. Milrinone drip

B. Nitroprusside drip

C. Start IV furosemide and metololazone

D. Add lisinopril and amlodipine, follow BP’s

Correct answer = B
VASODILATORS
**Vasodilators**

**Evidence for Low Perfusion**
- Narrow Pulse Pressure
- Pulsus Alternans
- Cool Forearms and Legs
- May Be Sleepy, Obtunded
- ACE Inhibitor-Related
- Symptomatic Hypotension
- Declining Serum Sodium Level
- Worsening Renal Function

**Diagram**

- **PCWP:**
  - **Yes:** >18
  - **No:** <18

- **CI:**
  - **Yes:** >2.2 L/min/m²
  - **No:** <2.2 L/min/m²

- **Congestion at Rest?**
  - **Yes:** Warm and Wet
  - **No:** Cold and Wet

IV Vasodilators: Overview

- Class IIB recommendation for treatment of ADHF
  - Hypertensive patients
  - Pulmonary congestion not responsive to initial diuretics and standard HF therapy

- Beneficial effects:
  - Decrease BP and improve the efficiency of cardiac work
  - Speed symptom relief
  - Possibly decrease risk for CCU, mechanical ventilation
  - No proven change in mortality

- Nitroglycerin, Nitroprusside, Nesiritide
Nitroglycerin

- Primarily venodilation
  - decreased pre-load → decreased pulmonary congestion
  - May get rebound tachycardia and 20% patients develop resistance
  - Preferred in ischemia
- Less potent arteriolar dilator than nitroprusside

Advantages
- Effective
- High comfort level
- Established safety profile
- Cost

Disadvantages
- Rapid tachyphylaxis
- Frequently underdosed
- Requires titration in CCU/IMCU
- Dose-limiting sx (20%)

J Am Coll Cardiol HF 2013; 1: 183–91
Nitroprusside

- Primary arteriolar dilator
- Most useful in patients with marked hypertension/ hypertensive emergency
- Improves symptoms of pulmonary congestion, and signs of peripheral perfusion
- Titration of infusion rate is initially based on invasive hemodynamic monitoring
- Nitroprusside toxicities:
  - Cyanide intoxication: metabolic acidosis
  - Thiocyanate toxicity: Hyper-reflexia, seizures, altered mental status. Serum concentration assay available

**Advantages**
- Potent
- Fine titration

**Disadvantages**
- ICU and arterial line
- Thiocyanate toxicity (esp in renal/hepatic insufficiency)
- No randomized trials
Nesiritide

- Recombinant brain naturetic peptide (BNP)
  - significant vasodilator effect (venous and arterial)
  - Natriuretic effect
  - Suppression of RAS and catechols
  - Indirect increase of cardiac output
- Reduces LV filling pressure, variable effect on CO, urine output, sodium excretion
- Better than diuretics for dyspnea
- Longer t ½ than nitroglycerin or nitroprusside

Advantages
- Faster than NTG
- Easy dosing
- Few side effects
- Tested in a randomized controlled trial

Disadvantages
- Hypotension
- Cost: $380/day
Initial trials:
- Improved PCWP and symptoms c/w placebo
- Lower PCWP than NTG, but similar dyspnea
- No difference in hard outcomes NTG vs nesiritide

Subsequent retrospective analysis: worsened renal function

Meta analysis: trend toward increased mortality at 30 days
Dyspnea ("moderately-markedly improved") at 6 hours:
- Improved (44.5% versus 42.1%, p=0.03)

Dyspnea ("moderately-markedly improved") at 24 hours:
- Improved (68.2% versus 66.1%, p=0.007)

Death or rehospitalization for HF at 30 days:
- No difference (9.4% versus 10.1%, p=0.31)

Renal function:
- No difference (31.4% versus 29.5%, p=0.11)

Hypotension:
- Worse
  - Symptomatic: 7.2% versus 4.0% (p<0.001)
  - Asymptomatic: 21.4% versus 12.4% (p<0.001)
Vasodilator Algorithm

Class III or IV ADHF AND preserved BP

Immediate
- Impending respiratory failure
- Chest pain

Immediate or early
ADHF and HTN (first-line)

Expectant
Poor response to diuretics
OTHER THERAPIES
Recombinant human relaxin-2

- Peptide that regulates maternal adaptations to pregnancy
- Increased arterial compliance, cardiac output, renal blood flow

