2017 ACC/AHA/HFSA Focused Update of the 2013 ACCF/AHA Guideline for the Management of Heart Failure

A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Failure Society of America

Developed in Collaboration With the American Academy of Family Physicians, American College of Chest Physicians, and International Society for Heart and Lung Transplantation

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Preamble

Since 1980, the American College of Cardiology (ACC) and American Heart Association (AHA) have translated scientific evidence into clinical practice guidelines (guidelines) with recommendations to improve cardiovascular health. These guidelines, which are based on systematic methods to evaluate and classify evidence, provide a cornerstone for quality cardiovascular care. The ACC and AHA sponsor the development and publication of guidelines without commercial support, and members of each organization volunteer their time to the writing and review efforts. Guidelines are official policy of the ACC and AHA.

Intended Use

Practice guidelines provide recommendations applicable to patients with or at risk of developing cardiovascular disease. The focus is on medical practice in the United States, but guidelines developed in collaboration with other organizations may have a global impact. Although guidelines may be used to inform regulatory or payer decisions, their intent is to improve patients’ quality of care and align with patients’ interests. Guidelines are intended to define practices meeting the needs of patients in most, but not all, circumstances and should not replace clinical judgment.

Clinical Implementation

Guideline recommended management is effective only when followed by healthcare providers and patients. Adherence to recommendations can be enhanced by shared decision making between healthcare providers and patients, with patient engagement in selecting interventions based on individual values, preferences, and associated conditions and comorbidities.

Methodology and Modernization

The ACC/AHA Task Force on Clinical Practice Guidelines (Task Force) continuously reviews, updates, and modifies guideline methodology on the basis of published standards from organizations including the Institute of Medicine (1, 2) and on the basis of internal reevaluation. Similarly, the presentation and delivery of guidelines are reevaluated and modified on the basis of evolving technologies and other factors to facilitate optimal dissemination of information at the point of care to healthcare professionals. Given time constraints of busy healthcare providers and the need to limit text, the current guideline format delineates that each recommendation be supported by limited text (ideally, <250 words) and hyperlinks to supportive evidence summary tables. Ongoing efforts to further limit text are underway. Recognizing the importance of cost-value considerations in certain guidelines, when appropriate and feasible, an analysis of the value of a drug, device, or intervention may be performed in accordance with the ACC/AHA methodology (3).

To ensure that guideline recommendations remain current, new data are reviewed on an ongoing basis, with full guideline revisions commissioned in approximately 6-year cycles. Publication of new, potentially practice-changing study results that are relevant to an existing or new drug, device, or management strategy will prompt evaluation by the Task Force, in consultation with the relevant guideline writing committee, to determine whether a focused update should be commissioned. For additional information and policies regarding guideline development, we encourage readers to consult the ACC/AHA guideline methodology manual (4) and other methodology articles (5-8).
Selection of Writing Committee Members
The Task Force strives to avoid bias by selecting experts from a broad array of backgrounds. Writing committee members represent different geographic regions, sexes, ethnicities, races, intellectual perspectives/biases, and scopes of clinical practice. The Task Force may also invite organizations and professional societies with related interests and expertise to participate as partners, collaborators, or endorsers.

Relationships With Industry and Other Entities
The ACC and AHA have rigorous policies and methods to ensure that guidelines are developed without bias or improper influence. The complete relationships with industry and other entities (RWI) policy can be found at http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/relationships-with-industry-policy. Appendix 1 of the current document lists writing committee members’ relevant RWI. For the purposes of full transparency, writing committee members’ comprehensive disclosure information is available online at http://circ.ahajournals.org/lookup/suppl/doi:10.1161/CIR.0000000000000509/-/DC1. Comprehensive disclosure information for the Task Force is available at http://www.acc.org/guidelines/about-guidelines-and-clinical-documents/guidelines-and-documents-task-forces.

Evidence Review and Evidence Review Committees
When developing recommendations, the writing committee uses evidence-based methodologies that are based on all available data (4-7). Literature searches focus on randomized controlled trials (RCTs) but also include registries, nonrandomized comparative and descriptive studies, case series, cohort studies, systematic reviews, and expert opinion. Only key references are cited.

An independent evidence review committee (ERC) is commissioned when there are 1 or more questions deemed of utmost clinical importance that merit formal systematic review. This systematic review will strive to determine which patients are most likely to benefit from a drug, device, or treatment strategy and to what degree. Criteria for commissioning an ERC and formal systematic review include: a) the absence of a current authoritative systematic review, b) the feasibility of defining the benefit and risk in a time frame consistent with the writing of a guideline, c) the relevance to a substantial number of patients, and d) the likelihood that the findings can be translated into actionable recommendations. ERC members may include methodologists, epidemiologists, healthcare providers, and biostatisticians. When a formal systematic review has been commissioned, the recommendations developed by the writing committee on the basis of the systematic review are marked with “SR”.

Guideline-Directed Management and Therapy
The term guideline-directed management and therapy (GDMT) encompasses clinical evaluation, diagnostic testing, and pharmacological and procedural treatments. For these and all recommended drug treatment regimens, the reader should confirm the dosage by reviewing product insert material and evaluate the treatment regimen for contraindications and interactions. The recommendations are limited to drugs, devices, and treatments approved for clinical use in the United States.

Class of Recommendation and Level of Evidence
The Class of Recommendation (COR) indicates the strength of the recommendation, encompassing the estimated magnitude and certainty of benefit in proportion to risk. The Level of Evidence (LOE) rates the
quality of scientific evidence that supports the intervention on the basis of the type, quantity, and consistency of data from clinical trials and other sources (Table 1) (4-6).

Glenn N. Levine, MD, FACC, FAHA
Chair, ACC/AHA Task Force on Clinical Practice Guidelines
1. Introduction

The purpose of this focused update is to update the “2013 ACCF/AHA Guideline for the Management of Heart Failure” (9) (2013 HF guideline) in areas in which new evidence has emerged since its publication. For this update and future heart failure (HF) guidelines, the Heart Failure Society of America (HFSA) has partnered with the ACC and AHA to provide coordinated guidance on the management of HF.

The scope of the focused update includes revision to the sections on biomarkers; new therapies indicated for stage C HF with reduced ejection fraction (HFrEF); updates on HF with preserved ejection fraction (HFpEF); new data on important comorbidities, including sleep apnea, anemia, and hypertension; and new insights into the prevention of HF.

This focused update represents the second part of a 2-stage publication; with the first part having been published as the “2016 ACC/AHA/HFSA Focused Update on New Pharmacological Therapy for Heart Failure” (10), which introduced guidance on new therapies, specifically for the use of an angiotensin receptor–neprilysin inhibitor (ARNI) (valsartan/sacubitril) and a sinoatrial node modulator (ivabradine). That focused update was published concurrently with the European Society of Cardiology’s complete guideline, “2016 ESC Guidelines for the Diagnosis and Treatment of Acute and Chronic Heart Failure” (11).

1.1. Methodology and Evidence Review

To identify key data that influence guideline recommendations, the Task Force and members of the 2013 HF guideline writing committee reviewed clinical trials that were presented at the annual scientific meetings of the ACC, AHA, and European Society of Cardiology and other scientific meetings and that were published in peer-reviewed format from April 2013 through November 2016. The evidence is summarized in tables in the Online Data Supplement (http://circ.ahajournals.org/lookup/suppl/doi:10.1161/CIR.0000000000000509/-/DC2). All recommendations (new, modified, and unchanged) for each clinical section are included to provide a comprehensive assessment. The text explains new and modified recommendations, whereas recommendations from the previous guideline that have been deleted or superseded no longer appear. Please consult the full-text version of the 2013 HF guideline (9) for text and evidence tables supporting the unchanged recommendations and for clinical areas not addressed in this focused update. Individual recommendations in this focused update will be incorporated into the full-text guideline in the future. Recommendations from the prior guideline that remain current have been included for completeness, but the LOE reflects the COR/LOE system used when the recommendations were initially developed. New and modified recommendations in this focused update reflect the latest COR/LOE system, in which LOE
B and C are subcategorized for greater specificity (4-6). The section numbers correspond to the full-text guideline sections.

1.2. Organization of the Writing Group

For this focused update, representative members of the 2013 HF guideline writing committee were invited to participate. They were joined by additional invited members to form a new writing group, which is referred to as the 2017 HF focused update writing group. Members were required to disclose all RWI relevant to the data under consideration. The group was composed of experts representing general cardiologists, HF and transplantation specialists, electrophysiologists, pharmacists, and general internists. The 2017 HF focused update writing group included representatives from the ACC, AHA, and HFSA, as well as the American Academy of Family Physicians, American College of Chest Physicians, American College of Physicians, and International Society for Heart and Lung Transplantation.

1.3. Document Review and Approval

The focused update was reviewed by 2 official reviewers each nominated by the ACC, AHA, and HFSA; 1 reviewer each from the American Academy of Family Physicians, American College of Chest Physicians, and International Society for Heart and Lung Transplantation; and 19 individual content reviewers. Reviewers’ RWI information is published in this document (Appendix 2).

This document was approved for publication by the governing bodies of the ACC, AHA, and HFSA.
Table 1. Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care* (Updated August 2015)

<table>
<thead>
<tr>
<th>Class (Strength) of Recommendation</th>
<th>Benefit</th>
<th>Risk</th>
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</thead>
<tbody>
<tr>
<td><strong>Class I (Strong)</strong></td>
<td>Benefit &gt;&gt; Risk</td>
<td></td>
</tr>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Is recommended</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Is indicated/useful/effective/beneficial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Should be performed/administered/other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Comparative-Effectiveness Phrases:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Treatment/strategy A is recommended/indicated in preference to treatment B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Treatment A should be chosen over treatment B</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Class IIa (Moderate)</strong></td>
<td>Benefit &gt;&gt; Risk</td>
<td></td>
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<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Is reasonable</td>
<td></td>
<td></td>
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<tr>
<td>- Can be useful/effective/beneficial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Comparative-Effectiveness Phrases:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Treatment/strategy A is probably recommended/indicated in preference to treatment B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- It is reasonable to choose treatment A over treatment B</td>
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<tr>
<td><strong>Class IIb (Weak)</strong></td>
<td>Benefit &gt; Risk</td>
<td></td>
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<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
<td></td>
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<tr>
<td>- May/might be reasonable</td>
<td></td>
<td></td>
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<tr>
<td>- May/might be considered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Usefulness/effectiveness is unknown/unclear/uncertain or not well established</td>
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<td></td>
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<tr>
<td><strong>Class III: No Benefit (Moderate)</strong></td>
<td>Benefit = Risk</td>
<td></td>
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<tr>
<td>(Generally, LOE A or B use only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Is not recommended</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Is not indicated/useful/effective/beneficial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Should not be performed/administered/other</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Class III: Harm (Strong)</strong></td>
<td>Risk &gt; Benefit</td>
<td></td>
</tr>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Potentially harmful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Causes harm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Associated with excess morbidity/mortality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Should not be performed/administered/other</td>
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<table>
<thead>
<tr>
<th>Level (Quality) of Evidence‡</th>
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<tbody>
<tr>
<td><strong>Level A</strong></td>
<td></td>
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<tr>
<td>- High-quality evidence† from more than 1 RCT</td>
<td></td>
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<tr>
<td>- Meta-analyses of high-quality RCTs</td>
<td></td>
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<tr>
<td>- One or more RCTs corroborated by high-quality registry studies</td>
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<tr>
<td><strong>Level B-R</strong></td>
<td>(Randomized)</td>
</tr>
<tr>
<td>- Moderate-quality evidence† from 1 or more RCTs</td>
<td></td>
</tr>
<tr>
<td>- Meta-analyses of moderate-quality RCTs</td>
<td></td>
</tr>
<tr>
<td><strong>Level B-NR</strong></td>
<td>(Nonrandomized)</td>
</tr>
<tr>
<td>- Moderate-quality evidence† from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies</td>
<td></td>
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<tr>
<td>- Meta-analyses of such studies</td>
<td></td>
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<tr>
<td><strong>Level C-LD</strong></td>
<td>(Limited Data)</td>
</tr>
<tr>
<td>- Randomized or nonrandomized observational or registry studies with limitations of design or execution</td>
<td></td>
</tr>
<tr>
<td>- Meta-analyses of such studies</td>
<td></td>
</tr>
<tr>
<td>- Physiological or mechanistic studies in human subjects</td>
<td></td>
</tr>
<tr>
<td><strong>Level C-EO</strong></td>
<td>(Expert Opinion)</td>
</tr>
<tr>
<td>Consensus of expert opinion based on clinical experience</td>
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</table>

COR and LOE are determined independently (any COR may be paired with any LOE). A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

* The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).
† For comparative-effectiveness recommendations (COR I and IIa; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.
‡ The method of assessing quality is evolving, including the application of standardized, widely used, and preferably validated evidence grading tools and for systematic reviews, the incorporation of an Evidence Review Committee.

COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized; and RCT, randomized controlled trial.
6. Initial and Serial Evaluation of the HF Patient

6.3. Biomarkers

Assays for BNP (B-type natriuretic peptide) and NT-proBNP (N-terminal pro-B-type natriuretic peptide), which are both natriuretic peptide biomarkers, have been used increasingly to establish the presence and severity of HF. In general, both natriuretic peptide biomarker values track similarly, and either can be used in patient care settings as long as their respective absolute values and cutpoints are not used interchangeably. Notably, BNP, but not NT-proBNP, is a substrate for neprilysin. Therefore, ARNI increases BNP levels (12) but not NT-proBNP levels (13). Note that the type of natriuretic peptide assay that has been performed must be considered during interpretation of natriuretic peptide biomarker levels in patients on ARNI. In 2 studies with ARNI, NT-proBNP levels were reduced (12, 14), with the reduction in 1 study being associated with improved clinical outcomes (12).

A substantial evidence base exists that supports the use of natriuretic peptide biomarkers to assist in the diagnosis or exclusion of HF as a cause of symptoms (e.g., dyspnea, weight gain) in the setting of chronic ambulatory HF (15-21) or in the setting of acute care with decompensated HF (22-30), especially when the cause of dyspnea is unclear. The role of natriuretic peptide biomarkers in population screening to detect incident HF is emerging (31-37). Elevated plasma levels of natriuretic peptide biomarkers are associated with a wide variety of cardiac and noncardiac causes (Table 2) (38-42). Obesity may be associated with lower natriuretic peptide concentrations, and this may modestly reduce diagnostic sensitivity in morbidly obese patients (42).

Because of the absence of clear and consistent evidence for improvement in mortality and cardiovascular outcomes (43-62), there are insufficient data to inform specific guideline recommendations related to natriuretic peptide–guided therapy or serial measurements of BNP or NT-proBNP levels for the purpose of reducing hospitalization or deaths in the present document.

Like natriuretic peptides, cardiac troponin levels may be elevated in the setting of chronic or acute decompensated HF, suggesting myocyte injury or necrosis (63). Troponins I and T respond similarly for acute coronary syndromes and acute decompensated HF. Elevations in either troponin I or T levels in the setting of acute HF are of prognostic significance and must be interpreted in the clinical context (64).

In addition to natriuretic peptides and troponins (65-67), multiple other biomarkers, including those of inflammation, oxidative stress, vascular dysfunction, and myocardial and matrix remodeling, have been implicated in HF (68-71). Biomarkers of myocardial fibrosis, soluble ST2 receptor, and galectin-3 are predictive of hospitalization and death and may provide incremental prognostic value over natriuretic peptide levels in patients with HF (72-74). Strategies that combine multiple biomarkers may
ultimately prove beneficial in guiding HF therapy in the future, but multicenter studies with larger derivation and validation cohorts are needed (75, 76). Several emerging biomarkers await validation with well-defined outcome measures and prognostic accuracy before they can reach the clinical arena (77-84).

This section categorizes the role of biomarkers into prevention, diagnosis, prognosis, and added risk stratification to clarify evidence-based objectives of their use in clinical practice.

Table 2. Selected Potential Causes of Elevated Natriuretic Peptide Levels (38-41)

<table>
<thead>
<tr>
<th>Cardiac</th>
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<tbody>
<tr>
<td>HF, including RV syndromes</td>
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<tr>
<td>Acute coronary syndromes</td>
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<tr>
<td>Heart muscle disease, including LVH</td>
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<tr>
<td>Valvular heart disease</td>
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<td>Pericardial disease</td>
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<tr>
<td>Atrial fibrillation</td>
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<tr>
<td>Myocarditis</td>
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<tr>
<td>Cardiac surgery</td>
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<tr>
<td>Cardioversion</td>
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<tr>
<td>Toxic-metabolic myocardial insults, including cancer chemotherapy</td>
<td></td>
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</tbody>
</table>

| Noncardiac                                                             |                   |
| Advancing age                                                          |                   |
| Anemia                                                                 |                   |
| Renal failure                                                          |                   |
| Pulmonary: obstructive sleep apnea, severe pneumonia                   |                   |
| Pulmonary hypertension                                                 |                   |
| Critical illness                                                       |                   |
| Bacterial sepsis                                                       |                   |
| Severe burns                                                           |                   |

HF indicates heart failure; LVH, left ventricular hypertrophy; and RV, right ventricular.

Modified from Table 8 of the 2013 HF guideline (9).

6.3.1. Biomarkers for Prevention: Recommendation

<table>
<thead>
<tr>
<th>Biomarkers: Recommendation for Prevention of HF</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COR</strong></td>
<td><strong>LOE</strong></td>
</tr>
<tr>
<td>IIa</td>
<td>B-R</td>
</tr>
<tr>
<td>For patients at risk of developing HF, natriuretic peptide biomarker–based screening followed by team-based care, including a cardiovascular specialist optimizing GDMT, can be useful to prevent the development of left ventricular dysfunction (systolic or diastolic) or new-onset HF (85, 86).</td>
<td></td>
</tr>
<tr>
<td><strong>Comment/Rationale</strong></td>
<td></td>
</tr>
<tr>
<td>NEW: New data suggest that natriuretic peptide biomarker screening and early intervention may prevent HF.</td>
<td></td>
</tr>
</tbody>
</table>

In a large-scale unblinded single-center study (STOP-HF [The St Vincent’s Screening to Prevent Heart Failure]) (85), patients at risk of HF (identified by the presence of hypertension, diabetes mellitus, or known vascular disease [e.g., stage A HF]), but without established left ventricular systolic dysfunction or symptomatic HF at baseline, were randomly assigned to receive screening with BNP testing or usual primary care. Intervention-group participants with BNP levels of ≥50 pg/mL underwent echocardiography and were referred to a cardiovascular specialist who decided on further investigation and management. All patients received further coaching by a specialist nurse who emphasized individual risk and the importance of adherence to medication.
and healthy lifestyle behaviors. BNP-based screening reduced the composite endpoint of asymptomatic left ventricular dysfunction (systolic or diastolic) with or without newly diagnosed HF (85). Similarly, in another small, single-center RCT, accelerated up-titration of renin-angiotensin-aldosterone system antagonists and beta blockers reduced cardiac events in patients with diabetes mellitus and elevated NT-proBNP levels but without cardiac disease at baseline (86). Developing a standardized strategy to screen and intervene in patients at risk of HF can be difficult because of different definitions of HF risk, heterogeneity of prevalence in different populations, variable duration until clinical HF or left ventricular dysfunction develops, and variable interventions for risk factor modification or treatment. Further studies are needed to determine cost-effectiveness and risk of such screening, as well as its impact on quality of life (QoL) and mortality rate.

6.3.2. Biomarkers for Diagnosis: Recommendation

<table>
<thead>
<tr>
<th>Biomarkers: Recommendation for Diagnosis</th>
<th>Recommendation</th>
<th>Comment/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>COR</td>
<td>LOE</td>
<td>In patients presenting with dyspnea, measurement of natriuretic peptide biomarkers is useful to support a diagnosis or exclusion of HF (15-24, 28-30).</td>
</tr>
<tr>
<td>I</td>
<td>A</td>
<td>See Online Data Supplements A and B.</td>
</tr>
</tbody>
</table>

Natriuretic peptide biomarker testing in the setting of chronic ambulatory HF provides incremental diagnostic value to clinical judgment, especially when the etiology of dyspnea is unclear (15-21). In emergency settings, natriuretic peptide biomarker levels usually have higher sensitivity than specificity and may be more useful for ruling out than ruling in HF (20). Although lower values of natriuretic peptide biomarkers exclude the presence of HF, and higher values have reasonably high positive predictive value to diagnose HF, clinicians should be aware that elevated plasma levels for both natriuretic peptides have been associated with a wide variety of cardiac and noncardiac causes (Table 2) (38-41).

6.3.3. Biomarkers for Prognosis or Added Risk Stratification: Recommendations

<table>
<thead>
<tr>
<th>Biomarkers: Recommendations for Prognosis</th>
<th>Recommendation</th>
<th>Comment/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>COR</td>
<td>LOE</td>
<td>Measurement of BNP or NT-proBNP is useful for establishing prognosis or disease severity in chronic HF (16, 87-92).</td>
</tr>
<tr>
<td>I</td>
<td>A</td>
<td>See Online Data Supplements A and B.</td>
</tr>
</tbody>
</table>

Measurement of baseline levels of natriuretic peptide biomarkers and/or cardiac troponin on admission to the hospital is useful to establish a prognosis in acutely decompensated HF (27, 93-100).

Higher levels of natriuretic peptide biomarkers on admission are usually associated with greater risk for clinical outcomes, including all-cause and cardiovascular mortality, morbidity, and composite outcomes, across different time intervals in patients with decompensated HF (20, 27, 29, 93-101). Similarly, abnormal levels of circulating cardiac troponin are commonly found in patients with acute decompensated HF, often without obvious
myocardial ischemia or underlying coronary artery disease (CAD), and this is associated with worse clinical outcomes and higher risk of death (95, 99, 102, 103).

Studies have demonstrated incremental prognostic value of these biomarkers to standard approaches of cardiovascular disease risk assessment (29, 95). However, there were differences in the risk prediction models, assay cutpoints, and lengths of follow-up (29). Furthermore, not all patients may need biomarker measurement for prognostication, especially if they already have advanced HF with established poor prognosis or persistently elevated levels of biomarkers in former settings. Therefore, assays of natriuretic peptide biomarkers for incremental prognostication should not preclude good clinical judgment; an individualized approach to each patient is paramount.

**IIa**

<table>
<thead>
<tr>
<th>B-NR</th>
<th>During a HF hospitalization, a predischarge natriuretic peptide level can be useful to establish a postdischarge prognosis (93, 96, 104-113).</th>
<th>NEW: Current recommendation reflects new observational studies.</th>
</tr>
</thead>
</table>
See Online Data Supplements A and B.

