The Heart Failure Management Paradigm: From the Emergency Department to Hospital Admission and Discharge
Faculty

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Faculty disclosure information provided in handout.
Sacubitril, which is now coformulated with valsartan in a new combination medication, takes action via a novel pathway by inhibiting neprilysin, which breaks down brain (or B-type) natriuretic peptide (BNP). Which of the following statements is false regarding neprilysin?

A. Neprilysin breaks down atrial natriuretic peptide (ANP), BNP, and C-type natriuretic peptide (CNP)
B. Neprilysin is an enzyme
C. N-Terminal pro-BNP (NT-proBNP) is not a substrate for neprilysin
D. In a clinical trial, valsartan/sacubitril decreased BNP levels but increased NT-proBNP levels
Which of the following acute heart failure treatments has class I, level A (the best!) supporting evidence?

A. Angiotensin-converting enzyme (ACE) inhibitors
B. Nitroglycerin
C. Furosemide
D. None of the above
E. A, B, and C
A 67-year-old man with a history of HFpEF, hypertension (HTN), COPD, and morbid obesity presents short of breath (SOB) and 10 lb heavier. No wheezing; no URI complaints. Heart rate, 87 bpm; BP, 157/85; oxygen saturation, 87% right atrial (RA). No wheezing on exam. Labs show a Cr of 1.1, a troponin of <0.02, and an NT-proBNP level of 288 (previous level was 9000 during a prior hospitalization). CTA of chest was negative for pulmonary embolism (PE) and pneumonia. After providing supplemental oxygen with a nasal cannula, what would be the next best step?

A. High-dose intravenous (IV) diuretics
B. IV vasodilator
C. Steroid, antibiotic, and bronchodilator therapy
D. Noninvasive positive pressure ventilation

BP=blood pressure; bpm=beats per minute; BUN=blood urea nitrogen; COPD=chronic obstructive pulmonary disease; Cr=creatinine; CTA=computed tomography angiography; HFpEF=heart failure with preserved ejection fraction; URI=upper respiratory tract infection.
Pre-Activity Assessment Question 4

Which of the following would be an example of an acute HF patient who could be placed in an observation unit?

A. A 60-year-old man with a history of myocardial infarctions (MIs) and renal insufficiency who is confused and has cool, mottled extremities.

B. An 84-year-old woman with minimal residual dyspnea post treatment who has mild dementia and lives by herself.

C. A 63-year-old woman accompanied by her son (with whom she lives) who responds well to emergency department (ED) treatment and has no high-risk features identified during ED evaluation.

D. A 71-year-old man who, after treatment in the ED, remains markedly hypertensive with significant dyspnea at rest.
Learning Objectives

- **Identify** heart failure (HF) patients by their clinical profiles and phenotypes and assess comorbid conditions

- **Produce** the diagnosis of acute heart failure (AHF) based on clinical presentation, history, laboratory assessment, and radiographic findings

- **Integrate** the data of related clinical trials and the evidence to support the use of current therapies as well as novel therapies that are in development for AHF

- **Collaborate** with the interdisciplinary team to properly assess when HF patients need to be admitted to the hospital, placed in observation status, or discharged

- **Distinguish** the importance of early re-initiation of guideline-directed medical therapy, including beta blockers, and discuss the initiation or continuation of newer FDA-approved treatments for patients admitted to the hospital or placed in observation status

- **Describe** evidence-based practices, including methods to improve care transitions for AHF patients once they are ready for discharge from the hospital
Introduction to the Epidemic
825,000 new HF cases annually

At 40 years of age, the lifetime risk of developing HF for both men and women is 1 in 5

The lifetime risk for people with BP >160/90 mm Hg is double that of those with BP <140/90 mm Hg

AHA=American Heart Association.
Median Survival

A. Male

<table>
<thead>
<tr>
<th>Age group</th>
<th>US population</th>
<th>Heart failure patients</th>
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<tbody>
<tr>
<td>65-70</td>
<td>15.3</td>
<td>3.8</td>
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<tr>
<td>70-75</td>
<td>11.8</td>
<td>2.9</td>
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<tr>
<td>75-80</td>
<td>8.8</td>
<td>2.1</td>
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<tr>
<td>80-85</td>
<td>6.4</td>
<td>1.6</td>
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<tr>
<td>85-90</td>
<td>4.7</td>
<td>0.9</td>
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B. Female

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<tr>
<th>Age group</th>
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<th>Heart failure patients</th>
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<td>65-70</td>
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<td>70-75</td>
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<td>75-80</td>
<td>11.0</td>
<td>2.6</td>
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<td>80-85</td>
<td>8.0</td>
<td>2.2</td>
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<tr>
<td>85-90</td>
<td>5.6</td>
<td>1.5</td>
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</table>

Hospital discharges for heart failure by sex (United States: 1980-2010)

The Burden of Acute Heart Failure on US Emergency Departments

Emergency Room Doctors Are Risk-Averse!

Early Deaths in Patients With Heart Failure Discharged From the Emergency Department: A Population-Based Analysis

\[ P = 0.016 \]

### Rehospitalizations Among Patients in the Medicare Fee-for-Service Program

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Most Frequent</th>
<th>Second Most Frequent</th>
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<td><strong>MEDICAL</strong></td>
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<tr>
<td>All</td>
<td>21.0</td>
<td>Heart failure (8.6)</td>
<td>Pneumonia (7.3)</td>
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<tr>
<td>Heart failure</td>
<td>26.9</td>
<td>Heart failure (37.0)</td>
<td>Pneumonia (5.1)</td>
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<tr>
<td>Pneumonia</td>
<td>20.1</td>
<td>Pneumonia (29.1)</td>
<td>Heart failure (7.4)</td>
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<td>COPD</td>
<td>22.6</td>
<td>COPD (36.2)</td>
<td>Pneumonia (11.4)</td>
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<td>Psychoses</td>
<td>24.6</td>
<td>Psychoses (67.3)</td>
<td>Drug toxicity (1.9)</td>
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<td>GI problems</td>
<td>19.2</td>
<td>GI problems (21.1)</td>
<td>Nutrition-related or metabolic issues (4.9)</td>
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<td><strong>SURGICAL</strong></td>
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<tr>
<td>All</td>
<td>15.6</td>
<td>Heart failure (6.0)</td>
<td>Pneumonia (4.5)</td>
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</tbody>
</table>

COPD=chronic obstructive pulmonary disease; GI, gastrointestinal.