RELAX-AHF—dyspnea relief with serelaxin versus placebo and standard HF care
Prospective, randomized, double-blind, placebo-controlled trial

- 1161 patients
- serelaxin 48h infusion versus placebo

Inclusion criteria:

- Acute heart failure within past 16 hours
- NYHA class 3-4 (dyspnea at rest or minimal exertion) with congestion
- Systolic BP > 125 mm Hg
RELAX-AHFT Trial

- Outcomes:
  - CV death/ HF or renal failure related hospitalization: similar
  - Length of initial hospitalization: shorter in serelaxin arm (9.1 vs 9.6 days, p<0.05)
  - Worsening HF within the first 5 days: lower in the serelaxin arm (6.7% vs. 12.2%, p<0.05)
Large phase 3 trials ongoing
No cost analysis yet
Granted “breakthrough therapy designation by FDA
All of the following are true regarding beta blockers in acute decompensated heart failure except:

A. Starting a beta blocker during a decompensated, volume overloaded state may cause further decompensation or even cardiogenic shock.

B. Carvedilol is superior to metoprolol tartrate (short acting) when started for dilated cardiomyopathy.

C. Decompensated normotensive patients who have their beta blocker stopped at admission for ADHF have better outcomes than patients whose beta blocker is continued during the hospital stay.

D. Beta blockers are better tolerated, and the eventual dose is higher when started at a low dose and titrated slowly over several weeks.

Correct answer: C
**B-CONVINCED**

- Randomized, controlled, open label
- Inclusion criteria:
  - Admitted for ADHF
  - EF<40%
  - on stable beta blocker therapy
- Randomized
  - Continuation of beta blocker at admission
  - Stop beta blocker at hospital admission
- (OPTIMIZE-HF registry with similar findings)

---

**Table 3 Clinical events**

<table>
<thead>
<tr>
<th></th>
<th>Keep BB, n = 69</th>
<th>Stop BB, n = 78</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>During hospitalization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durations (days)</td>
<td>11.5 ± 8.3</td>
<td>10.4 ± 9.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Median, range</td>
<td>9 (1–50)</td>
<td>8 (1–62)</td>
<td></td>
</tr>
<tr>
<td>Deaths (n)</td>
<td>1 (HF)</td>
<td>2 (HF)</td>
<td></td>
</tr>
<tr>
<td>Dobutamine (n)</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>After 3 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deaths, n (%)</td>
<td>6 (9)</td>
<td>6 (8)</td>
<td>0.83</td>
</tr>
<tr>
<td>Rehospital, n (%)</td>
<td>27 (40)</td>
<td>36 (47)</td>
<td>0.43</td>
</tr>
<tr>
<td>For HF</td>
<td>15 (22)</td>
<td>24 (32)</td>
<td>0.19</td>
</tr>
<tr>
<td>For arrhythmia</td>
<td>2 (3)</td>
<td>3 (4)</td>
<td>1</td>
</tr>
<tr>
<td>Receiving BB, n (%)</td>
<td>61 (90)</td>
<td>58 (76)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Rehospital, rehospitalization; HF, heart failure; BB, beta-blocker.

---

HOSPITAL DISCHARGE
Hospital Discharge

- Readmissions scrutinized by payers
  - Average readmission = $9300
- Transitions in care scrutinized by The Joint Commission
  - Patient safety issue
- Good discharge/follow-up practices decrease readmission and are therefore cost conscious care
- What are “good” discharge practices?
In all patients hospitalized with HF, both with preserved and low ejection fraction, transition from intravenous to oral diuretics prior to discharge (class I)

- Minimum 24 hours on PO regimen prior to discharge
- With all medication changes, the patient should be monitored for:
  - supine and upright hypotension
  - electrolyte disturbances
  - worsening renal function
  - worsening HF signs/symptoms
Hospital Discharge: What do the Guidelines Say?