Predischarge natriuretic peptide biomarker levels and the relative change in levels during hospital treatment are strong predictors of the risk of death or hospital readmission for HF (93, 96, 104-113). Several studies have suggested that predischarge natriuretic peptide biomarker levels had higher reclassification and discrimination value than clinical variables in predicting outcomes (96, 106, 108-111). Patients with higher predischarge levels and patients who do not have a decrease in natriuretic peptide biomarker levels during hospitalization have worse outcomes (96, 106, 108-111). Although observational or retrospective studies have suggested that patients with natriuretic peptide biomarker reduction had better outcomes than those without any changes or with a biomarker rise (93, 107, 112, 113), targeting a certain threshold, value, or relative change in these biomarker levels during hospitalization may not be practical or safe for every patient and has not been tested in a prospective large-scale trial. Clinical assessment and adherence to GDMT should be the emphasis, and the prognostic value of a predischarge value or relative changes does not imply the necessity for serial and repeated biomarker measurements during hospitalization.

**IIb**

<table>
<thead>
<tr>
<th>B-NR</th>
<th>In patients with chronic HF, measurement of other clinically available tests, such as biomarkers of myocardial injury or fibrosis, may be considered for additive risk stratification (27, 95, 98, 99, 103, 114-119).</th>
<th>MODIFIED: 2013 recommendations have been combined into prognosis section, resulting in LOE change from A to B-NR.</th>
</tr>
</thead>
</table>
See Online Data Supplements A and B.

Biomarkers of myocardial fibrosis (e.g., soluble ST2 receptor, galectin-3, high-sensitivity cardiac troponin, and others) are predictive of hospitalization and death in patients with HF and also are additive to natriuretic peptide biomarker levels in their prognostic value (117, 119-126). A combination of biomarkers may ultimately prove to be more informative than single biomarkers (127).
Figure 1. Biomarkers Indications for Use

Colors correspond to COR in Table 1.
*Other biomarkers of injury or fibrosis include soluble ST2 receptor, galectin-3, and high-sensitivity troponin.
ACC indicates American College of Cardiology; AHA, American Heart Association; ADHF, acute decompensated heart failure; BNP, B-type natriuretic peptide; COR, Class of Recommendation; ED, emergency department; HF, heart failure; NT-proBNP, N-terminal pro-B-type natriuretic peptide; NYHA, New York Heart Association; and pts, patients.

7. Treatment of Stages A to D

7.3. Stage C

7.3.2. Pharmacological Treatment for Stage C HF With Reduced Ejection Fraction: Recommendations

(See Figure 2 and Table 3).
7.3.2.10. Renin-Angiotensin System Inhibition With Angiotensin-Converting Enzyme Inhibitor or Angiotensin Receptor Blocker or ARNI: Recommendations

| Recommendations for Renin-Angiotensin System Inhibition With ACE Inhibitor or ARB or ARNI |
|--------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| COR | LOE | Recommendations | Comment/Rationale |
| I | ACE-I: A | The clinical strategy of inhibition of the renin-angiotensin system with ACE inhibitors (Level of Evidence: A) (128-133), OR ARBs (Level of Evidence: A) (134-137), OR ARNI (Level of Evidence: B-R) (138) in conjunction with evidence-based beta blockers (9, 139, 140), and aldosterone antagonists in selected patients (141, 142), is recommended for patients with chronic HFrEF to reduce morbidity and mortality. | NEW: New clinical trial data prompted clarification and important updates. |
| | ARB: A | |
| | ARNI: B-R | |

Angiotensin-converting enzyme (ACE) inhibitors reduce morbidity and mortality in heart failure with reduced ejection fraction (HFrEF). Randomized controlled trials (RCTs) clearly establish the benefits of ACE inhibition in patients with mild, moderate, or severe symptoms of HF and in patients with or without coronary artery disease (128-133). ACE inhibitors can produce angioedema and should be given with caution to patients with low systemic blood pressures, renal insufficiency, or elevated serum potassium. ACE inhibitors also inhibit kininase and increase levels of bradykinin, which can induce cough but also may contribute to their beneficial effect through vasodilation.

Angiotensin receptor blockers (ARBs) were developed with the rationale that angiotensin II production continues in the presence of ACE inhibition, driven through alternative enzyme pathways. ARBs do not inhibit kininase and are associated with a much lower incidence of cough and angioedema than ACE inhibitors; but like ACE inhibitors, ARBs should be given with caution to patients with low systemic blood pressure, renal insufficiency, or elevated serum potassium. Long-term therapy with ARBs produces hemodynamic, neurohormonal, and clinical effects consistent with those expected after interference with the renin-angiotensin system and have been shown in RCTs (134-137) to reduce morbidity and mortality, especially in ACE inhibitor–intolerant patients.

In ARNI, an ARB is combined with an inhibitor of neprilysin, an enzyme that degrades natriuretic peptides, bradykinin, adrenomedullin, and other vasoactive peptides. In an RCT that compared the first approved ARNI, valsartan/sacubitril, with enalapril in symptomatic patients with HFrEF tolerating an adequate dose of either ACE inhibitor or ARB, the ARNI reduced the composite endpoint of cardiovascular death or HF hospitalization significantly, by 20% (138). The benefit was seen to a similar extent for both death and HF hospitalization and was consistent across subgroups. The use of ARNI is associated with the risk of hypotension and renal insufficiency and may lead to angioedema, as well.

See Online Data Supplements 1, 2, 18-20.
<table>
<thead>
<tr>
<th>1</th>
<th>ACE-I: A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The use of ACE inhibitors is beneficial for patients with prior or current symptoms of chronic HFrEF to reduce morbidity and mortality (128-133, 143).</strong></td>
<td>2013 recommendation repeated for clarity in this section.</td>
</tr>
<tr>
<td>ACE inhibitors have been shown in large RCTs to reduce morbidity and mortality in patients with HFrEF with mild, moderate, or severe symptoms of HF, with or without coronary artery disease (128-133). Data suggest that there are no differences among available ACE inhibitors in their effects on symptoms or survival (143). ACE inhibitors should be started at low doses and titrated upward to doses shown to reduce the risk of cardiovascular events in clinical trials. ACE inhibitors can produce angioedema and should be given with caution to patients with low systemic blood pressures, renal insufficiency, or elevated serum potassium (&gt;5.0 mEq/L). Angioedema occurs in &lt;1% of patients who take an ACE inhibitor, but it occurs more frequently in blacks and women (144). Patients should not be given ACE inhibitors if they are pregnant or plan to become pregnant. ACE inhibitors also inhibit kininase and increase levels of bradykinin, which can induce cough in up to 20% of patients but also may contribute to beneficial vasodilation. If maximal doses are not tolerated, intermediate doses should be tried; abrupt withdrawal of ACE inhibition can lead to clinical deterioration and should be avoided. Although the use of an ARNI in lieu of an ACE inhibitor for HFrEF has been found to be superior, for <em>those patients for whom ARNI is not appropriate, continued use of an ACE inhibitor for all classes of HFrEF remains strongly advised.</em></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>ARB: A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The use of ARBs to reduce morbidity and mortality is recommended in patients with prior or current symptoms of chronic HFrEF who are intolerant to ACE inhibitors because of cough or angioedema (134-137, 145, 146).</strong></td>
<td>2013 recommendation repeated for clarity in this section.</td>
</tr>
<tr>
<td>ARBs have been shown to reduce mortality and HF hospitalizations in patients with HFrEF in large RCTs (134-137). Long-term therapy with ARBs in patients with HFrEF produces hemodynamic, neurohormonal, and clinical effects consistent with those expected after interference with the renin-angiotensin system (145, 146). Unlike ACE inhibitors, ARBs do not inhibit kininase and are associated with a much lower incidence of cough and angioedema, although kininase inhibition by ACE inhibitors may produce beneficial vasodilatory effects. Patients intolerant to ACE inhibitors because of cough or angioedema should be started on ARBs; patients already tolerating ARBs for other indications may be continued on ARBs if they subsequently develop HF. ARBs should be started at low doses and titrated upward, with an attempt to use doses shown to reduce the risk of cardiovascular events in clinical trials. ARBs should be given with caution to patients with low systemic blood pressure, renal insufficiency, or elevated serum potassium (&gt;5.0 mEq/L). Although ARBs are</td>
<td></td>
</tr>
</tbody>
</table>

See Online Data Supplement 18. See Online Data Supplements 2 and 19.
alternatives for patients with ACE inhibitor–induced angioedema, caution is advised because some patients have also developed angioedema with ARBs.

Head-to-head comparisons of an ARB versus ARNI for HF do not exist. For those patients for whom an ACE inhibitor or ARNI is inappropriate, use of an ARB remains advised.

| I | ARNI: B-R | In patients with chronic symptomatic HFrEF NYHA class II or III who tolerate an ACE inhibitor or ARB, replacement by an ARNI is recommended to further reduce morbidity and mortality (138). | NEW: New clinical trial data necessitated this recommendation. |

See Online Data Supplements 1 and 18.

Benefits of ACE inhibitors with regard to decreasing HF progression, hospitalizations, and mortality rate have been shown consistently for patients across the clinical spectrum, from asymptomatic to severely symptomatic HF. Similar benefits have been shown for ARBs in populations with mild-to-moderate HF who are unable to tolerate ACE inhibitors. In patients with mild-to-moderate HF (characterized by either 1) mildly elevated natriuretic peptide levels, BNP [B-type natriuretic peptide] >150 pg/mL or NT-proBNP [N-terminal pro-B-type natriuretic peptide] ≥600 pg/mL; or 2) BNP ≥100 pg/mL or NT-proBNP ≥400 pg/mL with a prior hospitalization in the preceding 12 months) who were able to tolerate both a target dose of enalapril (10 mg twice daily) and then subsequently an ARNI (valsartan/sacubitril; 200 mg twice daily, with the ARB component equivalent to valsartan 160 mg), hospitalizations and mortality were significantly decreased with the valsartan/sacubitril compound compared with enalapril. The target dose of the ACE inhibitor was consistent with that known to improve outcomes in previous landmark clinical trials (129). This ARNI has been approved for patients with symptomatic HFrEF and is intended to be substituted for ACE inhibitors or ARBs. HF effects and potential off-target effects may be complex with inhibition of the neprilysin enzyme, which has multiple biological targets. Use of an ARNI is associated with hypotension and a low-frequency incidence of angioedema. To facilitate initiation and titration, the approved ARNI is available in 3 doses that include a dose that was not tested in the HF trial; the target dose used in the trial was 97/103 mg twice daily (147). Clinical experience will provide further information about the optimal titration and tolerability of ARNI, particularly with regard to blood pressure, adjustment of concomitant HF medications, and the rare complication of angioedema (14).

| III | B-R | ARNI should not be administered concomitantly with ACE inhibitors or within 36 hours of the last dose of an ACE inhibitor (148, 149). | NEW: Available evidence demonstrates a potential signal of harm for a concomitant use of ACE inhibitors and ARNI. |
Oral neprilysin inhibitors, used in combination with ACE inhibitors can lead to angioedema and concomitant use is contraindicated and should be avoided. A medication that represented both a neprilysin inhibitor and an ACE inhibitor, omapatrilat, was studied in both hypertension and HF, but its development was terminated because of an unacceptable incidence of angioedema (148, 149) and associated significant morbidity. This adverse effect was thought to occur because both ACE and neprilysin break down bradykinin, which directly or indirectly can cause angioedema (149, 150). An ARNI should not be administered within 36 hours of switching from or to an ACE inhibitor.

### Harm

**ARNI should not be administered to patients with a history of angioedema.**

**NEW:** New clinical trial data.

Omapatrilat, a neprilysin inhibitor (as well as an ACE inhibitor and aminopeptidase P inhibitor), was associated with a higher frequency of angioedema than that seen with enalapril in an RCT of patients with HFrEF (148). In a very large RCT of hypertensive patients, omapatrilat was associated with a 3-fold increased risk of angioedema as compared with enalapril (149). Blacks and smokers were particularly at risk. The high incidence of angioedema ultimately led to cessation of the clinical development of omapatrilat (151, 152). In light of these observations, angioedema was an exclusion criterion in the first large trial assessing ARNI therapy in patients with hypertension (153) and then in the large trial that demonstrated clinical benefit of ARNI therapy in HFrEF (138). ARNI therapy should not be administered in patients with a history of angioedema because of the concern that it will increase the risk of a recurrence of angioedema.

### 7.3.2.11. Ivabradine: Recommendation

**Recommendation for Ivabradine**

<table>
<thead>
<tr>
<th>COR</th>
<th>LOE</th>
<th>Recommendation</th>
<th>Comment/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIa</td>
<td>B-R</td>
<td><em><em>Ivabradine can be beneficial to reduce HF hospitalization for patients with symptomatic (NYHA class II-III) stable chronic HFrEF (LVEF ≤35%) who are receiving GDEM</em>, including a beta blocker at maximum tolerated dose, and who are in sinus rhythm with a heart rate of 70 bpm or greater at rest (154-157).</em>*</td>
<td><strong>NEW:</strong> New clinical trial data.</td>
</tr>
</tbody>
</table>

Ivabradine is a new therapeutic agent that selectively inhibits the If current in the sinoatrial node, providing heart rate reduction. One RCT demonstrated the efficacy of ivabradine in reducing the composite endpoint of cardiovascular death or HF hospitalization (155). The benefit of ivabradine was driven by a reduction in HF hospitalization. The study included patients with HFrEF (NYHA class II-IV, albeit with only a modest representation of NYHA class IV HF) and left ventricular ejection fraction (LVEF) ≤35%, in sinus rhythm with a resting heart rate of ≥70 beats per minute. Patients enrolled included a small number with paroxysmal atrial fibrillation (<40% of the time) but otherwise in...
sinus rhythm and a small number experiencing ventricular pacing but with a predominant sinus rhythm. Those with a myocardial infarction within the preceding 2 months were excluded. Patients enrolled had been hospitalized for HF in the preceding 12 months and were on stable GDEM* for 4 weeks before initiation of ivabradine therapy. The target of ivabradine is heart rate slowing (the presumed benefit of action), but only 25% of patients studied were on optimal doses of beta-blocker therapy (9, 139, 140, 155). Given the well-proven mortality benefits of beta-blocker therapy, it is important to initiate and up titrate these agents to target doses, as tolerated, before assessing the resting heart rate for consideration of ivabradine initiation (155).

*In other parts of the document, the term “GDMT” has been used to denote guideline-directed management and therapy. In this recommendation, however, the term “GDEM” has been used to denote this same concept in order to reflect the original wording of the recommendation that initially appeared in the “2016 ACC/AHA/HFSA Focused Update on New Pharmacological Therapy for Heart Failure: An Update of the 2013 ACCF/AHA Guideline for the Management of Heart Failure” (10).
Figure 2. Treatment of HFrEF Stage C and D

Colors correspond to COR in Table 1. For all medical therapies, dosing should be optimized and serial assessment exercised.

*See text for important treatment directions.
†Hydral-Nitrates green box: The combination of ISDN/HYD with ARNI has not been robustly tested. BP response should be carefully monitored.
‡See 2013 HF guideline (9).
§Participation in investigational studies is also appropriate for stage C, NYHA class II and III HF.

ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor-blocker; ARNI, angiotensin receptor-neprilysin inhibitor; BP, blood pressure; bpm, beats per minute; C/I, contraindication; COR, Class of Recommendation; CrCl, creatinine clearance; CRT-D, cardiac resynchronization therapy–device; Dx, diagnosis; GDMT, guideline-directed management and therapy; HF, heart failure; HFrEF, heart failure with reduced ejection fraction; ICD, implantable cardioverter-defibrillator; ISDN/HYD, isosorbide dinitrate-hydral-nitrates; K+, potassium; LBBB, left bundle-branch block; LVAD, left ventricular assist device; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NSR, normal sinus rhythm; and NYHA, New York Heart Association.
### Table 3. Drugs Commonly Used for HFrEF (Stage C HF)

<table>
<thead>
<tr>
<th>Drug</th>
<th>Initial Daily Dose(s)</th>
<th>Maximum Doses(s)</th>
<th>Mean Doses Achieved in Clinical Trials</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACE inhibitors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captopril</td>
<td>6.25 mg TID</td>
<td>50 mg TID</td>
<td>122.7 mg QD</td>
<td>(158)</td>
</tr>
<tr>
<td>Enalapril</td>
<td>2.5 mg BID</td>
<td>10–20 mg BID</td>
<td>16.6 mg QD</td>
<td>(129)</td>
</tr>
<tr>
<td>Fosinopril</td>
<td>5–10 mg QD</td>
<td>40 mg QD</td>
<td>N/A</td>
<td>---</td>
</tr>
<tr>
<td>Lisinopril</td>
<td>2.5–5 mg QD</td>
<td>20–40 mg QD</td>
<td>32.5–35.0 mg QD</td>
<td>(130)</td>
</tr>
<tr>
<td>Perindopril</td>
<td>2 mg QD</td>
<td>8–16 mg QD</td>
<td>N/A</td>
<td>---</td>
</tr>
<tr>
<td>Quinapril</td>
<td>5 mg BID</td>
<td>20 mg BID</td>
<td>N/A</td>
<td>---</td>
</tr>
<tr>
<td>Ramipril</td>
<td>1.25–2.5 mg QD</td>
<td>10 mg QD</td>
<td>N/A</td>
<td>---</td>
</tr>
<tr>
<td>Trandolapril</td>
<td>1 mg QD</td>
<td>4 mg QD</td>
<td>N/A</td>
<td>---</td>
</tr>
<tr>
<td><strong>ARBs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Candesartan</td>
<td>4–8 mg QD</td>
<td>32 mg QD</td>
<td>24 mg QD</td>
<td>(137)</td>
</tr>
<tr>
<td>Losartan</td>
<td>25–50 mg QD</td>
<td>50–150 mg QD</td>
<td>129 mg QD</td>
<td>(136)</td>
</tr>
<tr>
<td>Valsartan</td>
<td>20–40 mg BID</td>
<td>160 mg BID</td>
<td>254 mg QD</td>
<td>(134)</td>
</tr>
<tr>
<td><strong>ARNI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sacubitril/valsartan</td>
<td>49/51 mg BID (sacubitril/valsartan) (therapy may be initiated at 24/26 mg BID)</td>
<td>97/103 mg BID (sacubitril/valsartan)</td>
<td>375 mg QD; target dose: 24/26 mg, 49/51 mg OR 97/103 mg BID</td>
<td>(138)</td>
</tr>
<tr>
<td><strong>If channel inhibitor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ivabradine</td>
<td>5 mg BID</td>
<td>7.5 mg BID</td>
<td>6.4 mg BID (at 28 d) 6.5 mg BID (at 1 y)</td>
<td>(155-157)</td>
</tr>
<tr>
<td><strong>Aldosterone antagonists</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spironolactone</td>
<td>12.5–25 mg QD</td>
<td>25 mg QD or BID</td>
<td>26 mg QD</td>
<td>(142)</td>
</tr>
<tr>
<td>Eplerenone</td>
<td>25 mg QD</td>
<td>50 mg QD</td>
<td>42.6 mg QD</td>
<td>(159)</td>
</tr>
<tr>
<td><strong>Beta blockers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bisoprolol</td>
<td>1.25 mg QD</td>
<td>10 mg QD</td>
<td>8.6 mg QD</td>
<td>(160)</td>
</tr>
<tr>
<td>Carvedilol</td>
<td>3.125 mg BID</td>
<td>50 mg BID</td>
<td>37 mg QD</td>
<td>(161)</td>
</tr>
<tr>
<td>Carvedilol CR</td>
<td>10 mg QD</td>
<td>80 mg QD</td>
<td>N/A</td>
<td>---</td>
</tr>
<tr>
<td>Metoprolol succinate extended release (metoprolol CR/XL)</td>
<td>12.5–25 mg QD</td>
<td>200 mg QD</td>
<td>159 mg QD</td>
<td>(139)</td>
</tr>
<tr>
<td><strong>Isosorbide dinitrate and hydralazine</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed-dose combination</td>
<td>20 mg isosorbide dinitrate / 37.5 mg hydralazine TID</td>
<td>40 mg isosorbide dinitrate / 75 mg hydralazine TID</td>
<td>90 mg isosorbide dinitrate / ~175 mg hydralazine QD</td>
<td>(162)</td>
</tr>
<tr>
<td>Isosorbide dinitrate and hydralazine</td>
<td>20–30 mg isosorbide dinitrate / 25–50 mg hydralazine TID or QD</td>
<td>40 mg isosorbide dinitrate TID with 100 mg hydralazine TID</td>
<td>N/A</td>
<td>(163)</td>
</tr>
</tbody>
</table>

Modified (Table 15) from the 2013 HF guideline (9).
ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor-neprilysin inhibitor; BID, twice daily; CR, controlled release; CR/XL, controlled release/extended release; HF, heart failure; HFpEF, heart failure with preserved ejection fraction; N/A, not applicable; QD, once daily; and TID, 3 times daily.

### 7.3.3. Pharmacological Treatment for Stage C HFpEF: Recommendations

<table>
<thead>
<tr>
<th>COR</th>
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<th>Recommendations</th>
<th>Comment/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>B</td>
<td>Systolic and diastolic blood pressure should be controlled in patients with HFpEF in accordance with published clinical practice guidelines to prevent morbidity (164, 165).</td>
<td>2013 recommendation remains current.</td>
</tr>
<tr>
<td>I</td>
<td>C</td>
<td>Diuretics should be used for relief of symptoms due to volume overload in patients with HFpEF.</td>
<td>2013 recommendation remains current.</td>
</tr>
<tr>
<td>IIa</td>
<td>C</td>
<td>Coronary revascularization is reasonable in patients with CAD in whom symptoms (angina) or demonstrable myocardial ischemia is judged to be having an adverse effect on symptomatic HFpEF despite GDMT.</td>
<td>2013 recommendation remains current.</td>
</tr>
<tr>
<td>IIa</td>
<td>C</td>
<td>Management of AF according to published clinical practice guidelines in patients with HFpEF is reasonable to improve symptomatic HF.</td>
<td>2013 recommendation remains current (Section 9.1 in the 2013 HF guideline).</td>
</tr>
<tr>
<td>IIa</td>
<td>C</td>
<td>The use of beta-blocking agents, ACE inhibitors, and ARBs in patients with hypertension is reasonable to control blood pressure in patients with HFpEF.</td>
<td>2013 recommendation remains current.</td>
</tr>
<tr>
<td>IIb</td>
<td>B-R</td>
<td>In appropriately selected patients with HFpEF (with EF ≥45%, elevated BNP levels or HF admission within 1 year, estimated glomerular filtration rate &gt;30 mL/min, creatinine &lt;2.5 mg/dL, potassium &lt;5.0 mEq/L), aldosterone receptor antagonists might be considered to decrease hospitalizations (83, 166, 167).</td>
<td>NEW: Current recommendation reflects new RCT data.</td>
</tr>
</tbody>
</table>

See Online Data Supplement C.

Mechanistic studies have suggested that mineralocorticoid receptor antagonists can improve measures of diastolic function in patients with HFpEF, possibly by a similar effect on remodeling (83, 168).