Readmission Risk After Heart Failure Hospitalization

The Relationship Between Hospital Admission Rates and Rehospitalizations

<table>
<thead>
<tr>
<th>Predictor</th>
<th>30 Days After Index Discharge</th>
<th>60 Days After Index Discharge</th>
<th>90 Days After Index Discharge</th>
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<tbody>
<tr>
<td></td>
<td>Univariate Analysis</td>
<td>Multivariate Analysis*</td>
<td>Univariate Analysis</td>
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<td>Percent of variance in readmission rates explained</td>
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<td></td>
<td></td>
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<tr>
<td>Congestive heart failure</td>
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<td></td>
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<td>Case mix</td>
<td>11.0</td>
<td>2.6</td>
<td>15.0</td>
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<tr>
<td>Discharge planning</td>
<td>10.5</td>
<td>1.0</td>
<td>12.9</td>
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<tr>
<td>HRR-level supply variables</td>
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<td>PCPs per 100,000 population</td>
<td>0.1</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Cardiologists per 100,000 population</td>
<td>11.6</td>
<td>0.8</td>
<td>13.6</td>
</tr>
<tr>
<td>Hospital beds per 1000 population</td>
<td>5.6</td>
<td>0.7</td>
<td>8.1</td>
</tr>
<tr>
<td>All-cause admission rate</td>
<td>27.5</td>
<td>16.0</td>
<td>33.5</td>
</tr>
</tbody>
</table>

HRR=hospital referral region; PCPs=primary care physicians.

Aiming for Fewer Hospital U-Turns: The Medicare Readmission Reduction Program

Going Back to the Hospital

Rates of ‘readmissions’ and ‘observation stays’ within 30 days of a hospitalization

- Readmission rate (top 319)
- Readmission rate (all)

- Rate of observation stays (top 319)
- Rate of observation stays (all)

1Q 2010, 1Q ’11, 1Q ’12, 1Q ’13

Evaluating Acute Heart Failure Patients in the ED—Initial Approach
Recognizing Acute Heart Failure (AHF)

Hypertensive AHF

ACS and HF

Pulmonary edema

Cardiogenic shock

Right HF

Acutely decompensated chronic HF

ACS=acute coronary syndrome.
Is Clinical Examination Really Useful?

<table>
<thead>
<tr>
<th>Finding</th>
<th>Pooled</th>
<th>Summary Likelihood Ratio (95% CI)</th>
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<tbody>
<tr>
<td></td>
<td>Sensitivity</td>
<td>Specificity</td>
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<tr>
<td>Initial clinical judgment</td>
<td>0.61</td>
<td>0.86</td>
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<tr>
<td>Physical examination</td>
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<td></td>
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<tr>
<td>Third heart sound (ventricular filling gallop)</td>
<td>0.13</td>
<td>0.99</td>
</tr>
<tr>
<td>Abdominojugular reflux</td>
<td>0.24</td>
<td>0.96</td>
</tr>
<tr>
<td>Jugular venous distension</td>
<td>0.39</td>
<td>0.92</td>
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<tr>
<td>Rales</td>
<td>0.60</td>
<td>0.78</td>
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<tr>
<td>Any murmur</td>
<td>0.27</td>
<td>0.90</td>
</tr>
<tr>
<td>Lower-extremity edema</td>
<td>0.50</td>
<td>0.78</td>
</tr>
<tr>
<td>Valsalva maneuver</td>
<td>0.73</td>
<td>0.65</td>
</tr>
<tr>
<td>Systolic blood pressure &lt;100 mm Hg</td>
<td>0.06</td>
<td>0.97</td>
</tr>
<tr>
<td>Fourth heart sound (atrial gallop)</td>
<td>0.05</td>
<td>0.97</td>
</tr>
<tr>
<td>Systolic blood pressure ≥150 mm Hg</td>
<td>0.28</td>
<td>0.73</td>
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<tr>
<td>Wheezing</td>
<td>0.22</td>
<td>0.58</td>
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<tr>
<td>Ascites</td>
<td>0.01</td>
<td>0.97</td>
</tr>
</tbody>
</table>

## Diagnosing Acute Heart Failure in the Emergency Department: A Systematic Review and Meta-Analysis

<table>
<thead>
<tr>
<th>Method</th>
<th>No. of Studies</th>
<th>No. of Patients</th>
<th>% AHF (95% CI)</th>
<th>Sensitivity, % (95% CI)</th>
<th>Specificity, % (95% CI)</th>
<th>LR+ (95% CI)</th>
<th>LR− (95% CI)</th>
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<tr>
<td>Electrocardiogram</td>
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<tr>
<td>Ischemic changes</td>
<td>2</td>
<td>1138</td>
<td>42.6 (39.8-45.5)</td>
<td>34.0 (29.8-38.4)</td>
<td>84.2 (81.2-86.9)</td>
<td>2.9 (1.2-7.1)</td>
<td>0.78 (0.73-0.84)</td>
</tr>
<tr>
<td>T-wave inversion</td>
<td>1</td>
<td>709</td>
<td>69.4 (65.9-72.7)</td>
<td>10.0 (7.5-13.0)</td>
<td>95.9 (92.3-98.1)</td>
<td>2.4 (1.2-4.8)</td>
<td>0.94 (0.90-0.98)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>6</td>
<td>2242</td>
<td>55.8 (53.7-57.8)</td>
<td>20.5 (18.3-22.9)</td>
<td>89.9 (87.9-91.7)</td>
<td>2.2 (1.4-3.5)</td>
<td>0.88 (0.85-0.91)</td>
</tr>
<tr>
<td>ST depression</td>
<td>2</td>
<td>1024</td>
<td>60.8 (57.8-63.8)</td>
<td>5.6 (3.9-7.7)</td>
<td>96.5 (94.2-98.1)</td>
<td>2.0 (1.0-3.8)</td>
<td>0.97 (0.95-1.00)</td>
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<tr>
<td>Normal sinus rhythm</td>
<td>3</td>
<td>1207</td>
<td>39.6 (36.9-42.4)</td>
<td>55.4 (50.9-60.0)</td>
<td>17.8 (15.1-20.8)</td>
<td>0.7 (0.5-0.9)</td>
<td>2.88 (1.26-6.57)</td>
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<tr>
<td>ST elevation</td>
<td>1</td>
<td>219</td>
<td>61.2 (54.6-67.4)</td>
<td>5.2 (2.1-10.5)</td>
<td>91.8 (83.8-96.6)</td>
<td>0.6 (0.2-1.7)</td>
<td>1.03 (0.96-1.11)</td>
</tr>
</tbody>
</table>

| Chest radiograph                |               |                |               |                        |                        |              |             |
| Kerley B lines                  | 2             | 814            | 46.8 (43.4-50.2) | 9.2 (6.5-12.5)        | 98.8 (97.3-99.6)       | 6.5 (2.6-16.2) | 0.88 (0.69-1.13) |
| Interstitial edema              | 3             | 2001           | 48.3 (46.2-50.5) | 31.1 (28.2-34.2)      | 95.1 (93.6-96.3)       | 6.4 (3.4-12.2) | 0.73 (0.68-0.78) |
| Cephalization                   | 5             | 1338           | 54.0 (51.3-56.6) | 44.7 (41.1-48.4)      | 94.6 (92.6-96.3)       | 5.6 (2.9-10.4) | 0.53 (0.39-0.72) |
| Alveolar edema                  | 3             | 2001           | 48.3 (46.2-50.5) | 5.7 (4.7-6.9)         | 98.9 (98.4-99.3)       | 5.3 (3.3-8.5) | 0.95 (0.94-0.97) |
| Pulmonary edema                 | 15            | 4393           | 46.6 (45.1-48.1) | 56.9 (54.7-59.1)      | 89.2 (87.9-90.4)       | 4.8 (3.6-6.4) | 0.48 (0.39-0.58) |
| Pleural effusion                | 5             | 1326           | 55.1 (52.4-57.8) | 16.3 (13.7-19.2)      | 92.8 (90.4-94.7)       | 2.4 (1.6-3.6) | 0.89 (0.80-0.99) |
| Enlarged cardiac silhouette     | 12            | 3515           | 51.7 (49.4-52.7) | 74.7 (72.9-76.5)      | 61.7 (59.4-63.9)       | 2.3 (1.6-3.4) | 0.43 (0.36-0.51) |