- Comprehensive written discharge instructions for all patients and their caregivers; special emphasis on the following 6 aspects of care:
  - Diet
  - Discharge medications- reconciled
    - Importance of adherence
    - Uptitration to recommended dose of guideline based therapies (ACEI/ARB, BB, aldosterone inhibitor, hydralazine/ntg as indicated)
  - Activity level
  - Follow-up appointments
  - Weight monitoring
  - What to do if HF symptoms worsen
Transition to Outpatient
American Heart Association Discharge/Transition Tools

Target: HF Strategies and Clinical Tools

Transition to Outpatient
American Heart Association Discharge/Transition Tools

Target: Heart Failure
Discharge Criteria for Patients Hospitalized With Heart Failure

Recommended for all heart failure patients:
- Prescribing and exacerbating factors addressed
- Dietary sodium restriction and adherence
- Transition from in-hospital to oral diuretics successfully
- Recommended activity level
- At least one goal volume status achieved
- Monitoring of daily weights
- At least one goal pharmacologic therapy for heart failure
- Plan to reassess volume status early after discharge
- Stable renal function and electrolytes within normal range
- Plan to monitor electrolytes and renal function early after discharge
- No symptomatic diuretic or standing hypotension
- Plan to titrate heart failure medications to target dose, if necessary
- Patient and family education completed
- Plan to reinforce patient and family education post-discharge
- Guide regarding medications and medication reconciliation
- Follow-up clinic visit scheduled within 7 days of hospital discharge
- Need for medication adherence
- Follow-up phone call scheduled

Should be considered for patients with advanced heart failure or recurrent admissions:
- Oral medication regimen stable for at least 24 hours
- Careful observation before and after discharge for development of renal dysfunction, electrolyte abnormalities, and symptomatic hypotension
- No intravenous vasodilator or inotropic agent for at least 24 hours
- Ambulation before discharge to assess functional capacity
- Referral for formal heart failure disease management

This is a general algorithm to assist in the management of HF patients. This tool is intended to be used in a non-invasive manner to incorporate any addition or deletion of questions as deemed appropriate by the provider.

Telephone Follow-up Form

GENERAL INFORMATION
Discharge date: 12/03/2013
Patient name: [Insert Name]
Date of birth: [Insert Date]
Primary care physician: [Insert Name]
Cardiologist: [Insert Name]
Homecare? □ YES □ NO
Labor ordered/done prior to first follow-up call or appointment? □ YES □ NO
Date: [Insert Date]

PATIENT EDUCATION
- Introduction: My name is [Insert Name]. I am calling from [Insert Hospital Name]. I am doing a follow-up courtesy call to see how you are doing.
- Weight monitoring:
  - Do you have a scale at home that you can use to weigh yourself?
  - If so, have you weighed yourself?
  - If you answered yes, do you have a scale?
  - Did you have a weight today?
- Do you have a weight today?
- If so, was the patient prescribed with a weight scale during this call?

- Do you understand how and when to check your weight?
- Did patient that weights should check weight every AM, after void, prior to PO intake, with some amount of clothing on?

- Do you understand the importance of measuring and recording your daily weight?
- Did patient that daily weights are important to follow-up for fluid repletion?

- Sustained understanding by Teach Back?
  - The patient or family members can verbalize your instructions back to you in their own words to confirm understanding?

- Patient needs reinforcement: □ YES □ NO

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# Target: Heart Failure Discharge Checklist

Please complete all boxes for each HF indicator:

- **Admit Date:** 
- **Admit Unit:** 
- **Discharge Date:** 
- **Discharge Unit:** 
- **Attending Physician:** 
- **Follow-up appointment (date/time/location):** 

<table>
<thead>
<tr>
<th>Complete All Boxes for Each HF Indicator</th>
<th>YES</th>
<th>NO</th>
<th>Reason Not Done/Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiotensin-converting enzyme inhibitor (if LVSD)</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
<tr>
<td>Angiotensin receptor blocker (if LVSD and ACEI not tolerated)</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
<tr>
<td>β-Blocker (if LVSD, use only carvedilol, metoprolol succinate, or bisoprolol)</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
<tr>
<td>Aldosterone antagonist (if LVSD, Cr ≤2.5 mg/dl in men, ≤2.0 mg/dl in women, and patient’s potassium and renal function will be closely monitored)</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
<tr>
<td>Hydralazine/nitrate (if self-identified African American and LVSD)</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
<tr>
<td>Most recent left ventricular ejection fraction (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date of most recent LVEF (______)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method of assessment: Echocardiogram, Cardiac catheterization, MUGA scan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-coagulation for atrial fibrillation or flutter (permanent or paroxysmal) or other indications</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
<tr>
<td>Precipitating factors for HF decompensation identified and addressed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood pressure controlled (&lt;140-90 mm Hg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumococcal vaccination administered</td>
<td></td>
<td></td>
<td>CI</td>
</tr>
<tr>
<td>Influenza vaccination administered (during flu season)</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
<tr>
<td>EP consult if sudden death risk or potential candidate for device therapy</td>
<td></td>
<td></td>
<td>NA, CI</td>
</tr>
</tbody>
</table>

| **Counseling** |     |    |                                   |
| Sodium restricted diet |     |    |                                   |
| Fluid restriction (if indicated) |     |    |                                   |
| Monitoring of daily weights |     |    |                                   |
| What to do if HF symptoms worsen |     |    |                                   |
| Physical activity level counseling |     |    |                                   |
| Treatment and adherence education |     |    |                                   |
| Enhanced HF education (at least 60 minutes by trained HF educator) |     |    |                                   |