The TOPCAT (Treatment of Preserved Cardiac Function Heart Failure With an Aldosterone Antagonist) trial (166) investigated the effects of spironolactone on a combined endpoint of death, aborted cardiac death, and HF hospitalization in patients with HFpEF. A small reduction (HR=0.89) in this composite endpoint did not reach statistical significance, although HF hospitalization was reduced (HR=0.83); known side effects of hyperkalemia and rising creatinine were seen more commonly in the treatment group (166). An unusual amount of regional variation was seen in this trial, prompting a post-hoc analysis (167) that showed that rates of the primary endpoint were 4-fold lower in Russia/Georgia than in North America and South America (the Americas). Rates in the Americas were comparable to those in other HFpEF trials (169, 170). The post-hoc analysis showed efficacy in the Americas (HR=0.83) but not in Russia/Georgia (HR=1.10). Moreover, a sample of the Russia/Georgia population, despite having been in the active treatment arm, had nondetectable levels of
the metabolite of spironolactone. These post-hoc analyses have significant limitations, but they suggest that in appropriately selected patients with symptomatic HFpEF (with ejection fraction [EF] ≥45%, elevated BNP level or HF admission within 1 year, estimated glomerular filtration rate >30 mL/min creatinine <2.5 mg/dL, and potassium <5.0 mEq/L), particularly in those with elevated BNP levels, use of spironolactone might be considered with close monitoring of potassium and renal function. Confirmatory studies are required.

With regard to the use of mineralocorticoid receptor antagonists, creatinine should be <2.5 mg/dL in men or <2.0 mg/dL in women (or estimated glomerular filtration rate >30 mL/min) and potassium should be <5.0 mEq/L. Careful monitoring of potassium, renal function, and diuretic dosing represents best practices at initiation and during follow-up thereafter to minimize risk of hyperkalemia and worsening renal function.

IIb B The use of ARBs might be considered to decrease hospitalizations for patients with HFpEF (169). 2013 recommendation remains current.

III: No Benefit B-R Routine use of nitrates or phosphodiesterase-5 inhibitors to increase activity or QoL in patients with HFpEF is ineffective (171, 172). NEW: Current recommendation reflects new data from RCTs.

See Online Data Supplement C.

Nitrate therapy can reduce pulmonary congestion and improve exercise tolerance in patients with HFpEF. However, the NEAT-HFpEF (Nitrate’s Effect on Activity Tolerance in Heart Failure With Preserved Ejection Fraction) trial (171) randomized 110 patients with EF ≥50% on stable HF therapy, not including nitrates, and with activity limited by dyspnea, fatigue, or chest pain, to either isosorbide mononitrate or placebo and found no beneficial effects on activity levels, QoL, exercise tolerance, or NT-proBNP levels. On the basis of this trial, routine use of nitrates in patients with HFpEF is not recommended. This recommendation does not apply to patients with HFpEF and symptomatic CAD for whom nitrates may provide symptomatic relief. Phosphodiesterase-5 inhibition augments the nitric oxide system by upregulating cGMP activity. The RELAX (Phosphodiesterase-5 Inhibition to Improve Clinical Status and Exercise Capacity in Heart Failure with Preserved Ejection Fraction) trial (172) randomized 216 patients with EF ≥50% on stable HF therapy and with reduced exercise tolerance (peak observed VO₂ <60% of predicted) to phosphodiesterase-5 inhibition with sildenafil or placebo. This study did not show improvement in oxygen consumption or exercise tolerance.

III: No Benefit C Routine use of nutritional supplements is not recommended for patients with HFpEF. 2013 recommendation remains current.

9. Important Comorbidities in HF

9.2. Anemia: Recommendations

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<tr>
<th>Recommendations for Anemia</th>
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<tr>
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<td>IIb</td>
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See Online Data Supplement D.

Routine baseline assessment of all patients with HF includes an evaluation for anemia in addition to other baseline laboratory measurements. Anemia is independently associated with HF disease severity, and iron
deficiency appears to be uniquely associated with reduced exercise capacity. When iron deficiency is diagnosed and after full evaluation for cause, intravenous repletion of iron, especially in the setting of concomitant hepcidin deficiency in HF, may improve exercise capacity and QoL. Studies examining correction of iron deficiency in HF have demonstrated improvement in surrogate endpoints, such as QoL, NT-proBNP, and LVEF; however, controlled trials have been underpowered to detect reductions in hard clinical endpoints. The FAIR-HF (Ferric Carboxymaltose Assessment in Patients With Iron Deficiency and Chronic Heart Failure) trial (173) demonstrated improvements in NYHA class and functional capacity over a short-term exposure. The CONFIRM-HF (Ferric Carboxymaltose Evaluation on Performance in Patients With Iron Deficiency in Combination with Chronic Heart Failure) trial (174) included a larger cohort of patients (n=304) and demonstrated improvements in 6-minute walk test. A meta-analysis of 5 prospective controlled studies (631 patients) evaluated the effect of intravenous iron on deaths, hospitalizations, and other events in patients with HF and iron deficiency (175). Patients receiving intravenous iron experienced limited but statistically significant improvements in functional capacity and LVEF but no reduction in mortality rate. The FAIR-HF 2 trial is underway to further address the potential benefit of intravenous iron in HF associated with iron deficiency. Therefore, a strong recommendation for intravenous iron repletion must await the results of an appropriately powered trial on morbidity and mortality. There is an uncertain evidence base for oral iron repletion in the setting of anemia associated with HF.

III: No Benefit

<table>
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<th>Recommendations</th>
<th>Comment/Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>B-R</td>
<td>In patients with HF and anemia, erythropoietin-stimulating agents should not be used to improve morbidity and mortality (176).</td>
<td><em>NEW</em>: Current recommendation reflects new evidence demonstrating absence of therapeutic benefit.</td>
</tr>
</tbody>
</table>

Small studies evaluating the treatment of anemia in patients with HF have suggested a trend toward improvement in functional capacity and reduction in hospitalization with the use of erythropoietin-stimulating agents (177-182), but results have varied (183) and have been limited because of sample size. Although a meta-analysis of 11 RCTs (n=794) comparing erythropoietin-stimulating agents to control in patients with HF demonstrated significant improvements in 6-minute walk, exercise duration, peak VO₂, NYHA functional status, EF, BNP, HF-related hospitalizations, and QoL (184), in the STAMINA-HeFT (Study of Anemia in Heart Failure) trial (183), darbepoetin alfa was not associated with significant clinical benefits. In the largest RCT to date (n=2,278), correction of anemia with darbepoetin alfa did not result in benefit and resulted in a significant increase in the risk of thromboembolic events and a nonsignificant increase in fatal and nonfatal strokes, supporting findings from other trials (176, 185-188). In summary, the strongest evidence on erythropoietin-stimulating agent therapy in HF suggests lack of benefit and increased adverse events. Therefore, erythropoietin-stimulating agent therapy cannot be recommended in patients with HF and anemia.

9.5. Hypertension (New Section)

9.5.1. Treating Hypertension to Reduce the Incidence of HF: Recommendation

<table>
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<tr>
<td>I</td>
<td>B-R</td>
<td>In patients at increased risk, stage A HF, the optimal blood pressure in those with hypertension should be</td>
<td><em>NEW</em>: Recommendation reflects new RCT data.</td>
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</table>
A large RCT demonstrated that in those with increased cardiovascular risk (defined as age >75 years, established vascular disease, chronic renal disease, or a Framingham Risk Score >15%), control of blood pressure to a goal systolic pressure of <120 mm Hg, as determined by blood pressure assessment as per research protocol, was associated with a significant reduction in the incidence of HF (191) and an overall decrease in cardiovascular death. Blood pressure measurements as generally taken in the office setting are typically 5 to 10 mm Hg higher than research measurements; thus, the goal of <130/80 mm Hg is an approximation of the target blood pressure in conventional practice. Targeting a significant reduction in systolic blood pressure in those at increased risk for cardiovascular disease is a novel strategy to prevent HF.

9.5.2. Treating Hypertension in Stage C HFrEF: Recommendation

<table>
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Clinical trials evaluating goal blood pressure reduction and optimal blood pressure–lowering agents in the setting of HFrEF and concomitant hypertension have not been done. However, it is apparent that in those patients at higher risk, blood pressure lowering is associated with fewer adverse cardiovascular events. GDMT for HFrEF with agents known to lower blood pressure should consider a goal blood pressure reduction consistent with a threshold now associated with improved clinical outcomes but not yet proven by RCTs in a population with HF.

9.5.3. Treating Hypertension in Stage C HFpEF: Recommendation

<table>
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<tr>
<td>I</td>
<td>C-LD</td>
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</table>

The use of nitrates in the setting of HFpEF is associated with a signal of harm and, in most situations, should be avoided. For many common antihypertensive agents, including alpha blockers, beta blockers, and calcium channel blockers, there are limited data to guide the choice of antihypertensive therapy in the setting of HFpEF (172). Nevertheless, RAAS inhibition with ACE inhibitor, ARB (especially mineralocorticoid receptor antagonists), and possibly ARNI would represent the preferred choice. A shared decision-making discussion with the patient influenced by physician judgment should drive the ultimate choice of antihypertensive agents.
## 9.6. Sleep Disordered Breathing: Recommendations

*(Moved from Section 7.3.1.4, Treatment of Sleep Disorders in the 2013 HF guideline.)*

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<th>Recommendations for Treatment of Sleep Disorders</th>
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<td>IIa</td>
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<td></td>
<td>In patients with NYHA class II–IV HF and suspicion of sleep disordered breathing or excessive daytime sleepiness, a formal sleep assessment is reasonable (200, 201).</td>
<td>NEW: Recommendation reflects clinical necessity to distinguish obstructive versus central sleep apnea.</td>
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<td>See Online Data Supplement G.</td>
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Sleep disorders are common in patients with HF. A study of adults with chronic HF treated with evidence-based therapies found that 61% had either central or obstructive sleep apnea (202). It is clinically important to distinguish obstructive sleep apnea from central sleep apnea, given the different responses to treatment. Adaptive servo-ventilation for central sleep apnea is associated with harm (203). Continuous positive airway pressure (CPAP) for obstructive sleep apnea improves sleep quality, reduces the apnea-hypopnea index, and improves nocturnal oxygenation (200, 201).

| IIb                                             | B-R  |     | In patients with cardiovascular disease and obstructive sleep apnea, CPAP may be reasonable to improve sleep quality and daytime sleepiness (204). | NEW: New data demonstrate the limited scope of benefit expected from CPAP for obstructive sleep apnea. |
| See Online Data Supplement G.                   |     |     |                  |                  |

In patients with sleep apnea, a trial evaluated the impact of CPAP with usual therapy versus usual therapy alone on subsequent cardiovascular events, including HF (204). In this RCT of >2,700 patients, there was no evidence of benefit on cardiovascular events at a mean follow-up of 3.7 years for CPAP plus usual care compared with usual care alone. Improvements in sleep quality were noteworthy and represented the primary indication for initiating CPAP treatment (204). However, in patients with atrial fibrillation (AF) (a frequent comorbidity noted with HF), the use of CPAP for obstructive sleep apnea was helpful. In a trial of 10,132 patients with AF and obstructive sleep apnea, patients on CPAP treatment were less likely to progress to more permanent forms of AF than were patients without CPAP (205).

| III: Harm                                       | B-R  |     | In patients with NYHA class II–IV HFrEF and central sleep apnea, adaptive servo-ventilation causes harm (203). | NEW: New data demonstrate a signal of harm when adaptive servo-ventilation is used for central sleep apnea. |
| See Online Data Supplement G.                   |     |     |                  |                  |

Mortality rate (all cause and cardiovascular) was higher with adaptive servo-ventilation plus GDMT than with GDMT alone in a single RCT to test the addition of adaptive servo-ventilation (≥5 hours/night, 7 days/week) to GDMT in patients with HFrEF and central sleep apnea (203). A similar risk has been seen in another trial, and a third trial of adaptive servo-ventilation in central sleep apnea and HF was aborted because of ethical concerns. The weight of evidence does not support the use of adaptive servo-ventilation for central sleep apnea in HFrEF.
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Key Words: AHA Scientific Statements • heart failure • focused update • angiotensin receptor-neprilysin inhibitor • ivabradine • angiotensin receptor blockers • angiotensin-converting enzyme inhibitors • beta blockers • angioedema • natriuretic peptides • ferric carboxymaltose • iron deficiency • hypertension • sleep apnea • natriuretic peptide biomarker
References

62. Stienen S, PRIMA II: can NT-pro-brain-natriuretic peptide (NT-proBNP) guided therapy during admission for acute heart failure reduce mortality and readmissions?


## Appendix 1. Author Relationships With Industry and Other Entities (Relevant)—2017 ACC/AHA/HFSA Focused Update of the 2013 ACCF/AHA Guideline for the Management of Heart Failure (December 2015)

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<th>Committee Member</th>
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<th>Consultant</th>
<th>Speakers Bureau</th>
<th>Ownership/Partnership/Principal</th>
<th>Personal Research</th>
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<th>Expert Witness</th>
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<tbody>
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<tr>
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<td>None</td>
<td>None</td>
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<td>• Merck†</td>
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<td>Michael M. Givertz</td>
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<td>Vanderbilt Heart and Vascular Institute—Director, Advanced Heart Failure and Transplant Section—Professor of Medicine</td>
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This table represents the relationships of committee members with industry and other entities that were determined to be relevant to this document. These relationships were reviewed and updated in conjunction with all meetings and/or conference calls of the writing committee during the document development process. The table does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of $\geq$5% of the voting stock or share of the business entity, or ownership of $\geq$5,000 of the fair market value of the business entity, or if funds received by the person from the business entity exceed 5% of the person’s gross income for the previous year. Relationships that exist with no financial benefit are also included for the purpose of transparency. Relationships in this table are modest unless otherwise noted.

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Appendix 2. Reviewer Relationships With Industry and Other Entities (Comprehensive)—2017 ACC/AHA/HFSA Focused Update of the 2013 ACCF/AHA Guideline for the Management of Heart Failure (October 2016)

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Appendix 3. Abbreviations

ACE = angiotensin-converting enzyme  
ARB = angiotensin-receptor blocker  
ARNI = angiotensin receptor–neprilysin inhibitor  
BNP = B-type natriuretic peptide  
BP = blood pressure  
COR = Class of Recommendation  
CPAP = continuous positive airway pressure  
EF = ejection fraction  
GDMT = guideline-directed management and therapy  
HFpEF = heart failure with preserved ejection fraction  
HFrEF = heart failure with reduced ejection fraction  
LOE = Level of Evidence  
LVEF = left ventricular ejection fraction  
NT-proBNP = N-terminal pro-B-type natriuretic peptide  
QoL = quality of life  
RCT = randomized controlled trial

Clyde W. Yancy, Mariell Jessup, Biykem Bozkurt, Javed Butler, Donald E. Casey, Jr, Monica M. CoIvin, Mark H. Drazner, Gerasimos S. Filippatos, Gregg C. Fonarow, Michael M. Givertz, Steven M. Hollenberg, JoAnn Lindenfeld, Frederick A. Masoudi, Patrick E. McBride, Pamela N. Peterson, Lynne Warner Stevenson and Cheryl Westlake

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### Appendix 1. Author Relationships With Industry and Other Entities (Relevant)—2017 ACC/AHA/HFSA Focused Update of the 2013 ACCF/AHA Guideline for the Management of Heart Failure (December 2015)

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| Javed Butler | Stony Brook University—Division Chief of Cardiology | • Bayer†  
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</table>

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| Hollenberg | Director, Coronary Care Unit, Professor of Medicine | None | None | • Abbott  
• Janssen Pharmaceuticals  
• Novartis  
• Relypsa†  
• ResMed† | None | None | 6.3, 7.3.2.10, 7.3.2.11, 7.3.3, 9.5 and 9.6. |
| JoAnn Lindenfeld | Vanderbilt Heart and Vascular Institute—Director, Advanced Heart Failure and Transplant Section—Professor of Medicine | None | None | • AstraZeneca  
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• NHLBI—INTERMACS (Co–PI) | None | None | 7.3.2.10, 7.3.2.11, 7.3.3, and 9.5. |
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ACC indicates American College of Cardiology; AHA, American Heart Association; DCRI, Duke Clinical Research Institute; DSMB, data safety monitoring board; HFSA, Heart Failure Society of America; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; PARENT, Pulmonary Artery Pressure Reduction With Entresto; UCLA, University of California, Los Angeles; and VA, Veterans Affairs.
# 2017 Heart Failure Focused Update Data Supplement

(Section numbers correspond to the 2013 full-text guideline.)

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## Key Search Terms:


## Master Abbreviation List:

1° indicates primary; 2°, secondary; ~, approximately; 6MWT, 6 min walk test; ACE, angiotensin-converting enzyme; ACEI indicates angiotensin-converting-enzyme inhibitor; ACS, acute coronary syndrome; ADHF, acute decompensated heart failure; ADHERE, Acute Decompensated Heart Failure National Registry; AF, atrial fibrillation; AHI, apnea-hypopnea index; AHQR, Agency for Healthcare Research and Quality; AIRE, Acute Infarction Ramipril Efficacy; ALLHAT, Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial; ALT, alanine aminotransaminase; AMI, acute myocardial infarction; APE, acute pulmonary embolism; ARB, angiotensin-receptor blocker; AKI/ARF, acute kidney injury/acute renal failure; ARNI, angiotensin receptor-neprilsin inhibitor; ASA, aspirin; AST, aspartate transaminase; ATLAS, Assessment of Treatment with Lisinopril and Survival; AUC, area under the curve; AV, atrioventricular; ; BEAUTIFUL, Morbidity-Mortality Evaluation of the If Inhibitor Ivabradine in Patients With Coronary Disease and
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Left-Ventricular Dysfunction; BID, twice a day; BL, baseline; BNP, plasma B-type natriuretic peptide; BP, blood pressure; bpm, beats per minute; BSA, body surface area; CABG, coronary artery bypass graft; CAD, coronary artery disease; CANPAP, Canadian Continuous Positive Airway Pressure for Patients with Central Sleep Apnea and Heart Failure Trial; CCB, calcium channel blockers; CKD, chronic kidney disease; cGMP, cyclic guanosine monophosphate; CHARM, Candesartan in Heart Failure Assessment of Reduction in Mortality and Morbidity; CHD, chronic heart disease; Cl, confidence interval; CM, contrast media; CONFIRM-HF, Ferric carboxymaltose evaluation on performance in patients with iron deficiency in combination with chronic heart failure; CONSENSUS Cooperative North Scandinavian Enalapril Survival Study; COPD, chronic obstructive pulmonary disease; CPAP, Continuous positive airway pressure; Cr, creatinine; CRT, cardiac resynchronization therapy; CSA, central sleep apnea; eTnl, cardiac troponin I; CTR, cardiothoracic ratio; CV, cardiovascular; CVA, cerebrovascular accident; CVD, cardiovascular disease; C/W, compared with; DBP, diastolic blood pressure; DM, diabetes mellitus; DOSE-AHF, Diuretic Optimization Evaluation Study; EQ-5D, EuroQoL five dimensions questionnaire; ET, Eplerenone in Mild Patients Hospitalization and Survival Study in Heart Failure; EZ-5Q, EuroQoL five dimensions questionnaire; FAIR-HF, Ferric Assessment in Patients with Iron Deficiency and Chronic Heart Failure; FCM, ferric carboxymaltose; FU, follow-up; GDEM, guideline-directed evaluation and management; GDMT, guideline-directed management and therapy; GP; HCM, high density lipoprotein; HEAAL study, effects of high-dose versus low-dose losartan on clinical outcomes in patients with heart failure; HF, heart failure; HFpEF, Heart failure with preserved ejection fraction; h/o, history of; HFref, Heart failure with reduced ejection fraction; HR, hazard ratio; hs-CRP, high sensitivity C-reactive protein; HTN, hypertension; HYVET, Hypertension in the Very Elderly Trial; ICD, implantable cardioverter defibrillator; ID, iron deficiency; IDI, integrated discrimination improvement; IHD, ischemic heart disease; IMPRESS, Comparison of Vasopressin Inhibitor, Omapatrilat, and Lisinopril on Exercise Tolerance and Morbidity; IPRESERVE, Irbesartan in Heart Failure with Preserved Ejection Fraction Study; IQR, interquartile range; ITT, intent to treat; IV, intravenous; KCCQ, Kansas City Cardiomyopathy Questionnaire; LCZ; LV, left ventricular; LVD, left ventricular dysfunction; LVEF, left ventricular ejection fraction; LVEDD; left ventricular end-diastolic dimension; LVEF, left ventricular ejection fraction; LVH, left ventricular hypertrophy; MACE, major adverse cardiac event; MI, myocardial infarction; MR-proANP, MR-proADM, MRA, mineralocorticoid receptor antagonists; MTD, maximal tolerated dose; MV, mitral valve; MWT, minute walk test; N/A, not available; NEAT-HFref, Nitrate’s Effect on Activity Tolerance in Heart Failure With Preserved Ejection Fraction; NEP, neutral endopeptidase; NNH, number needed to harm; NNT, number needed to treat; NP, natriuretic peptide; NRI, net reclassification improvement; NS, nonsignificant; NSTemi, non-ST-elevation myocardial infarction; NT-proBNP, N-terminal pro-B-type natriuretic peptide; NYHA, New York Heart Association; OCTAVE, The Omapatrilat Cardiovascular Treatment vs. Enalapril; ONTARGET, The Ongoing Telmisartan Alone and in Combination With Ramipril Global Endpoint Trial; OPTIMIZE-HF, Organized Program to Initiate Lifesaving Treatment in Hospitalized Patients with Heart Failure; OR, odds ratio; OSA, obstructive sleep apnea; OVERTURE, Omapatrilat Versus Enalapril Randomized Trial of Utility in Reducing Events; PAD, peripheral artery disease; PARADIGM-HF, Prospective Comparison of ARNI With ACE to Determine Impact on Global Mortality and Morbidity in Heart Failure; PARAMOUNT, Prospective Comparison of ARNI With ARB on Management of Heart Failure With Preserved Ejection Fraction; PAP, positive airway pressure; PCI, percutaneous coronary intervention; PCP, Primary Care Physician; PD, phosphodiesterase; PEP-CHF, Perindopril in Elderly People With Chronic Heart Failure; PGA, patient global assessment; PPM, permanent pacemaker; PSG, polysomnography; PTCa, percutaneous transluminal coronary angioplasty; PONTIAC, NT-proBNP Guided Primary Prevention of CV Events in Diabetic Patients; PRIMA, Can Pro-Brain-Natriuretic Peptide Guided Peptide Chosen to Improve Heart Failure Morbidity and Mortality?; PROTECT, PROBNP Ongoing Tailored Chronic Heart Failure Therapy; pts, patients; PVD, peripheral vascular disease; QoL, quality of life; RAAS, renin-angiotensin-aldosterone system; RAS, renin-angiotensin system; RCT, randomized controlled trial; RED-HF, Reduction of events by darbepoetin alfa in heart failure; RELAX, Phosphodiesterase-5 Inhibition to Improve Clinical Status and Exercise Capacity in Heart Failure With Preserved Ejection Fraction; ROC, receiver-operating characteristic; RR, relative risk; SBP, systolic blood pressure; SCR, serum creatinine; SERVE-HF, Adaptive Servo-Ventilation for Central Sleep Apnea in Systolic Heart Failure; SHEEP, Systolic Hypertension in the Elderly Program; SHIFT, Systolic Hypertension in the Elderly Program with the If Inhibitor Ibravadin; SIGNIFY, Study Assessing the Morbidity–Mortality Benefits of the If Inhibitor Ibravadin in Patients With Coronal Artery Disease; SOB, shortness of breath; SPRINT, Systolic Blood Pressure Intervention Trial; SR, systematic review; SSS, sick sinus syndrome; STARBRIT, The Strategies for Tailoring Advanced Heart Failure Regimens in the Outpatient Setting; STARS-BNP, Systolic Heart Failure Treatment Supported by BNP; STEMI, ST-elevation myocardial infarction; STOP-HF, St. Vincent's Screening to Prevent Heart Failure; SUPPORT, Supplemental Benefit of ARB in Hypertensive Patients With Stable Heart Failure Using Olmesartan; SURVIVE, Survival of Patients With Acute Heart Failure in Need of Intravenous Inotropic Support; TIA, transient ischemic attack; TIME-CHF, TOPCAT, Treatment of Preserved Cardiac Function Heart Failure With an Aldosterone Antagonist; TRANSCEND, the Telmisartan Randomised Assessment Study in ACE Intolerant Subjects With Cardiovascular Disease; TSAT, transferrin saturation; UA, unstable angina; UL, UPSTEP, Use of Peptides in Tailoring Heart Failure Project; VF, ventricular fibrillation; VHD, valvular heart disease VT, ventricular tachycardia; and w/o, without.