AHF, acute heart failure; LR+, likelihood ratio of a positive test; LR−, likelihood ratio of a negative test.
Diagnosing Acute Heart Failure in the ED: A Systematic Review and Meta-Analysis (cont’d)

<table>
<thead>
<tr>
<th>Method</th>
<th>No. of Studies</th>
<th>No. of Patients</th>
<th>% AHF (95% CI)</th>
<th>Sensitivity, % (95% CI)</th>
<th>Specificity, % (95% CI)</th>
<th>LR+ (95% CI)</th>
<th>LR− (95% CI)</th>
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<tr>
<td><strong>Lung ultrasound</strong></td>
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<tr>
<td>Positive B-line scan</td>
<td>8</td>
<td>1914</td>
<td>48.2 (46.0-50.5)</td>
<td>85.3 (82.8-87.5)</td>
<td>92.7 (90.9-94.3)</td>
<td>7.4 (4.2-12.8)</td>
<td>0.16 (0.05-0.51)</td>
</tr>
<tr>
<td>Pleural effusion(s)</td>
<td>2</td>
<td>155</td>
<td>40.7 (33.2-48.5)</td>
<td>63.5 (50.4-75.3)</td>
<td>71.7 (61.4-80.6)</td>
<td>2.0 (1.4-2.8)</td>
<td>0.49 (0.22-1.10)</td>
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<td><strong>Bedside echocardiography</strong></td>
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<tr>
<td>Restrictive mitral pattern</td>
<td>1</td>
<td>125</td>
<td>43.2 (34.9-52.0)</td>
<td>81.5 (68.6-90.7)</td>
<td>90.1 (80.7-95.9)</td>
<td>8.3 (4.0-16.9)</td>
<td>0.21 (0.12-0.36)</td>
</tr>
<tr>
<td>Reduced ejection fraction (EF)</td>
<td>3</td>
<td>325</td>
<td>41.2 (36.0-46.7)</td>
<td>80.6 (72.9-86.9)</td>
<td>80.6 (74.3-86.0)</td>
<td>4.1 (2.4-7.2)</td>
<td>0.24 (0.17-0.35)</td>
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<tr>
<td>Increased LV end-diastolic</td>
<td>1</td>
<td>84</td>
<td>58.3 (47.7-68.3)</td>
<td>79.6 (65.7-89.7)</td>
<td>68.6 (50.7-83.1)</td>
<td>2.5 (1.5-4.2)</td>
<td>0.30 (0.16-0.54)</td>
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<td>dimension</td>
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Chest Ultrasonography: Another Useful Adjunct?

<table>
<thead>
<tr>
<th>Mid-axillary</th>
<th>Anterior axillary</th>
<th>Mid-clavicular</th>
<th>Parasternal</th>
<th>Intercostal space</th>
<th>Parasternal</th>
<th>Mid-clavicular</th>
<th>Anterior axillary</th>
<th>Mid-axillary</th>
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<td>5</td>
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Ultrasound Lung Comets

Normal

Acute Heart Failure

### Table: Diagnostic Accuracy of Assays for Acute Heart Failure (AHF)

<table>
<thead>
<tr>
<th>Assay</th>
<th>Cutoff (pg/mL)</th>
<th>N</th>
<th>n</th>
<th>% AHF (95% CI)</th>
<th>Specificity % (95% CI)</th>
<th>Specificity % (95% CI)</th>
<th>LR+ (95% CI)</th>
<th>LR− (95% CI)</th>
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<td><strong>BNP</strong></td>
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<tr>
<td>Triage</td>
<td>100</td>
<td>19</td>
<td>9143</td>
<td>44.7 (43.7-45.8)</td>
<td>93.5 (92.6-94.2)</td>
<td>52.9 (51.6-54.2)</td>
<td>2.2 (1.8-2.7)</td>
<td>0.11 (0.07-0.16)</td>
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<tr>
<td></td>
<td>200</td>
<td>11</td>
<td>3279</td>
<td>50.4 (48.7-52.1)</td>
<td>85.9 (84.2-87.6)</td>
<td>72.2 (69.9-74.4)</td>
<td>3.1 (2.3-4.0)</td>
<td>0.18 (0.12-0.27)</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>8</td>
<td>3.915</td>
<td>46.7 (45.1-48.3)</td>
<td>67.7 (65.5-69.9)</td>
<td>89.8 (88.5-91.1)</td>
<td>9.1 (4.1-20.2)</td>
<td>0.34 (0.26-0.45)</td>
</tr>
<tr>
<td>AxSym</td>
<td>100</td>
<td>4</td>
<td>684</td>
<td>52.3 (48.6-56.1)</td>
<td>93.3 (90.2-95.7)</td>
<td>53.1 (47.5-58.6)</td>
<td>1.9 (1.5-2.4)</td>
<td>0.15 (0.08-0.29)</td>
</tr>
<tr>
<td>iSTAT</td>
<td>100</td>
<td>2</td>
<td>585</td>
<td>42.6 (38.6-46.6)</td>
<td>94.4 (90.7-96.9)</td>
<td>64.6 (59.2-69.7)</td>
<td>3.0 (1.2-7.4)</td>
<td>0.05 (0.02-1.23)</td>
</tr>
<tr>
<td><strong>NT-proBNP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elecsys</td>
<td>300</td>
<td>10</td>
<td>3498</td>
<td>45.0 (43.4-46.7)</td>
<td>90.4 (88.9-91.8)</td>
<td>38.2 (36.0-40.4)</td>
<td>1.8 (1.4-2.2)</td>
<td>0.09 (0.03-0.34)</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>8</td>
<td>2988</td>
<td>44.8 (43.0-46.6)</td>
<td>84.8 (82.8-86.7)</td>
<td>65.5 (63.2-67.8)</td>
<td>2.7 (1.9-3.9)</td>
<td>0.20 (0.12-0.33)</td>
</tr>
<tr>
<td></td>
<td>1550</td>
<td>9</td>
<td>3043</td>
<td>37.3 (35.6-39.0)</td>
<td>75.5 (73.4-77.9)</td>
<td>72.9 (70.6-75.0)</td>
<td>3.1 (2.3-4.3)</td>
<td>0.32 (0.20-0.51)</td>
</tr>
<tr>
<td>Dimension</td>
<td>300</td>
<td>1</td>
<td>401</td>
<td>30.4 (26.0-35.2)</td>
<td>95.9 (90.7-98.6)</td>
<td>48.0 (42.0-54.1)</td>
<td>1.9 (1.6-2.1)</td>
<td>0.09 (0.04-0.20)</td>
</tr>
</tbody>
</table>

AHF, acute heart failure; BNP, brain (or B-type) natriuretic peptide; LR+, likelihood ratio of a positive test; LR−, likelihood ratio of a negative test; NT-proBNP, N-Terminal pro-BNP.