Follow-up services scheduled:

- Cardiologist follow-up
- Primary care follow-up
- HF Disease Management Program
- Cardiac rehabilitation
- Stress testing
- Echocardiogram follow-up, EF determination
- Electrophysiology referral or follow-up (assess need for ICD or CRT)
- Lipid profile follow-up
- Anticoagulation service follow-up
- Electrolyte profile/serum lab work follow-up
- Clinical summary and patient education record faxed to appropriate physicians

**Notes:**

- **NA** = Not applicable or not indicated.
- **CI** = Contraindication documented with physician.

This is a general algorithm to assist in the management of HF. This clinical tool is not intended to replace individual medical judgment.
Multidisciplinary care for patients at high risk of readmission (class I)

Outpatient follow up within 7-14 days (2a)

Telephone call within 3 days (2a)

Use of clinical prediction tools and biomarkers to identify high risk patients (2a)

Performance improvement initiatives for discharge and early outpatient care to optimize use of GDMT
## Meta-analysis of the impact of post discharge HF care activities

<table>
<thead>
<tr>
<th>Intervention Arm</th>
<th>All cause mortality</th>
<th>All cause hospitalization</th>
<th>Heart failure hospitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary heart failure clinic</td>
<td>0.66 (0.42-1.05)</td>
<td>0.76 (0.59-1.01)</td>
<td>0.76 (0.58-0.99)</td>
</tr>
<tr>
<td>Multidisciplinary team providing specialized follow up in non-clinic setting</td>
<td>0.81 (0.65-1.01)</td>
<td>0.81 (0.72-0.91)</td>
<td>0.72 (0.59-0.87)</td>
</tr>
<tr>
<td>Summary for specialized multidisciplinary team follow up</td>
<td>0.75 (0.59-0.96)</td>
<td>0.81 (0.71-0.92)</td>
<td>0.74 (0.63-0.87)</td>
</tr>
<tr>
<td>Telephone follow up</td>
<td>0.91 (0.67-1.29)</td>
<td>0.98 (0.80-1.20)</td>
<td>0.75 (0.57-0.99)</td>
</tr>
<tr>
<td>Enhanced patient care activities</td>
<td>1.14 (0.67-1.94)</td>
<td>0.73 (0.57-0.93)</td>
<td>0.66 (0.52-0.83)</td>
</tr>
<tr>
<td>Total for all interventions</td>
<td>0.83 (0.70-0.99)</td>
<td>0.84 (0.75-0.93)</td>
<td>0.73 (0.66-0.82)</td>
</tr>
</tbody>
</table>

Hospitalization Rate Based on Physician Adherence to Guideline Directed Medical Therapy for Heart Failure

6 month hospitalization rate (%)

HEART FAILURE HOSPITALIZATION

GOOD | MODERATE | LOW
---|---|---
6.7 | 9.7 | 14.7

CARDIOVASCULAR HOSPITALIZATION

GOOD | MODERATE | LOW
---|---|---
11.2 | 15.9 | 20.6

GOOD = patient on all 5 HF therapies
MODERATE = patient on BB, ACEI, aldosterone blocker
LOW = patient on <3 therapies

Begin by assessing:
- Volume status
- Forward flow/ perfusion
- Etiology of exacerbation

Determine what quadrant your patient belongs in

Treat accordingly

Diuretics for most
- For refractory patients, may increase dose, add a thiazide, add low dose dopamine vs nesiritide, attempt ultrafiltration

IV vasodilators are underutilized, especially in “wet” patients with preserved BP who do not respond to diuretics

Lots of drugs on the horizon for HFrEF. Need definitive trials and cost effectiveness analysis.

For GDMT, start low and go slow

Good, comprehensive discharges with appropriate handoffs to outpatient care are important