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## Data Supplement A. RCTs and Meta-analyses With Biomarkers (Section 6.3)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2° Endpoint (if any); Study Limitations; Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biomarker Studies Pertinent to Stage A / B HF Patients</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
| **PONTIAC** Huelsmann et al. 2013 (1) 23810874 | **Aim:** To assess the effectiveness of neurohumoral therapy for the prevention of cardiac events in pts with type 2 DM with increased biomarker NT-proBNP | **Inclusion criteria:** Pts with type 2 DM, age ≥18 y, elevated NT-proBNP (≥125 pg/mL) | **Intervention:** Individualized up-titration of RAS antagonists and beta blockers in addition to diabetes treatment (150), treated at cardiology clinic | **1° endpoint:** Hospitalization or death due to cardiac disease following 24 mo  
• Results: Significant reduction of 1° endpoint in intervention group (HR: 0.351; 95% CI: 0.127–0.975; p=0.044)  
| **Safety endpoint:**  
• BP was significantly reduced in both intervention and control (p<0.05); heart rate was only reduced in the intensified group (p=0.004)  
| **Study limitations:** Absence of pt randomization for treatment, pt population mainly Caucasian, statistical analysis done without adjustment of co-variates  
• Pts treated with a RAS antagonist/beta-blocker and the dosage reached higher in intensified group (p<0.0001)  
| **Adverse Events:** All-cause hospitalizations, HF hospitalizations and unplanned CV hospitalizations or death (p<0.05 reduction)  
| **STOP-HF** Ledwidge et al. 2013 (2) 23821090 | **Aim:** To establish efficacy of BNP screening and collaborative care in at-risk population in reducing newly | **Inclusion criteria:** Pts ≥40 y, and history of HTN (on meds ≥1 mo), hypercholesterolemia, obesity, vascular disease including | **Intervention:** BNP screening at BL and annually and protocol referral for BNP ≥50 pg/mL for echocardiography and collaborative care (697) | **1° endpoint:**  
• LV dysfunction (systolic: LVEF <50% or diastolic: E/E’ ratio >15) with or without newly diagnosed HF(with symptoms of HF requiring admission to  
| **Safety endpoint:**  
• Emergency hospitalizations for major MACE [40 vs. 22 (0.60 OR; 95% CI: .45-0.81; p=.002)]  
| **CV investigations more likely to be done in the intervention group with BNP levels ≥50 pg/mL  
| **Increase in RAAS agents in the**
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<table>
<thead>
<tr>
<th>Study</th>
<th>Aim</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
<th>Intervention</th>
<th>Comparator</th>
<th>1st endpoint</th>
<th>Results</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunner-La Rocca et al. 2015 (3) 26419999</td>
<td>To assess which HF pts benefit from NT-pro BNP therapy</td>
<td>Studies that included individual pt data LVEF ≤45%</td>
<td>HFrEF (1,731)</td>
<td>NT-proBNP-guided therapy and HFrEF (301)</td>
<td>Usual 1° care (677)</td>
<td>All-cause mortality and admission for HF</td>
<td>Lower mortality in HFrEF with guided treatment (HR: 0.78; 95% CI: 0.62–0.97; p=0.03).</td>
<td>Bias due to exclusion of aggregate data, Lack of specific testing for diagnosis of comorbidities, absence of comorbidity index, insufficient sample size for pts with HFrEF, treatment management aspects unaddressed and statistical tests are not powerful</td>
</tr>
<tr>
<td>Don-Wauchope et al. 2015 (4) 25448029</td>
<td>Review evidence of SRs regarding utility of NPs in clinical practice.</td>
<td>SRs that authors were aware of through their participation in an AHRQ comparative effectiveness review.</td>
<td></td>
<td>NP-guided therapy</td>
<td>Clinically-guided care</td>
<td>8 SRs assessed all-cause mortality and “generally found there was a benefit.”</td>
<td>Underlying SRs largely comprised analysis of the same RCTs.</td>
<td>Results were qualitative.</td>
</tr>
</tbody>
</table>
### Xin W. et al. 2015 (5) 24888383

**Aim:** To assess the effects of NP-guided treatment of chronic HF on outcomes  
**Study type:** Meta-analysis  
**Size:** 14 studies, 3,004 pts

<table>
<thead>
<tr>
<th>Exclusion criteria:</th>
<th>Inclusion criteria:</th>
<th>Intervention:</th>
<th>1st endpoints:</th>
<th>1st Safety endpoint:</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>Prospective RCTs with adult HF pts comparing the effects of BNP or NT-proBNP-guided therapy with clinically guided therapy</td>
<td>BNP or NT-proBNP-guided therapy (1,503)</td>
<td>• All-cause mortality, HF hospitalization, all-cause hospitalization, safety (adverse events)</td>
<td>• NP-guided therapy was not associated with increased risk for serious adverse events.</td>
</tr>
</tbody>
</table>

**Comparator:** Clinically guided therapy (1,501)

**Results:**  
- Compared with clinical group, BNP-guided treatment significantly decreased the risk of HF-related hospitalization (RR: 0.79; 95% CI: 0.63–0.98; p=0.03), although did not significantly affect the risk of all-cause mortality (RR: 0.94, 95% CI: 0.81–1.08, p=0.39) or all-cause hospitalization (RR: 0.97; 95% CI: 0.89–1.07; p=0.56).

### Troughton RW et al. 2014 (6) 24603309

**Aim:** To assess the effects of NP-guided treatment of chronic HF on outcomes  
**Study type:** Meta-analysis  
**Size:** 9 reviews

<table>
<thead>
<tr>
<th>Exclusion criteria:</th>
<th>Inclusion criteria:</th>
<th>Intervention:</th>
<th>1st endpoint:</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>RCTs reporting all-cause mortality and comparing BNP-guided treatment of HF with clinically guided treatment and 1 study (PROTECT trial) that did not</td>
<td>BNP-guided therapy (1,006)</td>
<td>All-cause mortality</td>
</tr>
</tbody>
</table>

**Comparator:** Clinically guided therapy (994)

**Results:**  
- All-cause mortality was significantly reduced by NP-guided treatment [HR: 0.62 (0.45–0.86); p=0.004]  
- HF hospitalizations were reduced in the NP-guided group, compared with clinically guided pts [HR: 0.80 (0.67–0.94); p=0.009] as were CV admissions [HR: 0.82 (0.67–0.99); p=0.048]  
- Each of the included RCTs was relatively small and 2 trials did not
<table>
<thead>
<tr>
<th>Authors (Year)</th>
<th>Aim</th>
<th>Study type</th>
<th>Size</th>
<th>Inclusion Criteria</th>
<th>Intervention</th>
<th>1st endpoint</th>
<th>Results</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>De Vecchis et al. 2014 (7)</td>
<td>To assess the effects of NP-guided treatment of chronic HF on outcomes</td>
<td>Meta-analysis</td>
<td>6 studies, 1,775 pts</td>
<td>RCT to a strategy of titrating drug therapy based on the level of a circulating NP (BNP or NT-proBNP) compared to clinical conventional criteria, and they reported all-cause mortality. Should have included &gt;60 pts and its follow-up should have been longer than 90 d.</td>
<td>BNP or NT-proBNP-guided therapy</td>
<td>Combined endpoint of all-cause mortality and HF hospitalization</td>
<td>NP-guided therapy for outpatients with HF was shown to be associated with a decreased risk of death and HF hospitalizations (OR: 0.64; 95% CI: 0.43–0.95; p=0.026)</td>
<td>Each of the included RCTs was relatively small</td>
</tr>
<tr>
<td>Balion et al. 2014 (8)</td>
<td>To assess the effects of NP-guided treatment of chronic HF on outcomes</td>
<td>SR</td>
<td>9 RCTs; 2,104 pts</td>
<td>Meta-analysis was not done due to study heterogeneity.</td>
<td>BNP or NT-proBNP-guided therapy (1,503)</td>
<td>Clinically guided therapy (1,501)</td>
<td>Review: Overall, there was a wide variation in study design and how parameters were reported including pt selection, BL characteristics, therapy goals, BNP/NT-proBNP cutpoint, and outcome types. The strength of evidence for the outcome of mortality, reported in 7 studies, was found to be low due to inconsistency and</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Exclusion criteria: For 2 studies, data from the 3rd ('usual care') groups were not included.
### Savarese et al. 2013

**Aim:**
To determine whether NP-guided (BNP or NT-proBNP) therapy, compared to clinically guided therapy, improves outcomes

**Study type:**
Meta-analysis

**Size:**
12 trials enrolling 2,686 participants (730 in BNP, 1,956 in NT-proBNP related trials)

**Inclusion criteria:**
All randomized trials reporting clinical endpoints (all-cause mortality and/or HF related hospitalization and/or all-cause hospitalization) with comparison of BNP or NT-proBNP guided therapy vs. a control group in chronic HF pts

**Intervention:**
- BNP-guided therapy: BNP-guided: 373
- NT-proBNP guided: 872

**Comparator:**
Clinically guided therapy
- BNP group control 357
- NT-proBNP group control 1,084

**1° endpoints**
- All-cause mortality, all-cause hospitalization, HF hospitalization

**Results:**
NP-guided therapy (either BNP or NT-proBNP) significantly reduced all-cause mortality (OR: 0.738; 95% CI: 0.596–0.913; p=0.005) and HF related hospitalization (OR: 0.554; 95% CI: 0.399–0.769; p=0.000), but not all-cause hospitalization (OR: 0.803; 95% CI: 0.629–1.024; p=0.077)

- When separately assessed, NT-proBNP-guided therapy reduced all-cause mortality (OR: 0.717; 95% CI:0.563–0.914; p=0.007) and HF hospitalization (OR: 0.531; 95% CI: 0.347–0.811; p=0.003), but not all-cause hospitalization (OR: 0.779; CI:0.414–1.465; p=0.438), whereas BNP-guided therapy did not significantly reduce all-cause mortality (OR: 0.814; CI:0.518–1.279; p=0.371), HF related hospitalization (OR: 0.599; 95% CI: 0.303–1.187; p=0.14) or all-cause hospitalization (OR: 0.726; 95% CI:0.509 – 1.035; p=0.077)

- Analysis from 3 trials showed the composite outcome of all-cause mortality and HF hospitalization was significantly reduced by NP-guided therapy in younger pts (≤75 y) (OR: 0.449; 95% CI: 0.207–0.973; p=0.043), but not in older pts (>75 y) (OR: 0.800; 95% CI: 0.423–1.513; p=0.5).

### Li et al. 2013

**Aim:**
To assess the effects of NP-guided treatment of chronic HF on all-cause mortality and HF hospitalization

**Inclusion criteria:**
Studies with >40 pts and involved comparison of BNP-guided vs. guideline-guided drug therapy of the pts with chronic HF in the outpatient

**Intervention:**
BNP-guided therapy

**Comparator:**
Clinically guided therapy

**1° endpoint:**
- Combined end point of all-cause mortality and HF hospitalization

**Results:**
Significantly decreased risk of all-cause mortality (RR: 0.83; 95% CI: 0.69–0.99; p=0.035; and HF

- In the subgroup analysis, HF rehospitalization was significantly decreased in the pts <70 y (RR: 0.45; 95% CI: 0.33–0.61; p=0.000; or with BL higher BNP (≥2114 pg/mL) (RR: 0.53; 95% CI: 0.39–0.72; p=0.000)
### Study type: Meta-analysis
**Size:** 11 studies, 2,414 pts

#### Inclusion criteria
Prospective RCTs of pts with chronic HF randomized pts to a strategy of titrating medical therapy based on the level of a circulating biomarker compared to a parallel control group, reporting all-cause mortality.

#### Intervention:
BNP-guided therapy

#### Comparator:
Clinically guided therapy

#### 1° endpoint:
- All-cause mortality

Results: Significant mortality advantage for biomarker-guided therapy (HR: 0.69, 95% CI: 0.55–0.86) compared to control.

- In pts <75 y, all-cause mortality was significantly lower in the BNP-guided group (RR: 0.52; 95% CI: 0.33–0.82; p=0.005).
- No reduction in mortality with BNP-guided therapy in pts ≥75 y (RR: 0.94; 95% CI: 0.71–1.25; p=0.70).
- All-cause hospitalization and survival free of any hospitalization was not significantly different between groups (RR: 0.82; 95% CI: 0.64–1.05; p=0.12 and RR: 1.07; 95% CI: 0.85–1.34; p=0.58, respectively).
- Additional % pts achieving target doses of ACE-inhibitors and beta blockers 21% and 22% in the BNP group and 11.7% and 12.5% in the control group, respectively.

### RCTs of NP Guided Therapy in HF

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| **Aim:** To assess the effects of NT-proBNP-guided treatment of chronic HF on outcomes |
| **Study type:** RCT |
| **Size:** 69 pts |
| **Inclusion criteria:** Ambulatory pts with LVEF <40% and symptomatic HF (NYHA II-IV) |
| **Exclusion criteria:** Pts with unknown LVEF |
| **Follow up:** Minimum 6 mo (median 9.5 mo) |
| **Intervention:** (NT-pro)BNP-guided therapy with a target of NT-proBNP level <200 pmol |
| **Comparator:** Standardized clinical assessment (clinical group) |
| **1st endpoints:** • Death, CV hospitalization and outpatient HF event |
| **Results:** • Fewer CV events (death, hospitals, or HF decompensation) in the NT-proBNP group than in the clinical group (19 vs. 54; p=0.02) • At 6 mo, 27% of pts in the BNP group and 53% in the clinical group had experienced a first CV event (p=0.034). • Changes in LVEF, QoL, renal function, and adverse events were similar in both groups. • N-BNP-guided treatment of HF reduced total CV events, and delayed time to first event compared with intensive clinically guided treatment. • NP was reduced significantly and NP guidance changed therapy |

| **Aim:** To evaluate the prognostic impact of a therapeutic strategy using plasma BNP |
| **Study type:** RCT |
| **Size:** 220 pts |
| **Inclusion criteria:** Ambulatory NYHA class II to III pts considered optimally treated |
| **Exclusion criteria:** N/A |
| **Follow up:** median 15 mo |
| **Intervention:** BNP-guided therapy Target: BNP <100 pg/mL |
| **Comparator:** Medical treatment according to either current guidelines (clinical group) |
| **1st endpoint** • HF-related death or hospital stay for HF |
| **Results:** • Mean dosages of ACE inhibitors and beta blockers significantly higher in the BNP group (p<0.05), • BNP-guided strategy reduced the risk of HF related death or hospital stay for HF (24% vs. 52%, p<0.001), mainly obtained through an increase in ACE inhibitor and beta blocker dosages. • NP guidance changed therapy • Unknown whether BNP-guided therapy resulted in reduction in BNP levels |

<p>| <strong>Aim:</strong> To compare 18-mo outcomes of N-terminal BNP-guided vs. symptom guided HF therapy |
| <strong>Inclusion criteria:</strong> Ambulatory HF pts 60 y with systolic HF (LVEF ≤45%), NYHA class of II or greater, prior HF hospitalization within |
| <strong>Intervention:</strong> Up titration of guideline-based treatments to BNP level of ≤2 times of UL (BNP-guided therapy) |
| <strong>Targets:</strong> |
| <strong>1st endpoints:</strong> • 18 mo survival free of all-cause hospitalizations |
| <strong>Results:</strong> • N-terminal BNP and • Survival free of hospitalization for HF was higher among those in the N-terminal BNP-guided group (72% vs. 62%, respectively; HR: 0.68 [95% CI: 0.50–0.92]; p=0.01). • N-terminal BNP-guided therapy |</p>
<table>
<thead>
<tr>
<th>Study type</th>
<th>Size</th>
<th>Inclusion criteria</th>
<th>Intervention</th>
<th>Comparator</th>
<th>1° endpoints</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT</td>
<td>499 pts</td>
<td>1 y, and N-terminal BNP level of ≥2 times the upper limit of normal.</td>
<td>NT-proBNP &lt;400 pg/mL if age &lt;75 y, NT-proBNP &lt;800 pg/mL if 75 y</td>
<td>symptom-guided therapy resulted in similar rates of survival free of all-cause hospitalizations (41% vs. 40%, respectively; HR: 0.91 [95% CI: 0.72–1.14]; p=0.39)</td>
<td>• BNP guidance changed therapy (higher doses of ACE inhibitors, ARB, Beta blockers and higher use of spironolactone)</td>
<td>• NT-ProBNP levels were not different between groups</td>
</tr>
</tbody>
</table>

**BATTLESCARRED**  
Laichbury et al. 2009 (16)  
20117364  
Aim: to compare the effects of NT-proBNP-guided therapy with those of intensive clinical management and with usual care  
Study Type: RCT (Australia hospitals)  
Size: 364 pts  
Inclusion criteria: Pts admitted to a single hospital with HF, NT-proBNP >50 pmoL/l or 400 pg/mL (included HFpEF)  
Intervention: Outpatient post d/c therapy guided by NT-proBNP levels  
Target: NT-proBNP <150 pmoL/l (1,270 pg/mL)  
Comparators: Therapy guided by intensive clinical management, or according to usual care  
1° endpoints: Mortality  
Results: 1-y mortality was less in both the hormone (9.1%) and clinically-guided (9.1%) groups compared with usual care (18.9%; p=0.03)  
• 3 y mortality was selectively reduced in pts ≤75 y receiving hormone guided treatment (15.5%) compared with either clinically managed treatment (30.9%; p=0.048) or usual care (31.3%; p=0.021).  
• NP guidance changed therapy  
• NT-ProBNP levels were not different between groups |

**Berger et al. 2010 (17)**  
20170790  
Aim: To investigate whether the addition of NT-proBNP-guided, intensive pt management to multidisciplinary care improves outcome in pts following hospitalization due to HF  
Study Type: RCT (Australia hospitals)  
Size: 364 pts  
Inclusion criteria: Pts admitted to a hospital with HF, NYHA III or IV on admission, Cardiothoracic Index>0.5 or LVEF <40%  
Intervention: Outpatient post discharge discontinue  
• BM: NT-proBNP-guided, intensive up-titration of medication by HF specialists in high-risk pts.  
• Target: NT-proBNP (<2,200 pg/mL)  
Comparators  
• Multidisciplinary care: 2 consultations from an HF  
1° endpoints: Hospitalization  
Results:  
• Pt management reduced HF hospitalization (488 D) compared with the multidisciplinary care (1254 D) and usual care (1,588 d) groups (p<0.0001)  
• Combined end point of death or HF rehospitalization was lower  
• NT-ProBNP levels were not different between groups: Pt management group had the highest proportion of RAAS inhibition triple-therapy  
• Death rate was similar between the pt management (22%) and multidisciplinary care groups (22%), but was lower compared with the usual care group (39%; vs. pt management: p<0.02; vs. multidisciplinary care: p<0.02)
| Study Type: RCT (8 Viennese hospitals) | Inclusion criteria: specialist-therapeutic recommendations and home care by a HF nurse  • Usual care  • NT-ProBNP levels were lowered in guided pt management arm | Size: 278 pts | PRIMA Eurlings et al. 2010 (18) 21144969 | Aim: To assess whether management by an individualized NT-proBNP target would lead to improved outcome compared with HF management guided by clinical assessment alone | Intervention: | 1° endpoints: Number of d alive outside the hospital after index | Companors: Clinically-guided outpatient management (n=171) | Results: Management guided by NT-proBNP target did not significantly improve the 1° endpoint p=0.49)  • In the NT-proBNP-guided group mortality was lower, as 46 pts died (26.5%) vs. 57 (33.3%) in the clinically guided group, but this was not statistically significant (p=0.21)  • Individualized NT-proBNP target increased the use of HF medication (p=0.006) |
| Study Type: RCT | Inclusion criteria: Hospitalized HF pts with for decompensated, symptomatic HF with NT-proBNP levels >1,700 pg/mL at admission (included HfPEF) | Size: 345 pts | SIGNAL HF Trial Persson et al. 2010 (19) 20876734 | Aim: To investigate if NT-proBNP-guided therapy in HF pts in 1° care would improve clinical outcomes over and above treatment according to guidelines | Intervention: After discharge discontinue out pt management guided by an individually set NT-proBNP (n=174) defined by the lowest level at discharge or 2 wk thereafter. | 1° endpoints: Composite endpoint of d alive, d out of hospital and symptom score | Results: There were no differences between the groups concerning either the 1° endpoint (p=0.28) or its components (CV death, p=0.93; CV hospitalization, p=0.88; or symptom score, p=0.28)  • Treatment doses of beta blockers and RAS blockers were markedly increased towards target doses a similar degree in both groups |
## 2017 Heart Failure Focused Update Data Supplement