### BNP Value (pg/mL) vs. NT-proBNP Value (pg/mL)

<table>
<thead>
<tr>
<th>BNP Value (pg/mL)</th>
<th>Interval LR</th>
<th>N (%)</th>
<th>NT-proBNP Value (pg/mL)</th>
<th>Interval LR</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-100</td>
<td>0.14 (0.12-0.18)</td>
<td>617 (28)</td>
<td>0-100</td>
<td>0.09 (0.05-0.17)</td>
<td>150 (7.5)</td>
</tr>
<tr>
<td>100-200</td>
<td>0.29 (0.23-0.38)</td>
<td>308 (14)</td>
<td>100-300</td>
<td>0.23 (0.16-0.33)</td>
<td>205 (10.2)</td>
</tr>
<tr>
<td>200-300</td>
<td>0.89 (0.67-1.17)</td>
<td>188 (9)</td>
<td>300-600</td>
<td>0.28 (0.20-0.39)</td>
<td>212 (10.5)</td>
</tr>
<tr>
<td>300-400</td>
<td>1.34 (0.98-1.83)</td>
<td>148 (7)</td>
<td>600-900</td>
<td>0.63 (0.46-0.87)</td>
<td>151 (7.5)</td>
</tr>
<tr>
<td>400-500</td>
<td>2.05 (1.47-2.84)</td>
<td>148 (7)</td>
<td>900-1500</td>
<td>0.84 (0.67-1.06)</td>
<td>249 (12.4)</td>
</tr>
<tr>
<td>500-600</td>
<td>3.50 (2.30-5.35)</td>
<td>115 (5)</td>
<td>1500-3000</td>
<td>1.49 (1.19-1.86)</td>
<td>273 (13.6)</td>
</tr>
<tr>
<td>600-800</td>
<td>4.13 (3.01-5.68)</td>
<td>218 (10)</td>
<td>3000-5000</td>
<td>2.36 (1.81-3.08)</td>
<td>225 (11.2)</td>
</tr>
<tr>
<td>800-1000</td>
<td>5.00 (3.21-7.89)</td>
<td>130 (6)</td>
<td>5000-10,000</td>
<td>2.48 (1.91-3.21)</td>
<td>239 (11.9)</td>
</tr>
<tr>
<td>1000-1500</td>
<td>7.12 (4.53-11.18)</td>
<td>160 (70)</td>
<td>10,000-15,000</td>
<td>2.84 (1.90-4.23)</td>
<td>112 (5.6)</td>
</tr>
<tr>
<td>1500-2500</td>
<td>8.33 (4.60-15.12)</td>
<td>105 (5)</td>
<td>15,000-30,000</td>
<td>2.93 (1.95-4.39)</td>
<td>111 (5.5)</td>
</tr>
<tr>
<td>2500-5001</td>
<td>8.91 (4.09-19.43)</td>
<td>65 (3)</td>
<td>30,000-200,000</td>
<td>3.30 (2.05-5.31)</td>
<td>86 (4.3)</td>
</tr>
<tr>
<td>5000-1,000,000</td>
<td></td>
<td>2202 (100)</td>
<td></td>
<td></td>
<td>2013 (100)</td>
</tr>
</tbody>
</table>

**BNP**=brain (or B-type) natriuretic peptide; **LR**=likelihood ratio; **NT-proBNP**=N-Terminal pro-BNP.

Natriuretic Peptide Caveats

- Relative increase in women
- Inverse relationship with body mass index (BMI)
- Higher with renal dysfunction
Potential Impact of Sacubitril/Valsartan

AC=adenylate cyclase; ANP=A-type natriuretic peptide; BNP=B-type natriuretic peptide; cAMP=cyclic adenosine monophosphate; cGMP=cyclic guanosine monophosphate; CNP=C-type natriuretic peptide; NEP=neutral endopeptidase; NP=natriuretic peptide; NPR=natriuretic peptide receptor.

Mair J, et al. [Published online January 12, 2016.] Eur Heart J Acute Cardiovasc Care. pii: 2048872615626355.
Rising Levels = Worse Prognosis

Mechanism of Cardiac Troponin Release in Heart Failure

- Increased Wall Stress
- Epicardial Coronary Artery Disease (CAD)
- Neurohormonal Activation
- Oxidative Stress
- Inflammatory Cytokines
- Altered Calcium Handling
- Reversible Injury
- Myocyte Necrosis
- Troponin Degradation Products
- Myocyte Apoptosis

Procalcitonin Testing for Diagnosis and Short-term Prognosis in Bacterial Infection Complicated by Congestive Heart Failure

- Receiver operating characteristic curve for procalcitonin (PCT)-based diagnosis of infections complicated by different classes of heart failure

- As depicted, PCT had high areas under the receiver operating characteristic curve in each heart failure group; however, the best cutoff values for each group were different

Triggers and Treatment for the Failing Heart
Overview of Acute Therapy

Ultrafiltration: Aqua/natriuresis

Nitrates, nitroprusside, dobutamine: Arterial vasodilation

Nitrates, morphine: Venodilation

Furosemide: Natriuresis

Dobutamine, dopamine, milrinone: Increased inotropy

Bilevel or continuous positive airway pressure: Preload reduction
A Proposed Model for Initial Assessment and Management of Acute Heart Failure Syndromes

- De novo or chronic heart failure
- Comorbidities
- Precipitants
- Blood pressure
- Heart rate and rhythm

Clinical severity

ESC Guidelines for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012

Suspected Acute Heart Failure

History/Exam (including blood pressure and respiratory rate)
Chest X-Ray
EEG
Echocardiogram or NP (or both)
Blood Chemistry

Simultaneously assess for:
Ventilation/systemic oxygenation inadequate?
- Oxygen
- NIV
- ETT and invasive ventilation
Life-threatening arrhythmia/bradycardia?
- Electrical cardioversion
- Pacing
Blood pressure <85 mm Hg or shock
- Inotrope/vasopressor
- Mechanical circulatory support (e.g., IABP)
Acute coronary syndrome (ACS)
- Coronary reperfusion
- Antithrombotic therapy
Acute mechanical cause/severe valvular disease
- Echocardiography
- Surgical/percutaneous intervention

Urgent action if present:
- Oxygen
- NIV
- ETT and invasive ventilation
- Electrical cardioversion
- Pacing
- Inotrope/vasopressor
- Mechanical circulatory support (e.g., IABP)
- Coronary reperfusion
- Antithrombotic therapy
- Echocardiography
- Surgical/percutaneous intervention

Medical Management of Advanced Heart Failure

Low perfusion at rest (eg, narrow pulse pressure, cool extremities, hypotension)?