<table>
<thead>
<tr>
<th>Study</th>
<th>Size</th>
<th>Inclusion criteria</th>
<th>Intervention</th>
<th>1° endpoints</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STARBRITE Trial</strong></td>
<td>252 pts</td>
<td>Hospitalized HF pts with LEVF ≤35%</td>
<td>Outpatient post discharge BNP and clinical assessment guided therapy</td>
<td>Composite endpoint of d alive and d out of hospital,</td>
<td>No significant difference HR: 0.72; 95% CI: 0.41–1.27; p=0.25</td>
</tr>
<tr>
<td>Shah et al. 2011 (20) 21807321</td>
<td></td>
<td>Serum creatinine &gt;3.5 mg/dL and ACS</td>
<td>Comparator: Clinical assessment alone.</td>
<td></td>
<td>• Change in serum creatinine, or change in SBP not different</td>
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<tr>
<td></td>
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<td></td>
<td>• BNP strategy pts received significantly more ACE inhibitors, beta blockers</td>
</tr>
<tr>
<td><strong>PROTECT Study</strong></td>
<td>130</td>
<td>Chronic HF pts with LV systolic dysfunction</td>
<td>Management guided by NT-proBNP with a goal to lower NT-proBNP ≤1000 pg/mL over 10 mo</td>
<td>Total CV events in 2 age categories 75 and ≥75 y</td>
<td>Pts ≥75 y with NT-proBNP management had lowest rate of CV events (1.76 events per pt with standard of care vs. 0.71 events per pt with NT-proBNP guide, p=0.03)</td>
</tr>
<tr>
<td>Gaggin et al. 2012 (21) 22858078</td>
<td></td>
<td></td>
<td>Comparator: Standard of care</td>
<td></td>
<td>• Improvement in QoL, LVEF, and indices of LV volume with guided approach</td>
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<td></td>
<td>• NP guidance changed therapy: greater use of aldosterone antagonists and lesser use of loop diuretics in the guided therapy group (no difference in ACE inhibitors or beta blockers)</td>
</tr>
<tr>
<td><strong>UPSTEP-study group</strong></td>
<td>151</td>
<td>Ambulatory HF NYHA II-IV, LVEF &lt;40% and elevated BNP levels</td>
<td>BNP-guided (BNP) with a goal &lt;150 or 300 ng/L for elderly</td>
<td>Combined death and worsening/hosp for HF</td>
<td>Pts with &gt;30% decrease in BL BNP value vs. nonresponders.</td>
</tr>
<tr>
<td>Karlstrom et al. 2011 (22) 21715446</td>
<td></td>
<td></td>
<td>Comparator: Conventional (CTR) HF treatment</td>
<td></td>
<td>No differences for d out of hospital, and younger vs. elderly.</td>
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<td></td>
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<td></td>
<td>• Subgroup analysis: improved survival (p&lt;0.0001 for the 1° outcome) among responders with &gt;30% decrease in BL BNP value vs. nonresponders.</td>
</tr>
</tbody>
</table>
| Study Type: Multicenter RCT-probe design | Size: 279 | **Aim:** To validate and characterize the use of BNP in the diagnosis of HF in pts with dyspnea | **Study type:** Prospective, blinded, diagnostic accuracy study | **Size:** 1,856 | **Inclusion criteria:** Pts who came to the emergency department with acute dyspnea  
**Exclusion criteria:** Age <18 y and those whose dyspnea was clearly not secondary to HF (i.e., those with trauma or cardiac tamponade), acute myocardial infarction, unstable angina, or renal failure | **Intervention:** Comparisons of BNP values among diagnostic groups including HF and non HF pts  
**Comparator:** Non-HF pts such as pulmonary disease, cor pulmonale | **1st endpoint:** Diagnostic accuracy of BNP at a cutoff of 100 pg/mL was 83.4%. The negative predictive value of BNP <50 pg/mL was 96%.  
**Secondary endpoint:** In multiple logistic-regression analysis, measurements of BNP added significant independent predictive power to other clinical variables in models predicting which pts had HF. | **van Kimmenade et al. 2006 (24) 16860029** | **Aim:** To analyze the role of NT-pro-BNP in diagnosis of HF in pts presenting with dyspnea, the so-called natriuretic peptide gray zone. NT-pro-BNP concentrations, clinical characteristics, and 60-d mortality were studied in acutely dyspneic pts from an international | **Inclusion criteria:** Acutely dyspneic pts  
**Exclusion criteria:** With trauma or cardiac tamponade), acute myocardial infarction, unstable angina, or renal failure | **Intervention:** Comparisons of NT-pro-BNP among diagnostic groups including HF and non-HF pts  
**Comparator:** Non-HF pts such as pulmonary disease, cor pulmonale | **1st endpoint:** Subjects with HF and diagnostically elevated NT-pro-BNP concentrations had the highest mortality rates, subjects without HF and NT-pro-BNP concentrations < 300 ng/L had the lowest mortality rates, and subjects with gray-zone NT-pro-BNP had intermediate outcomes, irrespective of their final diagnoses.  
**Secondary endpoint:** Adding specific clinical information to NT-pro-BNP improves diagnostic accuracy in subjects with intermediate NT-pro-BNP concentrations. Mortality rates in subjects with intermediate NT-pro-BNP concentrations are lower than in those with NT-pro-BNP concentrations diagnostic for HF but are higher than in subjects with NT-pro-BNP concentrations less than the gray zone. | **Maisel et al. 2002 (23) 12124404** | **© 2017 American College of Cardiology Foundation, the American Heart Association, Inc., and the Heart Failure Society of America.** |
### Maisel et al. 2004 (25) 15364340

**Aim:** To examine the relationships among BNP levels and HF severity, clinical decision making, and outcomes

**Study type:** Multicenter, prospective, blinded, diagnostic accuracy study

**Size:** 464

**Inclusion criteria:** Pts over the age of 18 y presenting to the ED with HF and who received treatment in the ED or hospital admission for HF were included.

**Exclusion criteria:** Current MI or ACS with ST-segment deviation of ≥1 mm, renal failure requiring dialysis, or pts with a baseline BNP concentration of ≤100 pg/mL were excluded

**Intervention:** Physicians were blinded to the actual BNP level and subsequent BNP measurements.

**Comparator:** Comparison between severity of HF determined by physicians or BNP and outcomes

**1st endpoint:** ED doctor's intention to admit or discharge a pt had no influence on 90-d outcomes, while the BNP level was a strong predictor of 90-d outcome. The 90-d combined event rate (HF visits or admissions and mortality) in the group of pts admitted with BNP <200 pg/mL and >200 pg/mL was 9% and 29%, respectively (p=0.006).

- In pts presenting to the ED with HF, there is a disconnect between the perceived severity of HF by ED physicians and severity as determined by BNP levels. The BNP levels can predict future outcomes and thus may aid physicians in making triage decisions about whether to admit or discharge pts. Emerging clinical data will help further refine biomarker-guided outpatient therapeutic and monitoring strategies involving BNP.

### O'Connor et al. 2010 (26) 20185037

**Aim:** To identify high-risk HF pts at hospital discharge

**Study type:** Predictive modeling using variables obtained during hospitalization in the ESCAPE trial

**Derivation cohort:** ESCAPE trial, n=423

**Validation cohort:** FIRST trial, n=471

**Inclusion criteria:** Hospitalized with severe HF, LVEF ≤30%, SBP ≤125 mmHg.

**Exclusion criteria:** Creatinine >3.5 mg/dL, prior inotrope use

**Validation cohort:**

**1st endpoint:**
- 6-mo mortality and death or rehospitalization rates (64%)
- Multivariate discharge predictors of death included: BNP, per doubling (HR: 1.42), cardiac arrest or mechanical ventilation, yes/no (HR: 2.54), BUN, per 20 mg/dL increase (HR: 1.22) and sodium, per unit mEq/L increase (HR: 0.93)

- A simplified discharge score discriminated mortality risk from 5% (score=0) to 94% (score=8).

- Bootstrap validation demonstrated good internal validation for the model (c-index 0.78)

- Limitations: ESCAPE represented pts with severe LV dysfunction and advanced symptoms (not the general population of acute HF) managed at experienced centers; exclusion of pts with characteristics
known to be associated with worse outcomes (e.g., creatinine >3.5 mg/dL, requiring inotropes)

Search Terms and Date: natriuretic peptides, heart failure, human, last 5 years. Last search done on April 18, 2016.

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Primary Endpoint and Results (P values, OR or RR &amp; 95% CI)</th>
<th>Summary / Conclusion / Comments</th>
</tr>
</thead>
</table>
| Bayés-Genís et al. 2005 (27) 15948093 | Aim: Percentage of NT-proBNP reduction during admission and its prognostic significance  
Study type: NR  
Size: 74 pts | Inclusion criteria: Pts diagnosed with acute HF in emergency department and who had follow-up evaluation for 6 & 12 mo after admission  
Follow up: 12 mo | 1° endpoints:  
- Percent reduction in NT-proBNP and its association with CV mortality  
Results:  
- The area under the ROC curve for % NT-proBNP reduction to predict CV death was 0.78 (95% CI: 0.66–0.90; p=0.002)  
- 30% NT-proBNP reduction percentage cutoff value had 75% accuracy for the identification of high-risk pts and was the only variable that was associated with CV death in multivariate analysis (OR: 4.4; 95% CI: 1.12–17.4; p=0.03).  
- Study relatively old and small |
| Verdiani et al. 2008 (28) 18545069 | Aim: To evaluate the prognostic significance of NT-proBNP % reduction during ADHF  
Study type: Prospective cohort  
Size: 120 pts | Inclusion criteria: Pts consecutively admitted with ADHF  
Follow up: 6 mo | 1° endpoint  
- Percent reduction in NT-proBNP and its association with CV mortality  
Results:  
- In ROC, the mean AUC for NT-ProBNP % reduction was 0.63 (95% CI: 0.51–0.75; p=0.04) for the composite endpoint (death or readmission), and 0.81 (95% CI: 0.65–0.97, p=0.01) for CV mortality at risk of events.  
- NT-ProBNP reduction percentage <30% was the best cut off for the identification of pts  
- Study relatively old and small |
<table>
<thead>
<tr>
<th>Study</th>
<th>Aim</th>
<th>Inclusion criteria</th>
<th>1° endpoints</th>
<th>Results</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Bettencourt et al. 2004 (29) 15451800</td>
<td>To compare 18 mo outcomes of NT-BNP-guided vs. symptom guided HF therapy</td>
<td>Consecutive ADHF pts defined by ESC or Framingham criteria</td>
<td>Death or readmission</td>
<td>• Pts were classified into 3 groups: (1) decreasing NT-proBNP levels by at least 30% (n=82), (2) no significant modifications on NT-proBNP levels (n=49), and (3) increasing NT-proBNP levels by at least 30% (n=25).</td>
<td>• Among the 64 pts discharged without volume overload, a positive association between change in NT-proBNP and outcome was observed (HR: 2.66; 95% CI: 0.77–9.18 for change &lt;30%; HR: 16.04; 95% CI: 9.49 – 52.02 for increase ≥30% compared with those with decreasing NT-proBNP by at least 30%.)</td>
</tr>
<tr>
<td></td>
<td>Study type: Prospective cohort single center study</td>
<td>Follow up: 6 mo</td>
<td>• Pts demonstrating a ≥30% increase in NT-proBNP levels during the course of their admission had the most adverse prognosis</td>
<td>• Study relatively old and small</td>
<td></td>
</tr>
<tr>
<td>Kociol et al. 2013 (30) 23250981</td>
<td>Examine relationship between markers of decongestion and symptom relief and clinical outcomes</td>
<td>Pts enrolled in DOSE-AHF</td>
<td>Time to death, first rehospitalization or emergency department visit</td>
<td>• Of the weight loss, fluid loss, and NT-proBNP reduction, only % reduction in NT-proBNP was significantly associated with symptom relief (r=0.13; p=0.04). • Reduction in NT-proBNP Associated with better outcome (NT-proBNP HR: 0.95; 95% CI: 0.91–0.99 per 10% reduction).</td>
<td>• Favorable changes in each of the 3 markers of decongestion were associated with improvement in time to death, rehospitalization, or emergency department visit at 60 d</td>
</tr>
<tr>
<td>Kociol et al. 2011 (31) 21743005</td>
<td>To examine if admission, discharge, or change from admission to discharge BNP measure is the most important predictor of long-term outcomes</td>
<td>Linked pts ≥65 y of age from hospitals in OPTIMIZE-HF to Medicare claims</td>
<td>The discharge BNP had the best performance and was the most important characteristic for predicting 1 y mortality (HR for log transformation: 1.34; 95% CI: 1.28–1.40) and 1 y death or rehospitalization (HR: 1.15; 95% CI: 1.12–1.18).</td>
<td>• Compared with a clinical variables, discharge BNP model improved risk reclassification and discrimination in predicting each outcome (1 y mortality: NRI: 5.5%, p&lt;0.0001; IDI: 0.023, p&lt;0.0001; 1-y mortality or rehospitalization: NRI: 4.2%, p&lt;0.0001; IDI: 0.010, p&lt;0.0001)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Study type: retrospective analysis of the RCT, DOSE-AHF</td>
<td>Follow up: 1 y</td>
<td>• Study relatively old and small</td>
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<tr>
<td>Study type:</td>
<td>Retrospective analysis – from OPTIMIZE HF Trial</td>
<td></td>
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<tr>
<td>Size:</td>
<td>7,039 pts</td>
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</table>

**Aim:** To examine if admission, discharge, or change from admission to discharge BNP measure is the most important predictor of outcomes

**Study type:** Retrospective analysis from VA database

**Size:** 109,875 pts

| Inclusion criteria: | All hospital discharges with a 1° diagnosis of HF in the Veterans Affairs Health Care System from 2006 to 2009. |
| **Follow up:** | 30 d |

**1° endpoints:**
- 30 d readmission rate for HF

**Results:**
- 30 d HF readmission was associated with elevated admission BNP, elevated discharge BNP, and smaller percent change in BNP from admission to discharge.
- Pts with a discharge BNP ≥1,000 ng/L had an unadjusted 30 d HF readmission rate over 3 times as high as pts whose discharge BNP was ≤200 ng/L (15% vs. 4.1%).
- Discharge BNP had the greatest effect (C-statistic, 0.639–0.664 [p<0.0001]; NRI, 9% [p<0.0001]).
- Large sample size

| Study type: | Individual pt data meta-analyses of prospective cohort studies |
| Size: | 1,301 pts |

| Inclusion criteria: | Pts from 7 prospective cohorts with pts admitted because of clinically validated ADHF, discharged alive, and NT-proBNP measurements available at admission and at discharge |
| **Follow up:** | 180 d |

| 1° endpoints: | All-cause mortality and a composite of all-cause mortality and/or first readmission for CV reason within 180 d after discharge |

**Results:**
- NT-proBNP levels at discharge and the changes in NT-proBNP during hospitalization yielded the best C-statistic (AUC: 0.78; 95% CI: 0.74–0.82).
- In pts hospitalized for ADHF, the addition of the discharge NT-proBNP values as well as the change in NT-proBNP to known risk markers, generates a relatively simple yet robust discharge risk score that importantly improves the prediction of adverse events
<table>
<thead>
<tr>
<th>Reference</th>
<th>Aim</th>
<th>Study type</th>
<th>Size</th>
<th>Inclusion criteria</th>
<th>1st endpoints</th>
<th>Results</th>
<th>Study size and age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen-Solal et al. 2009 (34)</td>
<td>Examine whether decreases in BNP levels during the first few d of hospitalization were associated with greater survival in pts with ADHF</td>
<td>Retrospective analysis of SURVIVE</td>
<td>1,327 pts</td>
<td>Of 1,327 SURVIVE pts, this analysis included 1,038 who had BNP samples at both BL and d 5</td>
<td>All-cause mortality and a composite of all-cause mortality and/or first readmission for CV reason within 180 d after discharge</td>
<td>A pt was classified as a &quot;responder&quot; if the follow-up BNP level was ≥30% lower than BL BNP. Short-term 30 d mortality risk reduction was 67% in d 5 BNP responders compared with nonresponders, whereas long-term (180-d) all-cause mortality risk reduction was 47%</td>
<td>Study relatively old and small</td>
</tr>
<tr>
<td>Logeart et al. 2004 (35)</td>
<td>To determine the value of BNP predicting post-discharge outcome of pts admitted for ADHF</td>
<td>Prospective cohort</td>
<td>105 pts</td>
<td>Serial BNP measurements were performed from admission to discharge in 2 samples of consecutive pts</td>
<td>Combined death or first re-admission for HF</td>
<td>The predischarge BNP assay had the best discriminative power (AUC for ROC=0.80) and remained the lone significant variable in multivariate analysis (HR: 1.14; 95% CI: 1.02–1.28; p=0.027). High predischarge BNP assay is a strong, independent marker of death or readmission after decompensated HF, more relevant than common clinical or echocardiographic parameters and more relevant than changes in BNP levels during acute cares.</td>
<td>Study relatively old and small</td>
</tr>
<tr>
<td>O'Brien et al. 2003 (36)</td>
<td>To determine the value of BNP predicting post-discharge outcome of pts admitted for ADHF</td>
<td>Prospective cohort</td>
<td>96 pts</td>
<td>NT-proBNP was measured at admission in 96 pts hospitalized with acute LVF</td>
<td>Combined death or HF</td>
<td>Only pre-discharge plasma NT-proBNP (OR: 15.30; 95% CI: 1.4–168.9], p=0.026) was independently predictive of the composite endpoint. The AUC ROC curve for pre-discharge NT-proBNP was superior to that for admission NT-proBNP for prediction of death or HF (AUC ROC 0.87 cf 0.70), for death (0.79 cf 0.66), LVF hospitalization (0.78 cf 0.70) or HF as an outpatient (0.71)</td>
<td>Plasma NT-proBNP measured pre-discharge provides useful prognostic information following hospitalization with acute LVF. Study relatively old and small</td>
</tr>
<tr>
<td>Study Type</td>
<td>Inclusion criteria</td>
<td>1st Endpoint</td>
<td>Results</td>
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</table>
| Richards et al. 2001 (37) 11401111 | Ischemic CM, EF<45%, chronic stable CHF, NYHA II-III or prior II–IV | Association of plasma N-BNP and adrenomedullin with mortality and HF events at 18 mo | - Above median proBNP increased risk of mortality (HR: 4.7; CI 2–10.9) and HF admission (HR: 4.7; CI: 2–10)  
- Above median adrenomedullin increased risk of mortality (HR 3.9,CI 1.8-8.7) and HF admission (HR 2.4, CI 1.3-4.5)  
- Associations persist in multivariable modeling  
- NT-proBNP and adrenomedullin levels are independently associated with outcome in pts with heart failure from an ischemic cardiomyopathy |
| Tang et al. 2003 (38) 14662703      | Chronic systolic HF >3 mo duration, stable medical therapy, LVEF<50%, NYHA class I-III, followed in outpatient HF clinic at a single center who had BNP obtained at clinic visit | Prevalence, clinical characteristics, and characteristics of a BNP<100 pg/mL in a HF clinic population | - 21% of symptomatic HF pts had BNP <100 pg/mL  
- Characteristics associated with this phenotype include younger age, female gender, nonischemic etiology, better preserved cardiac and renal function, less have atrial fibrillation  
- A sizeable minority (21%) of ambulatory pts with chronic HF have a BNP <100 pg/mL  
- This phenotype (HF with non-diagnostic BNP) is associated with identifiable clinical characteristics |
| Januzzi et al. 2008 (39) 18243855   | Studies using NT-proBNP assays used commercially                                  | N/A                                                                           | - NT-proBNP testing can help with the diagnosis and triage of the patients with acute dyspnea.  |

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### Santaguida et al. 2014

**Study type:** Systematic review  
**Size:** 7 publications included  
**Inclusion criteria:** Study assessing incremental value of BNP or NT-proBNP for predicting morbidity and mortality in acute decompensated HF  
**Exclusion criteria:** Studies of stable HF; natriuretic peptide could not be included in base model to allow assessment of incremental value  

**1° endpoint:** BNP or NT-proBNP improved prognostic model performance for mortality as assessed by discrimination and or likelihood statistics  

**Results:**  
- 5 BNP publications consistently predicted all-cause mortality in short (3–6 mo) and long (9,12 mo) beyond base model but not all statistically significant  
- Two NT-proBNP publications both showed incremental value at 22 mo and 6.8 y with 1 being statistically significant  

- Clinical heterogeneity precluded formal meta-analysis

### Hill et al. 2014

**Study type:** Systematic review  
**Size:** 76 publications included (37 BNP alone, 25 NT-proBNP alone, 14 both)  
**Inclusion criteria:**  
- Age >18 y presenting to ED or urgent care center with signs/symptoms suggestive acute HF  
- English language articles from 1989-2012  
- FDA-approved assays  

**Exclusion criteria:**  
- Studies with pts who had conditions that may impact NP levels (transplant, HCM, valvular)  

**1° endpoint:** Test performance characteristics  

**Results:**  
- BNP pooled sensitivity=95%, 95% CI: 93–97%), specificity 67% (58–75%)  
- NT-proBNP pooled sensitivity 91% (95% CI: 88–93), specificity 67% (50–80%)  

- Both BNP and NT-proBNP had high sensitivity but low specificity  
- Overall strength of evidence for sensitivity and all decision cutpoints for both peptides was high; strength of evidence for specificity rated as moderate.  
- Both BNP and NT-proBNP performed well to rule out, but less well to rule in, for the diagnosis of heart failure among patients presenting to the ED or urgent care centers.

### Zaphiriou et al. 2005

**Study type:** Diagnostic accuracy study (observational)  
**Size:** 306 pts  
**Inclusion criteria:** Pts with new symptoms suggestive of HF referred by GP to rapid access HF clinics at 5 centers in UK between 201 and 2003  

**1° endpoint:** Sensitivity, specificity, PPV, NPV, LR, AUC for diagnosis of HF  

**Results:**  
- 104 (34%) of pts had HF  

- 2 of 5 sites withdrew after recruiting 18 and 14 pts  
- Both BNP and NT-proBNP are useful for ruling out HF in pts presenting to PCP with possible HF symptoms
<table>
<thead>
<tr>
<th>Study Type</th>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
<th>1st Endpoint</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Son et al. 2012 (43) 22564550</td>
<td>ED presentation for dyspnea (HF vs. Noncardiac control) Complete medical records</td>
<td>HF excluded if other diagnosis made</td>
<td>HF diagnosis</td>
<td>NT-proBNP was one of 6 variables identified in decision-tree rough set and one of 4 variables in logistic regression model</td>
</tr>
<tr>
<td>Kelder et al. 2011 (44) 22104551</td>
<td>Pts presenting with signs/symptoms of HF who were referred to 1 of 8 rapid access clinics in the Netherlands</td>
<td>Known, established HF Acute HF requiring immediate therapeutic intervention</td>
<td>Diagnosis of HF</td>
<td>NT-proBNP had utility beyond the history and physical for diagnosing HF among primary care outpatients presenting with signs/symptoms of HF</td>
</tr>
<tr>
<td>Booth et al. 2014 (45) 24969534</td>
<td>Pts presenting with signs or symptoms of HF or were at risk of HF a time of presentation Primary care setting</td>
<td>Studies with subjects with: Age &lt;18 y Acute HF Known exacerbation of chronic stable HF</td>
<td>Diagnostic accuracy of BNP or NT-proBNP</td>
<td>Both BNP and NT-proBNP have good diagnostic utility for diagnosing HF in the primary care setting in those with signs/symptoms of HF or at risk of developing HF Tests have better sensitivity than specificity Authors felt that it was unlikely that further studies will change these conclusions</td>
</tr>
</tbody>
</table>
### Conditions that may interfere with NP levels (heart transplant, obesity, HCM, valvular lesion)

- **Dao et al. 2001**
  - **Study type:** Observational, convenience sample at 1 VA urgent care center
  - **Size:** 250
  - **Inclusion criteria:** SOB as prominent complaint
  - **Exclusion criteria:** Dyspnea clearly not from HF, ACS (unless predominant presentation was HF)
  - **1st endpoint:** Diagnostic utility of point-of-care BNP for diagnosis of HF
  - **Results:**
    - BNP C-statistic = 0.98
    - Treating physician C statistic = 0.88
    - BNP remained independently associated with HF diagnosis in multivariable model beyond H+P, xray, ECG

- **Davis et al. 1994**
  - **Aim:** Assessed value of ANP and BNP in pts presenting with dyspnea
  - **Study type:** Observational
  - **Size:** 52
  - **Inclusion criteria:** Suspected HF among elderly pts presenting with acute dyspnea requiring admission
  - **Exclusion criteria:** Pneumonia, pulmonary thromboembolism, or pneumothorax
  - **1st endpoint:** Strong negative correlations between LVEF and log BNP (r=-0.7; p<0.001) and log ANP (r=-0.59; p<0.001).
  - **Results:** Admission plasma BNP more accurately reflected the final diagnosis of HF (93% sensitivity and 90% specificity when BNP ≥22 pmol/L) than LVEF or plasma ANP concentration.