- No
  - Warm and Dry
  - Cold and Dry
- Yes
  - Warm and Wet
  - Cold and Wet

Congestion at rest (eg, orthopnea, elevated jugular venous pressure, pulmonary rales, S3 gallop, edema)?

- No
  - Warm and Dry
  - Cold and Dry
- Yes
  - Warm and Wet
  - Cold and Wet

ESC Guidelines for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 (cont’d)

Suspected Acute Heart Failure

History/Exam (including blood pressure and respiratory rate)
- Chest X-Ray
- Echocardiogram or NP (or both)
- Blood Chemistry

ECG
- Oxygen Saturation
- Complete Blood Count

Ventilation/
systemic oxygenation inadequate?
- Oxygen
- NIV
- ETT and invasive ventilation

Life-threatening arrhythmia/bradycardia?
- Electrical cardioversion
- Pacing

Blood pressure <85 mm Hg or shock
- Inotrope/vasopressor
- Mechanical circulatory support (eg, IABP)

Acute coronary syndrome (ACS)
- Coronary reperfusion
- Antithrombotic therapy

Acute mechanical cause/severe valvular disease
- Echocardiography
- Surgical/percutaneous intervention

Simultaneously assess for:

Urgent action if present:

Medical Management of Advanced Heart Failure (cont’d)

Congestion at rest (eg, orthopnea, elevated jugular venous pressure, pulmonary rales, S3 gallop, edema)?

- **Yes**
  - Warm and Wet
- **No**
  - Warm and Dry

Low perfusion at rest (eg, narrow pulse pressure, cool extremities, hypotension)?

- **Yes**
  - Cold and Wet
- **No**
  - Cold and Dry

Medical Management of Advanced Heart Failure (cont’d)

Congestion at rest (eg, orthopnea, elevated jugular venous pressure, pulmonary rales, S3 gallop, edema)?

- **Yes**
  - Warm and Wet
  - Cold and Wet

- **No**
  - Warm and Dry
  - Cold and Dry

Low perfusion at rest (eg, narrow pulse pressure, cool extremities, hypotension)?

- **Yes**
  - Warm and Wet
  - Cold and Wet

- **No**
  - Warm and Dry
  - Cold and Dry

The Pathophysiology of Acute Heart Failure
Normotensive Phenotype: Systolic Blood Pressure 100-140 mm Hg

- Primary treatment
  - Diuresis
    - Furosemide
    - Bumetanide
    - Torsemide
Diuretic Dosing

- **Furosemide**
  - 40-mg intravenous (IV) push
  - Age + BUN
  - DOSE trial

*BUN=blood urea nitrogen.*
Diuretic Strategies in Patients With Acute Decompensated Heart Failure

Acute heart failure (1 symptom AND 1 sign)
Home diuretics dose ≥80 mg and ≤240 mg furosemide <24 hours after admission

2x2 Factorial randomization

- High-dose (2.5x oral) continuous infusion
- High-dose (2.5x oral) Q12 IV bolus
- Low-dose (1x oral) continuous infusion
- Low-dose (1x oral) Q12 IV bolus

1) Change to oral
2) Continue current dose
3) 50% increase in dose

48 hours

## Diuretic Dosing

<table>
<thead>
<tr>
<th>End Point</th>
<th>Bolus Every 12 Hours (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 hours</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 Cr 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 – hospital Median (days)</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td></td>
<td>0.55</td>
</tr>
<tr>
<td>Interquartile range (days)</td>
<td>3-9</td>
<td>3-8</td>
<td>4-9</td>
<td>3-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alive and out of the hospital Median (days)</td>
<td>51</td>
<td>51</td>
<td>50</td>
<td>52</td>
<td></td>
<td>0.42</td>
</tr>
<tr>
<td>Interquartile range (days)</td>
<td>42-55</td>
<td>38-55</td>
<td>39-54</td>
<td>42-56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AUC=area under the curve; Cr=creatinine; NT-proBNP=N-Terminal pro-BNP (brain [or B-type] natriuretic peptide).
Worsening Renal Function Persistent in Both Groups

Hypertensive Phenotype: Systolic Blood Pressure > 140 mm Hg

- **Primary treatment**
  - Nitrates
    - Topical/Sublingual (SL)
    - IV

- **Secondary treatment**
  - Diuretics
Nitrate Dosing

- **Nitroglycerin (NTG)**
  - Typical infusion range: 10-20 mcg/min
  - Increase by 5 mcg/min every 5 min as needed up to 400 mcg/min

- **High dose**
  - Repeat 2 mg bolus

<table>
<thead>
<tr>
<th></th>
<th>HD NTG</th>
<th>Controls</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical vent</td>
<td>20.7%</td>
<td>46.7%</td>
<td>0.023</td>
</tr>
<tr>
<td>ICU admit</td>
<td>37.9%</td>
<td>80.0%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hospital LOS (days)</td>
<td>4.1±3.4</td>
<td>6.2±7.3</td>
<td>0.171</td>
</tr>
<tr>
<td>NSTEMI</td>
<td>17.2%</td>
<td>28.9%</td>
<td>0.254</td>
</tr>
<tr>
<td>Low BP</td>
<td>3.4%</td>
<td>0%</td>
<td>0.210</td>
</tr>
</tbody>
</table>

HD=high-dose; ICU=intensive care unit; LOS=length of stay; NSTEMI=non-ST-elevation myocardial infarction; BP=blood pressure.

Next-Generation Vasodilators?

- **RELAX-AHF 2**
  - Serelaxin
- **TRUE AHF**
  - Ularitide
- **BLAST-AHF**
  - TRV027
- **PRONTO**
  - Clevidipine
Acute Heart Failure in the Emergency Department (ED)

Low blood pressure (BP), hypoxia, renal insufficiency, cardiac ischemia/infarction

1. Significant active comorbidities
2. Significant self-care barriers
3. Poor response to ED treatment

Intermediate risk

Comorbidities and self-care barriers

High risk

1. Need for invasive diagnostics or treatment?
2. Need for inotropes or intravenous (IV) vasodilators?

Low risk

Need for extended treatment beyond initial ED care

Intensive care unit (ICU)

Non-ICU

Observation unit

Discharge home

Sample Observation Unit Protocol

**Observation unit monitoring**
- Continuous-pulse oxygen and ECG
- Weigh patient
- Intake & output
- Fluid restriction (2000 mL/d)
- 2-g sodium diet
- Place on home dose of ACEI/ARB and β-blocker
- Consider echocardiogram

**Treatment**
- SBP 100-160 mm Hg
- Duration of symptoms: days to weeks
- Hypervolemic

**Improvement**
- Good urine output
- SBP normalized at 100-120 mm Hg
- Improved symptoms
- Serum sodium >135 mEq/L

**Partial response**
- Consider repeat diuretic
- Consider IV vasodilator

**Worse**
- Poor urine output
- SBP <90 mm Hg or >160 mm Hg
- Increased symptoms
- Serum sodium <135 mEq/L

- Admit to hospital

**Reassess every 4 to 6 hours**

- SBP >160 mm Hg
- Duration of symptoms: 24-48 h
- Euvolemic/mild hypervolemic

- Vasodilator NTG 0.4 mg, SL q5min x 3 doses then NTP 1"-2"
- Diuretic (moderate dose)