- **Cheng et al. 2001**
  - **Aim:** To determine if BNP levels predict outcomes of pts admitted with decompensated HF
  - **Study type:** Observational
  - **Size:** 72
  - **Inclusion criteria:** Pts admitted with decompensated NYHA class III to IV HF, measuring daily BNP levels
  - **Exclusion criteria:** Lack of levels
  - **1st endpoint:** Association between initial BNP and the predischARGE or premoribund BNP measurement and subsequent death and 30-d readmission
  - **Results:** In pts surviving hospitalization, BNP discharge concentrations were strong predictors for mortality and early readmission.

- **Fonarow et al. 2008**
  - **Aim:** To determine additive prognostic value of admission BNP and cardiac Tn levels
  - **Study type:** Hospitalizations for HF from April 2003 to December
  - **1st endpoint:** BNP above the median and increased Tn were associated with significantly increased
  - **Results:** Admission BNP and cardiac Tn levels are significant, independent predictors of in-hospital mortality in
<table>
<thead>
<tr>
<th>Study type:</th>
<th>Size:</th>
<th>Exclusion criteria:</th>
<th>1° endpoint:</th>
<th>Results:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registry analysis</td>
<td>48,629</td>
<td>Absence of BNP levels</td>
<td>risk of in-hospital mortality</td>
<td>Elevated serum levels of BNP, cTnI and hs-CRP upon admission offers</td>
</tr>
<tr>
<td>Study type: Registry analysis</td>
<td>48,629</td>
<td>Absence of BNP levels</td>
<td>(OR: 2.09 and 2.41 respectively, each p&lt;0.0001).</td>
<td>enhanced early risk stratification.</td>
</tr>
<tr>
<td>Size: 48,629</td>
<td></td>
<td>Inclusion criteria:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aim: To investigate the combined prognostic value of admission serum levels of BNP, cTnI and hs-CRP, in pts hospitalized because of acutely decompensated severe (NYHA class III/IV) low-output chronic HF.</td>
<td></td>
<td>Exclusion criteria: Competing diagnoses of renal failure, MI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclusion criteria:</td>
<td></td>
<td>Consecutive hospitalized acute decompensated HF pts with NYHA class III/IV recruited in the 5 participating centers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Results:</td>
<td></td>
<td>There was a significant gradual increased risk of 31-d cardiac death with increasing in the number of elevated biomarkers (p&lt;0.001).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1° endpoint:</td>
<td>Cardiac mortality by 31 d</td>
<td>By multivariate Cox regression analysis, elevated serum levels of BNP (p=0.002), cTnI (p=0.001) and hs-CRP (p=0.02) were independent predictors of the study end point.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study type: Multicenter</td>
<td></td>
<td>Inpts hospitalized for acute decompensation of severe (NYHA III/IV) low-output HF, BNP, cTnI and hs-CRP upon admission offers enhanced early risk stratification.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prospective cohort</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Size:</td>
<td>577</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Aim: Describe the association between elevated cardiac troponin levels and adverse events in hospitalized pts with acute decompensated HF</td>
<td></td>
<td>Exclusion criteria: Pts with a serum creatinine level ≥ 2.0 mg per deciliter</td>
<td>1° endpoint: Overall, 4,240 pts (6.2%) were positive for troponin.</td>
<td>In pts with acute decompensated HF, a positive cardiac troponin test is associated with higher in-hospital mortality, independently of other predictive variables.</td>
</tr>
<tr>
<td>Inclusion criteria:</td>
<td></td>
<td></td>
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<tr>
<td>Results:</td>
<td></td>
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<tr>
<td>Pts who were positive for troponin had lower SBP on admission, a lower EF, and higher in-hospital mortality (6.0% vs. 2.7%, p&lt;0.001) than those who were negative for troponin. The adjusted odds ratio for death in the group of pts with a positive troponin test was 2.55 (95% CI: 2.24–2.89; p&lt;0.001)</td>
<td></td>
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<tr>
<td>Study type: Registry analysis</td>
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<tr>
<td>Size:</td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Study Title</th>
<th>Size</th>
<th>Aim</th>
<th>Inclusion Criteria</th>
<th>1° endpoint</th>
<th>Results</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al. 2012</td>
<td>12,591</td>
<td>To derive and validate a model for acute HF mortality applicable in the ED.</td>
<td>Population-based random sample of 12,591 pts presenting to the ED from 2004 to 2007</td>
<td>Death within 7 d of presentation</td>
<td>Mortality risk increased with higher triage heart rate (OR: 1.15; [95% CI: 1.03–1.30] per 10 beats/min) and creatinine concentration (OR: 1.35; [CI: 1.14–1.60] per 1 mg/dL [88.4 micro mol/L]), and lower triage SBP (OR: 1.52 [CI: 1.31–1.77] per 20 mm Hg) and initial oxygen saturation (OR, 1.16 [CI: 1.01–1.33] per 5%).</td>
<td>A multivariate index comprising routinely collected variables stratified mortality risk with high discrimination in a broad group of pts with acute HF presenting to the ED.</td>
</tr>
<tr>
<td>Dhaliwal et al. 2009</td>
<td>203</td>
<td>Compare the relationship between absolute and relative changes in BNP with future clinical events, and whether serial BNP measurements add prognostic information in pts treated for decompensated HF</td>
<td>Pts hospitalized for acute decompensated HF by Framingham criteria</td>
<td>For the combined end point of total mortality or readmission for HF</td>
<td>Increasing tertiles of BNP levels after treatment had a hazard ratio of 1.4 (1.1–1.7, p&lt;0.01) and increasing tertiles of percent reduction in BNP, had a HR:0.7 (0.6–0.9; p=0.005), respectively, for the combined end point of total mortality or readmission for HF. Follow-up BNP performed better than did baseline BNP or percent reduction in BNP. More BNP measurements other than the follow-up BNP did not improve the fit of the model further.</td>
<td>Both lower absolute BNP levels and greater percentage reduction in BNP with treatment of decompensated HF are associated with better event-free survival. Advocating a threshold BNP to which pts should be treated may not be possible given that high BNP levels tend not to decrease to levels associated with better outcomes during the short period of treatment. More BNP measurements do not add prognostic information beyond that provided by a single BNP level after treatment.</td>
</tr>
<tr>
<td>Alonso-Martinez et al. 2002</td>
<td>203</td>
<td>To determine usefulness of CRP in predicting need for readmission in HF</td>
<td>Intervention group: admission with HF; control group: admission with syncope</td>
<td>18-mo HF readmission</td>
<td>CRP levels were higher in pts with HF compared to syncope (3.94 vs. 0.84, p&lt;0.0007)</td>
<td>Multivariate predictors of readmission were CRP levels, NYHA class and plasma K on discharge. Limitation: small, single-center.</td>
</tr>
</tbody>
</table>
### Dieplinger et al. 2010 (55) 20153308

**Aim:** To evaluate the prognostic value of established and novel biomarkers in pts with acute dyspnea

**Study type:** Observational

**Size:** 251

**Inclusion criteria:** Pts presenting to ED with acute dyspnea

**Exclusion criteria:** STEMI, NSTEMI or ACS troponin pos.

**Biomarkers:** BNP, MR-proANP, MR-proADM, copeptin, C-terminal pro-ET-1, soluble ST2, chromogranin A (CgA), adiponectin, proguanylin, prouroguanylin

**1° endpoint:** All-cause mortality at 1 y
- 25% died within 1 y
- At baseline, decedents (n=62) had higher median plasma concentrations of all 10 biomarkers than survivors (n=189)
- In multivariate model, only MR-proANP (RR: 1.6), ST2 (RR: 1.7) and CgA (RR: 1.5) were independent predictors of death
- Low systolic BP and advanced age were also independent predictors of 1-y mortality
- Limitations: post-hoc analysis; subgroup (87 of 251) had dyspnea due to acute HF alone; single-center, majority men (94%)
<table>
<thead>
<tr>
<th>Study type</th>
<th>Size</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
<th>1° endpoint</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manzano-Fernandez et al. 2011 (58) 21211603</td>
<td>Observational study combining 3 databases (Boston, MA; Linz, Austria; Murcia, Spain)</td>
<td>447</td>
<td>Acute HF</td>
<td>N/A</td>
<td>Pts with HFpEF had higher ST2 levels than HFpEF (median 0.55 ng/ml vs. 0.38 ng/ml; p&lt;0.001) Addition of ST2 to NT-proBNP improved C statistic and both net reclassification improvement and integrated discrimination improvement, regardless of LVEF Limitations: pooled multinational analysis that lacked predefined endpoints and complete echocardiographic measures; no pre-discharge ST2 levels</td>
</tr>
<tr>
<td>Rehman et al. 2008 (59) 19017513</td>
<td>Observational study combining 2 databases (Boston, MA; Linz, Austria)</td>
<td>346</td>
<td>Acute HF</td>
<td>N/A</td>
<td>Pts with HFpEF had lower ST2 levels compared to HFpEF 1-y mortality was 42% among 116 pts with elevation in both ST2 and BNP/NT-proBNP In the presence of a low ST2 level, BNP/NT-proBNP did not predict mortality Limitations: lack of serial measures of ST2; biologic role of ST2 in acute HF poorly understood</td>
</tr>
</tbody>
</table>
2017 Heart Failure Focused Update Data Supplement

Search Terms and Date: natriuretic peptides, heart failure, human, last 5 years. Last search done on April 18, 2016.

### Data Supplement 1. RCTs Comparing ARNI (Section 7.3.2.10)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Inclusion criteria:</th>
<th>Intervention:</th>
<th>Comparator:</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2° Endpoint (if any); Study Limitations; Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARAMOUNT Solomon et al. 2012 (61) 22932717</td>
<td>Aim: To address safety and efficacy of LCZ696 (ARNI) in pts with HFpEF</td>
<td>Pts ≥40 y of age, LVEF ≥45%, NYHA class II-III HF, NT-pro BNP &gt;400 pg/mL.</td>
<td>Right HF due to pulmonary disease, dyspnea due to noncardiac causes, valvular/myocardial disease, CAD or CVD needing revascularization within 3 mo of screening.</td>
<td>LCZ696 (149) target dose 200 mg BID achieved in 81%</td>
<td>Valsartan (152) target dose 160 mg BID achieved in 78%</td>
<td>Change from BL at 12 wk for NT-proBNP HR: 0.8 (95% CI: 0.71–0.89; p&lt;0.001)</td>
<td>• No difference in change in NT-proBNP from BL at 36 wk • BP reduced in the LCZ696 group vs. valsartan at 12 wk (p=0.001 for SBP and p=0.09 for DBP) • Change in BP correlated poorly with the change in pro-BNP • No difference in improvement in NYHA class at 12 wk (p=0.11) and 36 wk (p=0.05). • No difference in KCCQ scores • Trial not powered to ascertain clinical outcomes. Further studies needed to assess safety and efficacy in HFpEF pts.</td>
</tr>
</tbody>
</table>

| PARADIGM-HF McMurray et al. 2014 | Aim: To compare survival rates with the use of | ≥18 y of age, NYHA class II, III, IV; EF ≤35%, BNP of at least 150 | LCZ696 (4,187) target dose 200 mg BID (mean | LCZ696 (4,187) target dose 200 mg BID (mean | Valsartan (4,187) target dose 160 mg BID (mean | Composite of death (CV causes) or a first | Less CV death in LCZ696 arm (558 vs. 693) HR: 0.8 (95% CI: 0.71–0.89; p<0.001) |

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<table>
<thead>
<tr>
<th>Study type:</th>
<th>RCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size:</td>
<td>8,442</td>
</tr>
<tr>
<td>Comparator:</td>
<td>Enalapril (4,212) target 10 mg BID (mean 18.9±3.4 mg daily)</td>
</tr>
<tr>
<td>Exclusion criteria:</td>
<td>Symptomatic hypotension, SBP &lt;95 mm Hg, eGFR &lt;30 mL/min/min/1.73m² of body surface area, serum K level &gt;5.2 mmol/L, angioedema history, unacceptable side effects of ACE inhibitors or ARBs</td>
</tr>
<tr>
<td>Hospitalization for HF</td>
<td>375±71 mg daily</td>
</tr>
</tbody>
</table>

**Results:**
- Composite less in LCZ696 group vs. enalapril, 914 (21.8%) vs. 1,117 (26.5%), HR: 0.80 (95% CI: 0.73–0.87; p<0.001)
- Less HF hospitalizations in LCZ696 arm (537 vs. 658) HR: 0.79 (95% CI: 0.71–0.89; p<0.001)
- Less death from any cause in LCZ696 arm (711 vs. 835), HR: 0.84 (95% CI: 0.76–0.93; p<0.001)
- The change from baseline to 8 mo in the score on the KCCQ in LCZ696 arm (2.99 points reduction vs. 4.63 points), HR: 1.64 (95% CI: 0.63–2.65; p=0.001)
- No difference in new onset of AF (84 vs. 83; p=0.84)
- No difference in protocol defined decline in renal function, HR: 0.86 (95% CI: 0.65–1.13; p=0.28).
- More symptomatic hypotension (14% vs. 9.2%; p<0.001)
- No difference in angioedema, 19 vs. 10 (p=0.13)

**Study** LCZ696 with enalapril in HF

**Study details**
- pg/mL, hospitalized for HF ≤12 mo (≥BNP100 pg/mL), on ACE inhibitors or ARBs ≥4 wk before screening, required to take stable dose of beta blockers and an ACE inhibitor (or ARB) equal to 10 mg of enalapril. Prior to randomization pts were required to complete 2 wk each of enalapril 10 mg BID and LCZ 100 BID.

**Exclusion criteria**
- Symptomatic hypotension, SBP <95 mm Hg, eGFR <30 mL/min/min/1.73m² of body surface area, serum K level >5.2 mmol/L, angioedema history, unacceptable side effects of ACE inhibitors or ARBs

Search Terms and Date: 3 trials identified by chairs in December 2015.
## Data Supplement 2. RCTs Comparing RAAS Inhibition (Section 7.3.2.3)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2nd Endpoint (if any); Study Limitations; Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONTARGET Investigators et al. 2008 (63) <strong>18378520</strong></td>
<td>Aim: Compare ACE (ramipril), ARB (telmisartan), and combination ACE/ARB in pts with CVD or high-risk DM</td>
<td>Inclusion Criteria: Pts &gt;55 y of age, CAD, PVD, previous stroke, or high-risk DM with end-organ damage</td>
<td>Intervention: Run in, then randomization to ramipril (8,576) target dose 10 mg daily, telmisartan (8,542) target dose 80 mg daily or combination (8,502), titrated to BP</td>
<td>1st endpoint: • Composite of CV death, MI, stroke, or HF hospitalization at 5 y</td>
<td>No difference in outcome (16.5% ACE, 16.7% ARB, 16.3% combination; CI: ARB RR: 1.01 (95% CI: 0.94–1.09) • Compared to the ramipril arm: • Telmisartan had more hypotensive symptoms (p&lt;0.001); less cough (p&lt;0.001) and angioedema (p=0.01); same syncpe. • Combination arm had more hypotensive symptoms (p&lt;0.001); syncope (p=0.03); and renal dysfunction (p&lt;0.001) • BP fell by 6.4/7.4/9.8 mm Hg • Less angioedema with telmisartan</td>
</tr>
<tr>
<td>TRANSCEND Yusuf et al. 2008 (64) <strong>18757085</strong></td>
<td>Aim: To assess the effectiveness of ARB in ACE-intolerant pts with CVD or high-risk DM</td>
<td>Inclusion Criteria: ACE-intolerant pts with CAD, PVD, previous stroke, or high-risk DM with end-organ damage</td>
<td>Intervention: Run in, then randomization to telmisartan titrated to 80 mg as tolerated (2,954) Comparator: Titration of other medications as needed to control BP (2,944)</td>
<td>1st endpoint: • Composite of CV death, MI, stroke, or HF hospitalization at 5 y</td>
<td>No significant difference RR: 0.92 (95% CI: 0.81–1.05); p=0.216 No difference in 2nd outcomes; ARB was safe in this pt population - no angioedema</td>
</tr>
<tr>
<td>SUPPORT Sakata et al. 2015 (65) <strong>25637937</strong></td>
<td>Aim: Discover whether addition of ARB to ACE and beta blockers in pts with chronic HF will</td>
<td>Inclusion Criteria: Pts 20–79 y of age with hypertension, NYHA class II-IV, stable on ACE ± beta blockers</td>
<td>Intervention: Randomization to olmesartan (578) titrated up to 40 mg as tolerated (578) (mean dose achieved at 5 y, 17.9</td>
<td>1st endpoint: • Composite of all-cause death, MI, stroke, or HF hospitalization at 4.4 y</td>
<td>No significant difference RR: 1.18 (95% CI: 0.96–1.46); p=0.11 Pts on triple therapy with ACE/ARB/Beta blocker had more of 1st composite outcome, 38.1 vs. 28.2%, HR: 1.47 (95% CI: 1.11–1.95; p=0.006); all-cause death, 19.4 vs. 13.5%, HR: 1.50 (95% CI:</td>
</tr>
</tbody>
</table>
### Mineralocorticoids Antagonist Trials

<table>
<thead>
<tr>
<th>Study</th>
<th>Aim</th>
<th>Inclusion Criteria</th>
<th>Intervention</th>
<th>Comparator</th>
<th>1(^{st}) endpoint</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EMPHASIS</strong> subgroup analysis, Eschallier et al. 2013 (66)</td>
<td>Investigate the safety and efficacy of eplerenone in pts at high risk for hyperkalemia</td>
<td>Pts enrolled in EMPHASIS at high risk for hyperkalemia of worsening renal function (&gt;75 y, DM, eGFR &lt;60, or SBP &lt;123)</td>
<td>Randomization to eplerenone</td>
<td>Placebo</td>
<td>Efficacy: Hospitalization for HF or worsening renal failure. <strong>Safety:</strong> K &gt;5.5, &gt;6.0, &lt;3.5, hospitalization for significant hyperkalemia, hospitalization for worsening renal function</td>
<td>Efficacy: reduced composite endpoint. Safety: increased risk of K+ &gt;5.5 mmol/L, hospitalization for hyperkalemia or discontinuation of study medication due to adverse events. No differences from the main trial results in the high-risk subgroups. K &gt;5.5 was increased in the whole cohort and the subgroups, but K &gt;6.0, clinically significant hyperkalemia, and change in eGFR were not substantially higher.</td>
</tr>
<tr>
<td><strong>RALES</strong> Pitt et al. 1999 (67)</td>
<td>To investigate the effect of spironolactone on mortality and morbidity in pts with severe HF.</td>
<td>NYHA class III, IV; HF≤6 mo, Left EF≤35%, On ACE inhibitors, loop diuretic. Digitalis and vasodilators allowed.</td>
<td>Spironolactone 25 mg daily (822)</td>
<td>Placebo (841)</td>
<td>Death from all causes</td>
<td>Reduction in death from cardiac causes and Hospitalization for cardiac causes (p&lt;0.001) Improvement in NYHA class (p&lt;0.001) No clinically important safety concerns for electrolytes. Gynecomastia/breast pain more frequent in the spironolactone arm.</td>
</tr>
</tbody>
</table>
The ARB evidence table from the 2013 Heart Failure Guideline is included at the end of this document.

The ACE inhibitor evidence table from the 2013 Heart Failure Guideline is also included at the end of this document.

The Beta Blocker evidence table from the 2013 Heart Failure Guideline is included at the end of this document.

### Data Supplement 3. RCTs Comparing Pharmacological Treatment for of ARNI With ACE (Section 7.3.2.10)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2° Endpoint; Study Limitations; Adverse Events</th>
</tr>
</thead>
</table>
| IMPRESS Rouleau et al. 2000 (68) 10968433 | Aim: Determine if inhibition of neutral endopeptidase and ACE with the vasopeptidase inhibitor omapatrilat is better than ACE inhibition alone with lisinopril  
Study type: Double blind RCT  
Size: 573 pts | Inclusion criteria:  
- Informed consent  
- Age ≥18  
- Stable (>3 mo) symptomatic HF (NYHA class II–IV HF)  
- Decreased LVEF <40  
- ≥4 wk dose of ACE inhibitors  
- Seated SBP ≥90 mm Hg  
Exclusion criteria:  
- Uncontrolled hypertension  
- Acute coronary events within 3 mo  
- Revascularization within 3 mo  
- Serum potassium <3.5 or >5.3 mmol/L  
- Creatinine >221 mcmmol/L  
- Transaminases >2 upper limit of normal  
- Leucocytes <3.0x10^9/L, neutrophils <1.5x10^9/L, or platelets <120x10^9/L | Intervention: Omapatrilat (289) target dose 40 mg daily  
Comparator: Lisinopril (284) target dose 20 mg daily | 1° endpoint: Change in exercise duration from baseline to wk 12  
Results: Similar exercise duration at 12 wk (p=0.45)  
2° endpoint:  
- No difference in combined endpoint of death and admission for worsening HF (p=0.52)  
- Combined endpoint of death and comorbidity for worsening HF was better for omapatrilat HR: 0.52 (95% CI: 0.28–0.96; p=0.035)  
- Angioedema occurred in no pts taking omapatrilat vs. 1 taking enalapril  
Comments: Vasopeptidase inhibitor omapatrilat did not improve exercise tolerance compared with ACE inhibitor lisinopril |
### OVERTURE

**Packer et al. 2002**

**Aim:**
Determine dual ACE and NEP inhibitors provides greater benefit in pts with HF than ACE inhibitors alone

**Study type:**
Double blind RCT

**Size:**
5,770 pts

**Inclusion criteria:**
- NYHA class II–IV HF due to non/ischemic cardiomyopathy for ≥2 mo, or
- LVEF ≤30% and hospitalized for HF within 12 mo

**Exclusion criteria:**
- Surgically correctable or reversible cause of HF
- Likely to receive cardiac transplant or left ventricular assist device
- Severe 1° pulmonary, renal, or hepatic disease
- Hx of intolerance to ACE inhibitors
- ACS within 1 mo
- Coronary revascularization or an acute cerebral ischemic event within 3 mo
- Hx of ventricular tachycardia, ventricular fibrillation, or sudden death who did not have an ICD placed and had not fired within 2 mo
- Hx or hospitalization or intravenous therapy for HF within 48 h
- IV positive inotropic agent within 2 wk
- SBP >180 or <90 mm Hg
- Heart rate >130 bpm
- Serum creatinine >2.5 mg/dL
- Serum potassium <3.5 or >5.2 mmol/L

**Intervention:**
Omapatrilat (2,886), target dose 40 mg daily achieved 82.5%

**Comparator:**
Enalapril (2,884) target dose 10 mg BID achieved 86.4%

**1° endpoint:**
Combined risk of death or hospitalization for HF requiring IV treatment

**Results:**
No significant difference HR: 0.94 (95% CI: 0.86–1.03; p=0.187)

**Omapatrilat reduced risk of death and hospitalization for chronic HF:**
HR: 0.89 (95% CI: 0.82–0.98; p=0.012). For this analysis, pts were treated with intensification of oral medications.

**More frequent angioedema with omapatrilat (0.8% vs. 0.5%)**

### OCTAVE

**Kostis et al. 2004**

**Aim:**
Compare safety and efficacy of dual ACE and NEP inhibitors to ACE inhibitors alone

**Study type:**
Double blind RCT

**Inclusion criteria:**
- Age ≥18
- 3 separate BP criteria for 3 groups: Group 1 untreated hypertension (SBP ≥140 mm Hg or DBP ≥90 mm Hg); Group 2 hypertension and persistent mild hypertension (trough SBP 140–159 mm Hg and DBP <100 mm Hg, or trough DBP 90–99 mm Hg and SBP <160 mm Hg);

**Intervention:**
Omapatrilat target dose 80 mg daily

**Comparator:**
Enalapril target dose 40 mg daily

**1° endpoints:**
- Reduction in SBP at wk 8
- Need for new adjunctive antihypertensive therapy by wk 24

**2° endpoints:**
- Reduction in DBP at wk 8
- Reduction in SBP and DBP at wk 24
- BP control (SBP <140 mm Hg and DBP <90 mm Hg) at wk 8 and 24

**Comments:**
Group 3 hypertension with persistent moderate to severe hypertension (trough SBP 160–179 mm Hg and DBP <110 mm Hg, or trough DBP 100–109 mm Hg and SBP <180 mm Hg)

**Exclusion criteria:**
- Contraindication to therapy with ACE inhibitors or angiotensin II receptor antagonists
- Hx of angioedema, anaphylaxis, drug-induced or chronic urticarial, or multiple drug sensitivities
- Recent hospitalization for MI, unstable angina, stroke, TIA or COPD
- Recent treatment for malignancy, chronic renal disease 2° to autoimmune disease, or end-stage renal disease of any etiology
- Hypertensive pts treated with ACE inhibitors whose BP placed them in study group 3

- Greater reductions in BP in omapatrilat within each study (p<0.001)
- Overall mean reduction in SBP ≥3.6 mm Hg
- Larger reductions in BP in black pts with omapatrilat than with enalapril. But overall reduction smaller with both drugs than in other subgroups.
- Adverse events, serious adverse events, and deaths were the same for omapatrilat and enalapril
- More angioedema with omapatrilat (2.17% vs. 0.68%)
- More angioedema in blacks with omapatrilat (5.54% vs. 1.62%) and current smokers (3.93% vs. 0.81%)

### Data Supplement 4. RCTs Comparing Pharmacological Treatment for Stage C HFrEF (Section 7.3.2.11)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2° Endpoint (if any); Study Limitations; Adverse Events</th>
</tr>
</thead>
</table>
| SHIFT HF Böhm et al. 2015 (71) 26508709 | Aim: To assess influence of comorbidities on outcomes and ivabradine treatment effect of heart rate reduction in stable HF. **Study type:** Post hoc analysis of RCT | Inclusion criteria: Pts ≥18 y of age in sinus rhythm, heart rate at rest ≥70 bpm, MTD for HF meds | **Intervention:** Ivabradine **Comparatot:** Placebo | **1° endpoint:**
- CV death or HF hospitalization rate increased with the comorbidity load (p<0.0001) with most events in pts with >3 comorbidities for both drug and placebo.
- Hospitalization rate lower for comorbidity loads of ivabradine |
- Number of comorbidities was related to outcomes
- Heart rate reduction with Ivabradine is conserved at all comorbidity loads |
<table>
<thead>
<tr>
<th>Study</th>
<th>Size: 6,505</th>
<th>Inclusion criteria: Over 18 y of age, in sinus rhythm, resting heart rate of ≥70 bpm, stable symptomatic chronic HF (NYHA class II-IV) for ≥4 wk, previous admission to the hospital for HF within 12 mo, LVEF ≤35%</th>
<th>Intervention: Ivabradine</th>
<th>1st endpoint:</th>
<th>Adverse Effects:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHIFT</td>
<td></td>
<td>Study type: randomized, double-blind placebo-controlled trial. 677 centers 37 countries</td>
<td>Comparator: Placebo</td>
<td>• Composite of CV death or hospital admission for worsening HF</td>
<td>• 1% withdrew due to bradycardia (p&lt;0.001)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size: 6,558 6,505 analyzed 3,241 ivabradine 3,264 placebo</td>
<td></td>
<td>• Primary endpoint: ivabradine better. Event rate 24% vs. 29%, HR 0.82 (0.75–0.90); p&lt;0.0001</td>
<td>• Phosphenes 3% (p&lt;0.001)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inclusion criteria: HF due to congenital heart disease or 1° severe valvular disease. MI within 2 mo, ventricular or AV pacing for ≥40% of the d, AF or flutter, symptomatic hypotension</td>
<td></td>
<td>• Hospitalization for worsening HF: ivabradine better. 16% vs 21%, HR: 0.74 (95% CI: 0.66–0.83; p&lt;0.001)</td>
<td>• Comparable across age groups</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The following treatments not allowed during study:</td>
<td></td>
<td>• Death from HF: ivabradine better. 3% vs. 5%; HF: 0.74 (0.58–0.94); p=0.014</td>
<td>• AF - ivabradine 9% vs. placebo 8% (p=0.012)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• diltiazem and verapamil (nondihydropyridine CCB)</td>
<td></td>
<td></td>
<td>Adverse Events: Increased bradycardia, AF, phosphenes and cardiac disorders.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• class I antiarrhythmics</td>
<td></td>
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<td></td>
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<td>• strong inhibitors of CYP450 3A4</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Aim: Assess the mortality-morbidity</th>
<th>Inclusion criteria: Stable CAD without clinical HF and heart rate of ≥70</th>
<th>Intervention: Ivabradine (n=9,550)</th>
<th>1st endpoint:</th>
<th>Adverse Events:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGNIFY</td>
<td></td>
<td></td>
<td></td>
<td>• Composite of CV death and nonfatal MI</td>
<td></td>
</tr>
<tr>
<td>Fox et al. 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(73)</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

© 2017 American College of Cardiology Foundation, the American Heart Association, Inc., and the Heart Failure Society of America.
| Study type: | RCT |
| Size: | 19,102 |

**Exclusion criteria:**
Serum creatinine >200 mc mole/L, significant anemia, ALT or AST >3 times upper normal value, unstable CV condition, LVEF ≤40%; MI, coronary revascularization, stroke ≤3 mo.

**Comparator:** Placebo (n=9,552)

**Results:**
- No significant difference in incidence of 1° endpoint (HR: 1.08; 95% CI: 0.96–1.20; p=0.20), death from CV causes (HR: 1.10; 95% CI: 0.94–1.28; p=0.25), nonfatal MI (HR: 1.04; 95% CI: 0.90–1.21; p=0.60) and rate of death (HR: 1.06; 95% CI: 0.94–1.21; p=0.35)

**Safety endpoint:***
- Incidence of bradycardia higher in Ivabradine group (p=0.001)

---

**BEAUTIFUL**
Fox et al. 2008
(74) 18757088

**Aim:** Assess the mortality-morbidity benefits of Ivabradine in pts with CAD and LV systolic dysfunction

**Study type:** Randomized, double-blind, placebo-controlled

**Size:** 10,917

5,479 ivabradine

5,438 placebo

**Inclusion criteria:**
- Pts ≥55 y of age with stable CAD defined as: previous MI, previous revascularization (PCI or surgery), or angiographic evidence of ≥1 stenosis of ≤50%) AND LVEF <40% and end diastolic internal dimension of >56 mm. Sinus rhythm with resting heart rate of ≥60 bpm. 
- Angina and HF symptoms stable for 3 mo 
- Appropriate conventional CV medication for 1 mo.

**Exclusion criteria:**
MI or coronary revascularization within the previous 6 mo; stroke or TIA within 3 mo, PPM or ICD, valvular disease likely to

**Intervention:** Ivabradine n=5,479

**Comparator:**
- Placebo in addition to appropriate CV medication n=5,438

**1° endpoint:**
- Composite of CV death, admission for MI and admission for HF

**2° endpoints:**
- All-cause mortality
- Cardiac death (death from MI or HF or related to a cardiac procedure)
- CV death (death from a vascular procedure, presumed arrhythmic death, stroke death, other vascular death or sudden death of unknown cause) or admission for HF, 
- Composite of admission for fatal and nonfatal MI or UA 
- Coronary revascularization 
- CV death 
- Admission for HF 
- Admission for MI

- No differences in 2° endpoints in overall population.

- In subgroup with heart rate of ≥70, ivabradine reduced
  1) admission for AMI (fatal and nonfatal) (HR 0.64; 0.49–0.84; p=0.001) 
  2) composite of admission for AMI or UA (HR 0.78; 0.62–0.97; p=0.023)
need surgery within 3 y, SSS, sinoatrial block, congenital long QT, complete AV block, severe or uncontrolled hypertension, NYHA class IV HF

3) coronary revascularization (HR 0.7; 0.52–0.93; p=0.16)
• 28% in Ivabradine group discontinued medication (vs. 16%), largely due to bradycardia (13% vs. 2%)
• No significant difference in adverse effects (23% vs. 23%; p=0.70)

Search Terms and Date: studies identified by chairs in December 2015, one study added by Jan 2016.

Data Supplement C. RCTs Comparing Pharmacologic Treatment for HFpEF: Recommendations (Section 7.3.3)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2° Endpoint (if any); Study Limitations; Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYVET Beckett et al. 2008 (75) 18378519</td>
<td>Aim: To determine whether treatment of HTN is beneficial in the elderly. Study type: RCT Size: 3,845</td>
<td>Inclusion criteria: Age &gt;80, persistent HTN (SBP &gt;160) Exclusion criteria: Known HF, creatinine &gt;150 μmol/L (1.7 mg/dL), CVA &lt;6 mo</td>
<td>Intervention: Indapamide + perindopril if needed for BP control. Target 150/80 mm Hg (1,933) Comparator: Placebo (1,912)</td>
<td>1° endpoint: • Fatal or nonfatal stroke. • Trend for improved outcome with active treatment 51 strokes (12.4/1,000 pt-y) vs. placebo 69 (17.7/1,000 pt-y), HR: 0.70; 95% CI: 0.49–1.01; p=0.06 and significantly reduced fatal stroke 27 (6.5/1000 pt-y) vs. placebo 42 (10.7/1000 pt-y), HR: 0.61; 95% CI: 0.38–0.99; p=0.046</td>
<td>• Significantly reduced all-cause death HR: 0.79 (95% CI: 0.65–0.95; p=0.02) and HF incidence HR: 0.36 (95% CI: 0.22–0.58, p=0.001) with active treatment • Trend for decreased CV and HF death (p=0.06 for both)</td>
</tr>
<tr>
<td>ALLHAT Long-term Follow-up Piller et al. 2011 (76) 21969009</td>
<td>Aim: To compare diuretic-based to ACE-inhibitor or CCB-based treatment of HTN Study type: RCT</td>
<td>Inclusion criteria: Age &gt;55, HTN (SBP ≥140, DBP≥90), at least 1 CV risk factor (MI, stroke, LVH, diabetes, low HDL, PVD)</td>
<td>Intervention: Amlodipine (8,898) 572 with in-trial HF, Lisinopril (8,904); 469 with in-trial HF Comparator: Chlorthalidone (15,002); 720 with in-trial HF</td>
<td>1° endpoint: • Adjusted mortality risk • Increased mortality with in-trial incident HF, both HFpEF: HR: 2.42 (95% CI: 2.08–2.81, p=0.001) and HFrEF: HR: 3.06; 95% CI: 2.67–3.51; p=0.001</td>
<td>• Increased HF mortality with incident HF, both HFpEF: HR: 3.81 (95% CI: 2.18–6.67, p=0.001) and HFrEF: HR: 6.80; 95% CI: 4.36–10.62; p&lt;0.001 • No difference in mortality in pts with incident HF by drug treatment</td>
</tr>
</tbody>
</table>
### SHEP HF Results
Kostis et al. 1997  
(77) 9218667

#### Aim:
To assess the effect of antihypertensive treatment in isolated systolic HTN

#### Study type:
RCT

#### Size:
4,736

#### Inclusion criteria:
- Age > 60, SBP 160–219, DBP<90
- Recent MI or CABG, pts with DM, stroke, AF

#### Exclusion criteria:
- Recent MI or CABG, pts with DM, stroke, AF

#### Intervention:
- Antihypertensive therapy: step 1, chlorthalidone, step 2, atenolol (2,365)
- Comparator: Placebo (2,371)

#### 1° endpoint:
- Incident HF
- Active treatment decreased BP from mean of 170/77 to mean of and decreased HF events from 105 (4.4%) with placebo to 55 (2.3%) RR: 0.51 (95% CI: 0.37–0.71, p<0.001) at 4.5 y

#### 2° results of SHEP showed decreased stroke risk with active treatment 149 (8.2%) with placebo to 96 (5.4%) RR: 0.64 (95% CI: 0.49–0.82, p=0.003) at 4.5 y

#### Limitations:
- LV function was not measured

### CHARM-Preserved
Yusuf et al. 2003  
(78) 13678871

#### Aim:
To ascertain efficacy of candesartan in pts with HFpEF.

#### Study type:
RCT

#### Size:
3,023

#### Inclusion criteria:
- HF pts in NYHA class II-IV with EF >40%
- Creatinine >265 μmol/L (3.0 mg/dL), potassium >5.5 mmol/L, MI, stroke, or open-heart surgery in the previous 4 wk

#### Exclusion criteria:
- Creatinine >265 μmol/L (3.0 mg/dL), potassium >5.5 mmol/L, MI, stroke, or open-heart surgery in the previous 4 wk

#### Intervention:
- Candesartan (1,514)
- Comparator: Placebo (1,509)

#### 1° endpoint:
- CV death or admission for HF.
- No difference for candesartan 333 (22%) vs. placebo 366 (24%) at 3.5 y, HR: 0.92; 95% CI: 0.70– 1.21; p=0.5.
- HF hospitalization lower at 1 y with perindopril: 34 events (8.0%) vs. placebo 53 (12.4%), HR: 0.63; 95% CI: 0.41–0.97; p=0.033.
- Limitations: Some pts may have had previous EF <40%.

### PEP-CHF
Cleland et al. 2003  
(79) 16963472

#### Aim:
To ascertain efficacy of perindopril in pts with HFpEF.

#### Study type:
RCT

#### Size:

#### Inclusion criteria:
- Age ≥70, Rx with diuretics for clinical diagnosis of HF, echo criteria for diastolic dysfunction

#### Exclusion criteria:
- Age ≥70, Rx with diuretics for clinical diagnosis of HF, echo criteria for diastolic dysfunction

#### Intervention:
- Perindopril (424)
- Comparator: Placebo (426)

#### 1° endpoint:
- All-cause mortality or admission for HF.
- No difference for perindopril 107 (25.1%) vs. placebo 131 (23.6%) at 3 y, HR: 0.92; 95% CI: 0.70– 1.21; p=0.5.
- HF hospitalization lower at 1 y with perindopril: 34 events (8.0%) vs. placebo 53 (12.4%), HR: 0.63; 95% CI: 0.41–0.97; p=0.033.
- Limitations: Many pts withdrew (40% by 18 mo), often to take open-label ACE inhibitors (36% by study end).
<table>
<thead>
<tr>
<th>Study</th>
<th>Aim:</th>
<th>Inclusion criteria:</th>
<th>Intervention:</th>
<th>1° endpoint:</th>
<th>Limitations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-PRESERVE</td>
<td>To ascertain efficacy of irbesartan on in pts with HFpEF.</td>
<td>Age &gt; 60, HF pts in NYHA class II-IV with EF &gt;45%</td>
<td>Irbesartan (2,067)</td>
<td>CV death or hospitalization for CV cause.</td>
<td>No differences for mortality or any other 2° endpoints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Previous EF &lt;40%, creatinine &gt;222 μmol/L (2.5 mg/dL) ACS, stroke, or revascularization in the previous 3 mo</td>
<td>Comparator: Placebo (2,061)</td>
<td>No difference for irbesartan vs. placebo (742 (36%) vs. 763 (37%), HR: 0.95; 95% CI: 0.86 – 1.05; p=0.35)</td>
<td>Minnesota living with HF scale improved in both, groups to the same</td>
</tr>
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<td>No difference in BNP levels</td>
</tr>
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<td></td>
<td>No difference in adverse effects requiring discontinuation: doubling of creatinine, 6% vs. 4%; p&lt;0.001; K &gt;6.0 3% vs. 2%; p=0.01)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Limitations: Study drug discontinuation in 34% of pts by end of study. High rate of concomitant ACE-I (40%)</td>
</tr>
<tr>
<td>NEAT-HFpEF</td>
<td>To ascertain efficacy of isosorbide mononitrate on daily activity in pts with HFpEF.</td>
<td>Age ≥50 y on stable HF therapy, EF ≥50%, activity limited by dyspnea, fatigue, or chest pain</td>
<td>Isosorbide mononitrate (110)</td>
<td>Average daily activity assessed by accelerometer units during 120 mg phase.</td>
<td>No differences for any of the 3 doses on QoL scores, 6MWT and levels of NT-proBNP (trend unfavorable for nitrates)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SBP &lt;110 mm Hg and &gt;180 mm Hg, current nitrates or PDE-5 inhibitors</td>
<td>Comparator: Placebo (110)</td>
<td>Nonsignificant trend for lower daily activity in the treatment group. (-381 accelerometer units; 95% CI: -780–17; p=0.06) and significant decrease in h of activity/d (-0.30 h; 95% CI: -0.55– -0.05; p=0.02)</td>
<td>Limitations: Rapid dose escalation of study drug.</td>
</tr>
<tr>
<td>RELAX</td>
<td>To ascertain effects of sildenafil on exercise capacity in pts with HFpEF.</td>
<td>Age ≥18 on stable HF therapy, EF ≥50%, peak VO₂ &lt;60% normal and either n-t-proBNP &gt;400 or elevated</td>
<td>Sildenafil (113)</td>
<td>Change in peak VO₂ from BL at 24 wk</td>
<td>No differences in clinical rank score or 6-min walk</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Comparator: Placebo (103)</td>
<td>No difference between sildenafil (-0.20, IQR -1.7– 1.11) and placebo (-0.20,</td>
<td>Limitations: Urinary cGMP levels were not increased in sildenafil group, raising questions about dosing. High prevalence of</td>
</tr>
</tbody>
</table>
### TOPCAT

**Pitt et al. 2014**  
**Reference:** [24716680](https://doi.org/10.1161/JAHA.113.002095)

- **New England Research Institutes**
- **Post-hoc analysis that captures differences in outcomes by geography - for reference list only**

<table>
<thead>
<tr>
<th><strong>Aim:</strong></th>
<th>To assess the effects of spironolactone in pts with HFpEF.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study type:</strong></td>
<td>RCT</td>
</tr>
<tr>
<td><strong>Size:</strong></td>
<td>3,445</td>
</tr>
</tbody>
</table>

**Inclusion criteria:**

- Symptomatic HF,
- Age ≥50y, LVEF ≥45% stratified according to - HF Hospitalization within past y - Elevated NPs

**Exclusion criteria:**

- Renal disease (eGFR <30 or creatinine >22 μmol/L (2.5 mg/dL), systemic illness with life expectancy <3 y. Specific co-existing conditions, meds, and acute events

**Intervention:**

- Spironolactone (1,722)

**Comparator:**

- Placebo (1,723)

**1° endpoint and results:**

- **Composite of CV mortality, HF hospitalization, or aborted cardiac arrest.**
- **No difference with spironolactone vs. placebo**

<table>
<thead>
<tr>
<th>320 (18.6%) vs. 351 (20.4%), HR: 0.89; 95% CI: 0.77–1.04; p=0.138</th>
</tr>
</thead>
</table>
| **HF hospitalization was reduced with spironolactone**  
206 (12.0%) vs. 245 (14.2%), HR: 0.83; 95% CI: 0.69–0.99; p=0.04 |
| **Increased hyperkalemia (18.7% vs. 9.1%), decreased hypokalemia (16.2% vs. 22.9%)**  
and more doubling of creatinine (10.2% vs. 7.0%) with spironolactone |

**Double-blind | **

- **Size:** 216
- **PCWP**
- **Exclusion criteria:**
  - Systolic BP <110mm Hg and >180 mm Hg, MMI or revascularization within 60 d, eGFR <20 mL/min
- **IQR -0.70–1.0) |
  - More worsening of renal function in sildenafil group (p=0.047) |
- **chronotropic incompetence in study population.**

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<table>
<thead>
<tr>
<th>Study</th>
<th>Aim</th>
<th>Inclusion criteria</th>
<th>Intervention</th>
<th>1st endpoint and results</th>
<th>1st Safety endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOPCAT Regional Analysis</strong>&lt;br&gt;Pfeffer et al. 2015 (84) <strong>25406305</strong></td>
<td>To assess regional differences in the effects of spironolactone in pts with HFrEF.</td>
<td>Symptomatic HF, Age ≥50y, LVEF ≥45% stratified according to HF Hospitalization within past y Elevated NPs</td>
<td>Spironolactone (1,722)</td>
<td>Composite of CV mortality, HF hospitalization, or aborted cardiac arrest across regions.</td>
<td>Spironolactone had markedly greater effects on BP (4.2 mm Hg drop vs. 0.6 mm Hg; p&lt;0.001, potassium change relative to placebo (0.26 mmol/L vs. 0.08 mmol/L), and increase in creatinine (0.10 vs. 0.02 mg/dL; p&lt;0.001)</td>
</tr>
<tr>
<td>Study type: RCT</td>
<td>Size: 3,445</td>
<td>Comparator: Placebo (1,723)</td>
<td>1° outcome events in 522 (29.5%) pts in the Americas and 149 (8.9%) in Russia/Georgia. 1° outcome event rates with spironolactone and placebo 10.4/100 pt y and 12.6/100 pt y in the Americas and 2.5/100 pt y and 2.3/100 pt y in Russia/Georgia. HR spironolactone vs. placebo 0.82; 95% CI: 0.69–0.98; p=0.026) in the Americas and 1.10 95% CI: 0.79–1.51; p=0.12) in Russia/Georgia.</td>
<td></td>
<td>Limitations: post-hoc analysis</td>
</tr>
<tr>
<td><strong>Chen et al. 2015 (85) 25598008</strong></td>
<td>To assess effects of MRAs in pts with HFrEF.</td>
<td>Prospective, RCTs that enrolled adult pts with LVEF ≥40% (including post-MI and those with symptomatic or asymptomatic HF) with a study duration of ≥24 mo that assessed at least 1 clinical outcome of interest.</td>
<td>MRAs (3,249)</td>
<td>All-cause mortality and HF hospitalization</td>
<td>MRAs improved QOL (weighted mean difference −5.2; 95% CI: −8.0–−2.3).</td>
</tr>
<tr>
<td>Study type: Meta-analysis</td>
<td>Size: 14 RCTs with 6,428 pts</td>
<td>Comparator: Placebo (2,861) Or standard therapy (301) Or active comparator (31)</td>
<td>1° endpoint and results:</td>
<td>No difference in all-cause mortality (RR: MRAs vs. placebo 0.90; 95% CI: 0.78–1.04; p=0.17)</td>
<td>MRA’s improved echo indices of LV function: E/e’, E/A ratio, deceleration time, interventricular relaxation time</td>
</tr>
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<td></td>
<td>Reduced risk of HF hospitalization (RR: MRA vs. placebo 0.83; 95% CI: 0.70–0.98; p=0.03)</td>
<td>Renal failure in 1.19% of pts with MRAs vs. 0.39%</td>
</tr>
<tr>
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<td></td>
<td>More hyperkalemia with MRAs (12.2% vs. 6.2%, p&lt;0.001)</td>
<td>Gynecomastia in 2.81%R vs. 0.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Limitations: discrepancies in definitions of HFrEF in different trials; heterogeneity of trial outcomes and their assessment, including follow-up duration; 1° outcome results driven by</td>
<td>Limitations: discrepancies in definitions of HFrEF in different trials; heterogeneity of trial outcomes and their assessment, including follow-up duration; 1° outcome results driven by</td>
</tr>
</tbody>
</table>
**Aim:** To address safety and efficacy of LCZ696 in pts with HFpEF.