Inpatient Management
Therapeutic Goals

- **Stabilization phase** (first 24-48 hours)
  - Improve symptoms
  - Balance hemodynamics
  - Achieve euvolemia
  - *Avoid harm!*
    - Myocyte injury
    - Renal damage

- **Implementation phase** (>48 hours)
  - Initiate lifesaving interventions
    - Angiotensin-converting enzyme (ACE) inhibitors, β-blockers, etc

Stabilization Phase

- **Achieve euvolemia**
  - Adjust dose/frequency of diuretics as needed

- **Monitoring**
  - Standing weight
  - Intake and output (I & O)
  - Heart and lung exam
  - Electrolytes and renal function
  - Telemetry
  - Serial inferior vena cava (IVC) measurements/IVC collapsibility index (IVCCI)

- **Ensure proper medication reconciliation on admission**
Medication Reconciliation During Transitions of Care as a Patient Safety Strategy

Stabilization Phase

- Identify trigger of exacerbation
  - Nonadherence to diet
  - Nonadherence to medications
  - Progression of disease
  - Ischemia
  - Arrhythmia
Impact of Medication Nonadherence on Hospitalizations and Mortality in Heart Failure

<table>
<thead>
<tr>
<th>Admission Diagnosis</th>
<th>Principal Discharge Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortness of breath</td>
<td>428.08 Congestive heart failure, unspecified</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>428.08 Congestive heart failure, unspecified</td>
</tr>
<tr>
<td>Chest pain, unspecified</td>
<td>786.59 Chest pain, other</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>486 Pneumonia, organism unspecified</td>
</tr>
<tr>
<td>Fever</td>
<td>486 Pneumonia, organism unspecified</td>
</tr>
<tr>
<td>Fever</td>
<td>486 Pneumonia, organism unspecified</td>
</tr>
<tr>
<td>Fever</td>
<td>996.62 Infection and inflammatory reaction due to other vascular</td>
</tr>
<tr>
<td>Abdominal pain, unspecified site</td>
<td>device, implant, or graft</td>
</tr>
<tr>
<td>Fever</td>
<td>577.0 Acute pancreatitis</td>
</tr>
<tr>
<td>Fever</td>
<td>577.0 Acute pancreatitis</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>491.21 Obstructive chronic bronchitis with acute exacerbation</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>415.19 Pulmonary embolism and infarction, other</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>493.22 Chronic obstructive asthma with acute exacerbation</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>493.22 Chronic obstructive asthma with acute exacerbation</td>
</tr>
</tbody>
</table>

Implementation Phase: Long-term Therapy

At Risk for Heart Failure (HF)

**STAGE A**
At high risk for HF but without structural heart disease or symptoms of HF

eg. Patients with:
- Hypertension (HTN)
- Atherosclerotic disease
- Diabetes mellitus (DM)
- Obesity
- Metabolic syndrome

Patients:
- Using cardiotoxins
- With family history of cardiomyopathy

**THERAPY**
Goals
- Heart-healthy lifestyle
- Prevent vascular, coronary disease
- Prevent LV structural abnormalities

Drugs
- ACEI or ARB in appropriate patients for vascular disease or DM
- Statins as appropriate

**STAGE B**
Structural heart disease but without signs or symptoms of HF

eg. Patients with:
- Previous MI
- LV remodeling, including LV hypertrophy (LVH) and low EF
- Asymptomatic valvular disease

**THERAPY**
Goals
- Prevent HF symptoms
- Prevent further cardiac remodeling

Drugs
- ACEI or ARB as appropriate
- Beta-blockers as appropriate

In selected patients
- Implantable cardioverter-defibrillator (ICD)
- Revascularization or valvular surgery as appropriate

**Development of symptoms of HF**

eg. Patients with:
- Known structural heart disease, and
- HF signs and symptoms

**STAGE C**
Structural heart disease with prior or current symptoms of HF

**THERAPY**
Goals
- Control symptoms
- Improve HRQoL
- Prevent hospitalization
- Prevent mortality

Drugs
- Diuretics for fluid retention
- ACEI or ARB
- Beta-blockers
- Aldosterone antagonists

In selected patients
- Hydralazine/isosorbide dinitrate
- ACEI and ARB
- Digoxin

**THERAPY**
Goals
- Control symptoms
- Patient education
- Prevent hospitalization
- Prevent mortality

Drugs for routine use
- Diuretics for fluid retention
- ACEI or ARB
- Beta-blockers
- Aldosterone antagonists

In selected patients
- Hydralazine/isosorbide dinitrate
- ACEI and ARB
- Digoxin

**THERAPY**
Goals
- Control symptoms
- Prevent hospitalization
- Prevent mortality

Drugs for routine use
- Diuretics for fluid retention
- ACEI or ARB
- Beta-blockers
- Aldosterone antagonists

In selected patients
- Hydralazine/isosorbide dinitrate
- ACEI and ARB
- Digoxin

**THERAPY**
Goals
- Control symptoms
- Prevent hospitalization
- Prevent mortality

Drugs for routine use
- Diuretics for fluid retention
- ACEI or ARB
- Beta-blockers
- Aldosterone antagonists

In selected patients
- Hydralazine/isosorbide dinitrate
- ACEI and ARB
- Digoxin

**THERAPY**
Goals
- Control symptoms
- Prevent hospitalization
- Prevent mortality

Drugs for routine use
- Diuretics for fluid retention
- ACEI or ARB
- Beta-blockers
- Aldosterone antagonists

In selected patients
- Hydralazine/isosorbide dinitrate
- ACEI and ARB
- Digoxin

Heart Failure

**STAGE D**
Refractory HF

eg. Patients with:
- Marked HF symptoms at rest
- Recurrent hospitalizations despite guideline-determined medical therapy (GDMT)

**THERAPY**
Goals
- Control symptoms
- Improve HRQoL
- Reduce hospital readmissions
- Establish patient’s end-of-life goals

Options
- Advanced care measures
- Heart transplant
- Chronic inotropes
- Temporary or permanent mechanical circulatory support (MCS)
- Experimental surgery or drugs
- Palliative care and hospice
- ICD deactivation

Primary and Secondary Outcomes in the PARADIGM-HF Clinical Trial

- **Decline in renal function**: Enalapril 2.6%, LCZ696 2.2%, $P = .28$
- **New-onset atrial fibrillation**: Enalapril 3.1%, LCZ696 3.1%, $P = .83$
- **All-cause mortality**: Enalapril 19.8%, LCZ696 17%, $P < .001$
- **First hospitalization for worsening HF**: Enalapril 15.6%, LCZ696 12.8%, $P < .001$
- **Cardiovascular mortality**: Enalapril 16.5%, LCZ696 13.3%, $P < .001$
Sacubitril/Valsartan

**Renin Angiotensin System**

- Angiotensinogen (liver secretion)
- Angiotensin I
- Angiotensin II

**Heart Failure**

- Vasoconstriction
- Elevated blood pressure
- Increased sympathetic tone
- Aldosterone elevation
- Increased fibrosis
- Ventricular hypertrophy

**Natriuretic Peptide System**

- ANP BNP CNP Adrenomedullin
- Substance P Bradykinin
- Angiotensin II Others

- Valsartan
- LCZ696
- Sacubitril (AHU377)
- LBQ657

- Neprilysin
- NT-proBNP (not a substrate for neprilysin)

- Vasodilation
- Lower blood pressure
- Reduced sympathetic tone
- Reduced aldosterone levels
- Natriuresis/Diuresis

Discharge Planning

Is this patient medically ready for discharge today?
### BNP, IVC Size, Collapsibility in All Patients and 2 Subgroups

<table>
<thead>
<tr>
<th></th>
<th>All Patients</th>
<th>Admission</th>
<th>Discharge</th>
<th>P Value</th>
<th>Admission</th>
<th>Discharge</th>
<th>P Value</th>
<th>No Readmit</th>
<th>Readmit</th>
<th>P Value</th>
<th>No Readmit</th>
<th>Readmit</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BNP (pg/mL)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>6139 (9714)</td>
<td>3497 (4824)</td>
<td>-</td>
<td></td>
<td>6177 (10,091)</td>
<td>5982 (9208)</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge</td>
<td>3497 (4824)</td>
<td>-</td>
<td></td>
<td>-.001</td>
<td>3.5±0.6</td>
<td>2.0±0.6</td>
<td>-.001</td>
<td>1.7±0.6</td>
<td>2.3±0.5</td>
<td>.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>logBNP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>3.8±0.5</td>
<td>3.5±0.6</td>
<td>&lt;.001</td>
<td>.28</td>
<td>3.7±0.6</td>
<td>3.8±0.5</td>
<td>.28</td>
<td>3.3±0.7</td>
<td>3.6±0.4</td>
<td>.04</td>
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</tr>
<tr>
<td>Discharge</td>
<td>3.5±0.6</td>
<td>2.0±0.6</td>
<td>&lt;.001</td>
<td>.02</td>
<td>2.2±0.5</td>
<td>2.4±0.4</td>
<td>.02</td>
<td>1.7±0.6</td>
<td>2.3±0.5</td>
<td>.001</td>
<td></td>
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</tr>
<tr>
<td><strong>IVCmax (cm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Admission</td>
<td>2.3±0.5</td>
<td>2.0±0.6</td>
<td>&lt;.001</td>
<td>.03</td>
<td>2.2±0.5</td>
<td>2.4±0.4</td>
<td>.03</td>
<td>0.9±0.7</td>
<td>1.5±0.7</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge</td>
<td>2.0±0.6</td>
<td>1.2±0.8</td>
<td>&lt;.001</td>
<td>.002</td>
<td>1.5±0.7</td>
<td>1.9±0.6</td>
<td>.002</td>
<td>0.9±0.7</td>
<td>1.5±0.7</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IVCsniff (cm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>1.7±0.7</td>
<td>1.2±0.8</td>
<td>&lt;.001</td>
<td>.10</td>
<td>1.5±0.7</td>
<td>1.9±0.6</td>
<td>.10</td>
<td>57±27</td>
<td>36±22</td>
<td>.002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discharge</td>
<td>1.2±0.8</td>
<td>1.0±0.7</td>
<td>&lt;.001</td>
<td>.002</td>
<td>1.5±0.7</td>
<td>1.9±0.6</td>
<td>.002</td>
<td>57±27</td>
<td>36±22</td>
<td>.002</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>IVCCI (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission</td>
<td>27±21</td>
<td>45±27</td>
<td>&lt;.001</td>
<td>.10</td>
<td>31±23</td>
<td>23±16</td>
<td>.10</td>
<td>57±27</td>
<td>36±22</td>
<td>.002</td>
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<td></td>
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<tr>
<td>Discharge</td>
<td>45±27</td>
<td>-</td>
<td></td>
<td>-.001</td>
<td>23±16</td>
<td>16±10</td>
<td>-.001</td>
<td>36±22</td>
<td>-</td>
<td>-.001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BNP=brain natriuretic peptide; IVC=inferior vena cava; IVCCI=inferior vena cava collapsibility index; IVCmax=maximum diameter of the inferior vena cava; IVCsniff=minimum diameter of the inferior vena cava; logBNP=log-transformed values for brain natriuretic peptide.

## Factors Associated With Readmission Preventability as Determined by Patient Opinion

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total Sample (N=98)</th>
<th>Preventable Readmission or Undecided (n=30)</th>
<th>Nonpreventable Readmission (n=68)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Felt they were discharged before ready</td>
<td>(n=96)</td>
<td>(n=29)</td>
<td>(n=67)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No</td>
<td>67 (70)</td>
<td>9 (31)</td>
<td>58 (87)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>29 (30)</td>
<td>20 (69)</td>
<td>9 (13)</td>
<td></td>
</tr>
<tr>
<td>Felt all concerns were addressed before discharge</td>
<td>(n=93)</td>
<td>(n=27)</td>
<td>(n=66)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>No</td>
<td>28 (30)</td>
<td>18 (67)</td>
<td>10 (15)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>65 (70)</td>
<td>9 (33)</td>
<td>56 (85)</td>
<td></td>
</tr>
</tbody>
</table>
### Pictographs with the lowest and highest recognition scores

<table>
<thead>
<tr>
<th>Pictograph</th>
<th>Non-Weighted Score</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes Education</td>
<td>8%</td>
<td>RWJF</td>
</tr>
<tr>
<td>Social Service</td>
<td>24%</td>
<td>RWJF</td>
</tr>
<tr>
<td>Outpatient</td>
<td>30%</td>
<td>RWJF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pictograph</th>
<th>Non-Weighted Score</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take this drug with food</td>
<td>100%</td>
<td>Authors</td>
</tr>
<tr>
<td>Do not drink more than 2 liters of fluid per day</td>
<td>100%</td>
<td>Authors</td>
</tr>
<tr>
<td>Do not operate any machinery while taking this drug</td>
<td>96%</td>
<td>Authors</td>
</tr>
</tbody>
</table>

## Discharge Medication Reconciliation

<table>
<thead>
<tr>
<th>Pill Name</th>
<th>Used for?</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>furosemide</td>
<td>Reduce Water</td>
<td>Take 2 pills in the morning and 2 pills in the evening.</td>
</tr>
<tr>
<td>40 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lisinopril</td>
<td>High Blood Pressure</td>
<td>Take 1 pill in the morning.</td>
</tr>
<tr>
<td>10 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>metformin</td>
<td>Diabetes</td>
<td>Take 1 pill in the morning and 1 pill in the evening.</td>
</tr>
<tr>
<td>500 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>simvastatin</td>
<td>Cholesterol</td>
<td>Take 1 pill at bedtime.</td>
</tr>
<tr>
<td>20 mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fluoxetine</td>
<td>Depression</td>
<td>Take 1 pill every morning for 2 weeks. Then, take 2 pills every morning.</td>
</tr>
<tr>
<td>10 mg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ALLERGIES:** Penicillin  
**YOUR DOCTOR:** Dr. Robert Thompson  
**YOUR PHARMACY:** Greenbrier Pharmacy  

**Name:** Fred Smith  
**User:** fred123@gmail.com  

**Date Printed:** Feb. 15, 2017

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Effectiveness of Remote Patient Monitoring After Discharge of Hospitalized Patients With Heart Failure: The Better Effectiveness After Transition–Heart Failure (BEAT-HF) Randomized Clinical Trial

Unadjusted and Adjusted Relationships Between Early Physician Follow-up by Quartile and 30-Day All-Cause Readmission

<table>
<thead>
<tr>
<th>Quartile (% of follow-up)</th>
<th>Unadjusted HR (95% CI)</th>
<th>P Value</th>
<th>Adjusted HR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1: Early follow-up with a physician</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (&lt;32.4)</td>
<td>1 [reference]</td>
<td></td>
<td>1 [reference]</td>
<td></td>
</tr>
<tr>
<td>2 (32.4-37.9)</td>
<td>0.86 (0.78-0.94)</td>
<td>.001</td>
<td>0.85 (0.78-0.93)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>3 (38.3-44.5)</td>
<td>0.85 (0.76-0.94)</td>
<td>.002</td>
<td>0.87 (0.78-0.96)</td>
<td>.005</td>
</tr>
<tr>
<td>4 (&gt;44.5)</td>
<td>0.87 (0.79-0.95)</td>
<td>.002</td>
<td>0.91 (0.83-1.00)</td>
<td>.05</td>
</tr>
<tr>
<td><strong>Model 2: Early follow-up with a cardiologist</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (&lt;4.1)</td>
<td>1 [reference]</td>
<td></td>
<td>1 [reference]</td>
<td></td>
</tr>
<tr>
<td>2 (4.1-7.4)</td>
<td>0.91 (0.82-1.02)</td>
<td>.09</td>
<td>0.92 (0.83-1.02)</td>
<td>.09</td>
</tr>
<tr>
<td>3 (7.5-13.8)</td>
<td>0.91 (0.82-1.00)</td>
<td>.05</td>
<td>0.91 (0.82-1.00)</td>
<td>.05</td>
</tr>
<tr>
<td>4 (&gt;13.8)</td>
<td>0.91 (0.82-1.00)</td>
<td>.06</td>
<td>0.95 (0.85-1.05)</td>
<td>.30</td>
</tr>
<tr>
<td><strong>Model 3: Early follow-up with the same physician</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (&lt;13.5)</td>
<td>1 [reference]</td>
<td></td>
<td>1 [reference]</td>
<td></td>
</tr>
<tr>
<td>2 (13.5-17.5)</td>
<td>0.93 (0.84-1.04)</td>
<td>.20</td>
<td>0.96 (0.86-1.05)</td>
<td>.36</td>
</tr>
<tr>
<td>3 (18.1-24.1)</td>
<td>0.91 (0.81-1.02)</td>
<td>.11</td>
<td>0.94 (0.84-1.04)</td>
<td>.23</td>
</tr>
<tr>
<td>4 (&gt;24.1)</td>
<td>0.93 (0.83-1.03)</td>
<td>.16</td>
<td>0.97 (0.87-1.08)</td>
<td>.54</td>
</tr>
<tr>
<td><strong>Model 4: 14-Day follow-up with a physician</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (&lt;56.6)</td>
<td>1 [reference]</td>
<td></td>
<td>1 [reference]</td>
<td></td>
</tr>
<tr>
<td>2 (56.6-64.5)</td>
<td>0.88 (0.80-0.97)</td>
<td>.01</td>
<td>0.89 (0.81-0.97)</td>
<td>.01</td>
</tr>
<tr>
<td>3 (64.6-70.0)</td>
<td>0.87 (0.78-0.97)</td>
<td>.009</td>
<td>0.90 (0.81-1.00)</td>
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<tr>
<td>4 (&gt;70.0)</td>
<td>0.87 (0.79-0.96)</td>
<td>.004</td>
<td>0.93 (0.84-1.02)</td>
<td>.13</td>
</tr>
</tbody>
</table>

HR=hazard ratio.
The Diuresis Clinic: A New Paradigm for the Treatment of Mild Decompensated Heart Failure

Sacubitril, which is now coformulated with valsartan in a new combination medication, takes action via a novel pathway by inhibiting neprilysin, which breaks down brain (or B-type) natriuretic peptide (BNP). Which of the following statements is **false** regarding neprilysin?

A. Neprilysin breaks down atrial natriuretic peptide (ANP), BNP, and C-type natriuretic peptide (CNP)

B. Neprilysin is an enzyme

C. N-Terminal pro-BNP (NT-proBNP) is not a substrate for neprilysin

D. In a clinical trial, valsartan/sacubitril decreased BNP levels but increased NT-proBNP levels
Which of the following acute heart failure treatments has class I, level A (the best!) supporting evidence?

A. Angiotensin-converting enzyme (ACE) inhibitors
B. Nitroglycerin
C. Furosemide
D. None of the above
E. A, B, and C
A 67-year-old man with a history of HFpEF, hypertension (HTN), COPD, and morbid obesity presents short of breath (SOB) and 10 lb heavier. No wheezing; no URI complaints. Heart rate, 87 bpm; BP, 157/85; oxygen saturation, 87% right atrial (RA). No wheezing on exam. Labs show a Cr of 1.1, a troponin of <0.02, and an NT-proBNP level of 288 (previous level was 9000 during a prior hospitalization). CTA of chest was negative for pulmonary embolism (PE) and pneumonia. After providing supplemental oxygen with a nasal cannula, what would be the next best step?

A. High-dose intravenous (IV) diuretics
B. IV vasodilator
C. Steroid, antibiotic, and bronchodilator therapy
D. Noninvasive positive pressure ventilation

BP=blood pressure; bpm=beats per minute; BUN=blood urea nitrogen; COPD=chronic obstructive pulmonary disease; Cr=creatinine; CTA=computed tomography angiography; HFpEF=heart failure with preserved ejection fraction; URI=upper respiratory tract infection.
Which of the following would be an example of an acute HF patient who could be placed in an observation unit?

A. A 60-year-old man with a history of myocardial infarctions (MIs) and renal insufficiency who is confused and has cool, mottled extremities.

B. An 84-year-old woman with minimal residual dyspnea post treatment who has mild dementia and lives by herself.

C. A 63-year-old woman accompanied by her son (with whom she lives) who responds well to emergency department (ED) treatment and has no high-risk features identified during ED evaluation.

D. A 71-year-old man who, after treatment in the ED, remains markedly hypertensive with significant dyspnea at rest.
Thank you for joining us in the CME activity, we hope this presentation was valuable to you and the way you practice.

Please complete the CME post-test and evaluation to receive your CME credit.