**Study type:** RCT

**Size:** 308

**Inclusion criteria:**
- Pts ≥40 y of age,
- LVEF ≥45%,
- NYHA class II-III HF, NT-pro BNP >400 pg/mL

**Exclusion criteria:**
- Previous EF <45%,
- isolated right HF,
- noncardiac dyspnea, CAD or CVD needed revascularization <3 mo
- Right HF due to pulmonary disease, dyspnea due to noncardiac causes, valvular/myocardial disease, CAD or CVD needing revascularization within 3 mo of screening.

**Intervention:** LCZ696 (149)

**Comparator:** Valsartan (152)

**1° endpoint:**
- Change in BNP at 12 wk
- Greater reduction with LCZ696 (ratio of change compared to valsartan 0.77; 95% CI: 0.64–0.92; p=0.001)

**1° Safety endpoint:**
- Serious adverse events 15% in LCZ676 group and 20% in valsartan group (p=NS)

- Effect persisted after adjustment for more lowering of BP in LCZ676 group
- Improvement in NYHA class at 36 wk in LCZ676 group compared to valsartan.
- Reduction of LA size at 36 wk in LCZ676 group compared to valsartan.
- BNP levels higher than in other HFpEF trials, perhaps because this was an entry criterion.

Date: Some studies added by chairs in December 2015, others added by the writing committee.

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**Data Supplement D. RCTs Comparing Anemia (Section 9.2)**

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2° Endpoint (if any); Study Limitations; Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONFIRM-HF</strong>&lt;br&gt;Ponikowski et al. 2015&lt;br&gt;(86) 25176939</td>
<td><strong>Aim:</strong>&lt;br&gt;To assess benefits&lt;br&gt;and safety of long&lt;br&gt;term FCM in iron-deficient pts with&lt;br&gt;HF</td>
<td><strong>Inclusion criteria:</strong>&lt;br&gt;Pts at least 18 y,&lt;br&gt;NYHA class II or III,&lt;br&gt;LVEF ≤45%,&lt;br&gt;elevated NPs, ID&lt;br&gt;defined as ferritin&lt;br&gt;&lt;100 ng/mL, or&lt;br&gt;ferritin 100–300 ng/mL if TSAT&lt;br&gt;&lt;20%, Hb &lt;15&lt;br&gt;mg/dL</td>
<td><strong>Intervention:</strong>&lt;br&gt;FCM (152)</td>
<td><strong>1st endpoint:</strong>&lt;br&gt;• Change in 6MWT distance&lt;br&gt;from BL to wk 24&lt;br&gt;• Results: Change in 6MWT&lt;br&gt;distance FCM vs. placebo of&lt;br&gt;33±11 m (p=0.002)</td>
<td><strong>2°Endpoints:</strong>&lt;br&gt;• Changes in NYHA class&lt;br&gt;• PGA&lt;br&gt;• 6MWT distance&lt;br&gt;• Fatigue score&lt;br&gt;• KCCQ&lt;br&gt;• EQ-5D&lt;br&gt;• Assessed at wk 6, 12, 24, 36, 52&lt;br&gt;• Rate of any hospitalization, rate of hospitalization for any CV reason, and rate of hospitalization due to worsening HF;&lt;br&gt;• Time to first hospitalization for any reason, time to first hospitalization for any CV reason and time to first hospitalization due to worsening HF;&lt;br&gt;• Time to death for any reason, time to death for any CV reason, and time to death due to worsening HF.</td>
</tr>
</tbody>
</table>

<p>| <strong>Study type:</strong>&lt;br&gt;RCT (1:1) | <strong>Comparator:</strong>&lt;br&gt;Placebo (152) | <strong>Exclusion criteria:</strong>&lt;br&gt;Pts in need of&lt;br&gt;transfusion, if not&lt;br&gt;able to complete&lt;br&gt;6MWT, uncontrolled&lt;br&gt;HTN, infection,&lt;br&gt;malignancy, impaired&lt;br&gt;liver or renal function | <strong>Size:</strong>&lt;br&gt;304 |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>Aim</th>
<th>Inclusion criteria</th>
<th>Intervention</th>
<th>1st endpoint</th>
<th>1st Safety endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAIR-HF</td>
<td>To evaluate the effects of intravenous iron (FCM) on HF symptoms in pts with systolic HF and ID, with and without anemia.</td>
<td>Chronic HF, NYHA class II or III, LVEF ≤40% (or pts in NYHA class II) or ≤45% (or pts in NYHA class III), Hemoglobin level 95–135 g/L, ID</td>
<td>Ferric carboymaltose 200 mg weekly until hemoglobin was corrected (n=304)</td>
<td>PGA at 24 wk</td>
<td>Improvement in the FCM group in PGA and NYHA at wk 4 and 12 (p&lt;0.001)</td>
</tr>
<tr>
<td></td>
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<td>Comparator: Placebo (n=155)</td>
<td>Results: improvement in the FCM group compared to placebo</td>
<td>NYHA class at 24 wk</td>
<td>Mean improvement in 6MWT of 35±8m at 24 wk (p&lt;0.001); also significant improvements at 4 and 12 wk</td>
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<td>50% much or moderately improved vs. 28% (OR for being in a better rank, 2.51; 95% CI: 1.75–3.61; p&lt;0.001)</td>
<td>NYHA class at 24 wk</td>
<td>Safety endpoint: Trend towards fewer HF hospitalizations in the FCM group (p=0.08)</td>
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<tr>
<td></td>
<td></td>
<td>Results: improvement in the FCM arm compared to placebo</td>
<td>47% with NYHA I or II vs. 30% in the placebo arm (OR for improvement by 1 class, 2.40; 95% CI: 1.55–3.71; p&lt;0.001)</td>
<td>Limitation: pts with severe anemia were excluded</td>
<td></td>
</tr>
<tr>
<td>RED-HF</td>
<td>To assess effects of darbepoetin alfa on pts with systolic HF and anemia.</td>
<td>NYHA class II, III, or IV HF; LVEF≤40%; Hgb: 9.0–12.0 g/dL; on guideline-recommended HF treatment.</td>
<td>Darbepoetin alfa (1,136)</td>
<td>Composite of death from any cause or hospitalization for worsening HF</td>
<td>Limitation: pts with severe anemia were excluded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exclusion criteria: Transferrin saturation &lt;15%, bleeding or other causes of anemia, serum creatinine &gt;3 mg/dL, BP</td>
<td>Comparator: Placebo (1,142)</td>
<td>Results: 1st outcome occurred in 576 pts in the darbepoetin alfa group vs. 562 in the placebo group (HR: 1.01; 95% CI: 0.90–1.13; p=0.87)</td>
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<td>Increased thromboembolic adverse events in the treatment group (p=0.01);</td>
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</table>
### Data Supplement E. RCTs Comparing HTN (Section 9.5)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2º Endpoint (if any); Study Limitations; Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xie et al. 2016 (89) 26559744</td>
<td>Aim: To assess the efficacy and safety of intensive BP lowering strategies. Study Type: SR and meta-analysis Size: 19 trials with 44,989 pts; 3.8 y of follow-up.</td>
<td>Inclusion Criteria: RCTs with different BP targets or different BP changes between more vs. less intense therapy with at least 6 mo follow-up. Exclusion Criteria: Trials that did not assess a different target or relevant outcome.</td>
<td>5 RCTs (6,960 pts) enrolled only pts with DM and 6 trials (2,809 pts) specifically recruited pts with CKD.</td>
<td>1º Outcomes: Major CV events, defined as MI, stroke, HF or CV death, separately and combined; nonvascular and all-cause mortality; ESRD; and adverse events; new onset microalbuminuria/macroalbuminuria or change from micro- to macroalbuminuria and retinopathy in pts with DM. Results: Pts in the more intensive BP-lowering treatment group had mean BP 133/76 mm Hg compared with 140/81 mm Hg in the less intensive group. Intensive BP-lowering treatment achieved RR reductions for major CV events: 14% (95% CI: 4, 22), MI: 13% (95% CI: 0, 24), stroke: 22% (95% CI: 10, 32), albuminuria: 10% (95% CI: 3, 16), and retinopathy progression: 19% (95% CI: 0–34). However, more</td>
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<td>Study Limitations: Only 6,960 pts with DM were included in the total study size of 44,989 pts.</td>
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<tr>
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<td>Conclusions: The absolute CV benefits were greatest in trials in which all enrolled pts had vascular disease, renal disease or DM. However, only 6,960 of the 44,989 pts had DM and no subanalysis for DM was provided; however, the outcome benefits were qualitatively most striking for pts with DM, CKD and/or vascular disease.</td>
</tr>
</tbody>
</table>
intensive treatment had no clear effects on HF: RR: 15% (95% CI: -11, 34), CV death: 9% (-11, 26),
total mortality: 9% (95% CI: -3, 19), or ESRD: 10% (95% CI: -6, 23). The reduction in major CV
events was consistent across pt groups, and additional BP lowering had a clear benefit even
in pts with SBP <140 mm Hg. The absolute benefits were greatest in trials in which all enrolled pts had
vascular disease, renal disease, or DM. Serious adverse events
associated with BP lowering were
only reported by 6 trials and had an event rate of 1.2% per y in
intensive BP lowering group pts,
compared with 0.9% in the less
intensive treatment group (RR: 1.35 (95% CI: 0.93, 1.97)).
Severe hypotension was more
frequent in the more intensive
treatment regimen (RR: 2.68 (95% CI: 1.21, 5.89), p=0.015),
but the absolute excess was
small (0.3% vs. 0.1% per pt-y for
the duration of follow-up).

### SPRINT
Wright et al. 2015
(90) 26551272

| Aim: | To test the effectiveness of a goal SBP <120 mm Hg vs. a goal SBP <140 mm Hg for the prevention of CVD in pts with SBP ≥130 mm Hg at BL. |
| Inclusion criteria: | SBP ≥130 mm Hg, with upper limit varying as number of pre-trial BP-lowering meds increased. Age ≥50 y Presence of at least 1: • Clinical or subclinical CVD |
| Intervention: | Intensive BP lowering treatment to goal SBP <120 mm Hg (4,678) |
| 1st Endpoint: | • Composite of MI, non-MI ACS, stroke, ADHF, CV death; HR: 0.75 (95% CI: 0.64, 0.89) |
| Comparison: | • Standard BP lowering treatment to goal SBP <140 mm Hg (4,678) • Net treatment difference ~3 drugs (2.8) on average vs. 2 drugs (1.8) on |
| Summary: | • More intensive SBP lowering to a goal of <120 mm Hg with achieved mean of ~121 mm Hg resulted in less CVD and lower total mortality over 3.26 y in comparison with a goal SBP <140 mm Hg and achieved SBP of ~135 mm Hg. • There were small increases in some expected SAEs. Perhaps unexpected, a sizable increase in...
<table>
<thead>
<tr>
<th>RCT</th>
<th><strong>Size:</strong> 9361 pts followed median of 3.26 y.</th>
</tr>
</thead>
</table>
| **Exclusion criteria:** | • CKD stage 3 or greater  
• Age ≥75  
• Framingham General CVD risk ≥15% in 10 y  

| **Average** | • During the trial, mean SBP was 121.5 vs. 134.6. |
| **Other endpoints:** | p=0.003)  
• Total deaths HR: 0.73 (95% CI: 0.60–0.90)  
• 1° or death HR: 0.78 (95% CI: 0.67–0.90)  
• Components of 1° composite mostly consistent in direction other than ACS – no difference.  

| **CKD outcomes:** | • 1° in CKD pts: reduction in GFR of ≥50% or ESRD HR: 0.89 (95% CI: 0.42, 1.87)  
• Incident albuminuria HR: 0.72 (95% CI: 0.48, 1.07)  
• In pts without CKD: reduction in GFR ≥30% and to <60 HR: 3.49 (95% CI: 2.44–5.10)  
• Incident albuminuria HR: 0.81 (95% CI: 0.63–1.04)  

| **Adverse events:** | • SAEs: 1.04, p=0.25  
• Significant absolute increases seen in intensive group for hypotension (1%), syncope (0.6%), electrolyte abnormality (0.8%), AKI/ARF (1.6%) over the study period.  
• 1.7% fewer pts had orthostatic hypotension in intensive group, p=0.01. |

| **Limitations:** | Few pts were untreated at BL ~9%, so SPRINT provides little if any insight at present regarding BP lowering medication initiation for untreated people with SBP 130–139. |
### SPRINT Senior Williamson et al. 2016 (91) 27195814

**Aim:**
Intensive SBP goal <120mmHg vs standard (SBP goal <140)

**Study Type:**
RCT

**Size:**
2,636

30% met criteria for being classified as ambulatory frail

**Mean follow-up:**
3.1 y

**Inclusion:**
Men and women age 75+; mean age 79.8 y; 38% women; 17% black, 74% Caucasian; Exclusions: Nursing home residents; diabetes, Stroke, symptomatic HF in past 6 mo or EF <35%, dx or treatment of dementia, unintentional wt loss >10% in past 5 mo. SBP<110 after standing 1 min, expected survival <3y

**Intervention:**
Medications and dietary advice to achieve SBP of <120 mm Hg

**Comparator:**
Medications and dietary advice to achieve SBP of <140 mm Hg

**Achieved SBP:**
Intensive= 123.4 mm Hg Standard= 134.8 mm Hg

**1 endpoint:**
Composite CVD outcome (AMI, non-MI ACS, Stroke, HF, CVD death.

**Results:**
102 events in the intensive treatment group vs 148 events in the standard treatment group; HR: 0.66; 95%CI: 0.51–0.85 and all-cause mortality (73 deaths vs. 107 deaths, respectively; HR: 0.67; 95%CI: 0.49–0.91. No significant difference in falls, orthostatic hypotension, or overall SAEs. NNT for primary outcome=27 and NNT for all-cause mortality=41

**Limitations:**
Does not apply to nursing home patients or those with dementia

**Conclusions:**
Intensive SBP is safe and effective for lowering CVD events and total mortality in persons age 75 and older

### TOPCAT Regional Analysis

Pfeffer et al. 2015 (84) 25406305

Post-hoc analysis that captures differences in outcomes by geography

**Aim:**
To assess regional differences in the effects of spironolactone in pts with HFpEF.

**Study type:**
RCT

**Size:**
3,445

**Inclusion criteria:**
Symptomatic HF, Age ≥50y, LVEF ≥45% stratified according to • HF Hospitalization within past y • Elevated NPs

**Exclusion criteria:**
Renal disease (eGFR <30 or creatinine >22 μmol/L (2.5 mg/dL), systemic illness with life expectancy <3 y. Specific co-existing

**Intervention:**
Spironolactone (1,722)

**Comparator:**
Placebo (1,723)

**1^ endpoint and results:**
- Composite of CV mortality, HF hospitalization, or aborted cardiac arrest across regions.
- 1^ outcome events in 522 (29.5%) pts in the Americas and 149 (8.9%) in Russia/Georgia. 1^ outcome event rates with spironolactone and placebo 10.4/100 pt y and 12.6/100 pt y in the Americas and 2.5/100 pt y and 2.3/100 pt y in Russia/Georgia. HR spironolactone vs. placebo 0.82; 95% CI: 0.69–0.98; p=0.026) in the Americas and 1.10 95% CI: 0.79–1.51; p=0.12) in Russia/Georgia.

- Spironolactone had markedly greater effects on BP (4.2 mm Hg drop vs. 0.6 mm Hg; p<0.001, potassium change relative to placebo (0.26 mmol/L vs. 0.08 mmol/L), and increase in creatinine (0.10 vs. 0.02 mg/dL; p<0.001)

- Limitations: post-hoc analysis

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| Law et al., 2009 (92) 19454737 | **Study type:** Meta-analysis of use of BP lowering drugs in prevention of CVD from 147 randomized trials.  
**Size:** Of 147 randomized trials of 464,000 pts, 37 trials of beta blockers in CAD included 38,892 pts, and 37 trials of other antihypertensive drugs in CAD included 85,395 pts. | **Inclusion criteria:** The database search used Medline (1966-Dec. 2007 in any language) to identify randomized trials of BP lowering drugs in which CAD events or strokes were recorded. The search also included the Cochrane Collaboration and Web of Science databases and the citations in trials and previous meta-analyses and review articles.  
**Exclusion criteria:** Trials were excluded if there were <5 CAD events and strokes or if treatment duration was <6 mo. | **1st endpoint:** CAD events; stroke  
**Results:** In 37 trials of pts with a history of CAD, beta blockers reduced CAD events 29% (95% CI: 22%–34%). In 27 trials in which beta blockers were used after acute MI, beta blockers reduced CAD events 31% (95% CI: 24%–38%), and in 11 trials in which beta blockers were used after long term CAD, beta blockers insignificantly reduced CAD events 13%. In 7 trials, beta blockers reduced stroke 17% (95% CI: 1%–30%). CAD events were reduced 14% (95% CI: 2%–25%) in 11 trials of thiazide diuretics, 17% (95% CI: 11%–22%) in 21 trials of ACE inhibitors, insignificantly 14% in 4 trials of angiotensin receptor blockers, and 15% (95% CI: 8%–22%) in 22 trials of CCBs. Stroke was reduced 38% (95% CI: 28%–47%) in 10 | • With the exception of the extra protective effect of beta blockers given shortly after a MI and the minor additional effect of CCBs in preventing stroke, all the classes of BP lowering drugs have a similar effect in reducing CAD events and stroke for a given reduction in BP. |
<table>
<thead>
<tr>
<th>Study</th>
<th>Aim</th>
<th>Inclusion criteria</th>
<th>Intervention/Comparator</th>
<th>1st endpoint</th>
<th>Relevant 2nd Endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aronow et al. 1997 (93) 9230162</td>
<td><strong>Aim:</strong> To determine the effect of propranolol vs. no propranolol on mortality plus nonfatal MI in pts with prior MI and HF&lt;sub&gt;pEF&lt;/sub&gt;</td>
<td><strong>Inclusion criteria:</strong> Pts ≥62 y with MI and LVEF ≥40% and HF NYHA class II or III treated with diuretics and ACE inhibitors for 2 mo</td>
<td><strong>Intervention:</strong> 79 pts were randomized to treatment with propranolol vs. no propranolol. <strong>Comparator:</strong> 79 pts were randomized to no propranolol. All pts continued diuretic and ACE inhibitor therapy.</td>
<td><strong>1st endpoint:</strong> At 32-mo mean follow-up, multivariate Cox regression analysis showed that compared with no propranolol, propranolol reduced mortality 35% (p=0.03) and mortality plus nonfatal MI 37% (p=0.018)</td>
<td><strong>Relevant 2nd Endpoint:</strong> At 1-y follow-up, LVEF was increased by propranolol from 57% to 63% (p&lt;0.001) and LV mass was decreased by propranolol from 312 grams to 278 grams (p=0.001) Propranolol was stopped because of adverse effects in 11 of 79 pts (14%)</td>
</tr>
<tr>
<td>Van Veldhuisen et al. 2009 (94) 19497441</td>
<td><strong>Aim:</strong> To determine the effect of nebivolol vs. placebo in pts with HF&lt;sub&gt;rEF&lt;/sub&gt; and HF&lt;sub&gt;pEF&lt;/sub&gt;</td>
<td><strong>Inclusion criteria:</strong> Pts ≥70 y history of HF and HF&lt;sub&gt;rEF&lt;/sub&gt; or HF&lt;sub&gt;pEF&lt;/sub&gt;</td>
<td><strong>Intervention/Comparator:</strong> 1,359 pts with a history of HF&lt;sub&gt;rEF&lt;/sub&gt; and 752 pts with a history of HF&lt;sub&gt;pEF&lt;/sub&gt; were randomized to nebivolol or to placebo</td>
<td><strong>1st endpoint:</strong> At 21-mo follow-up, the primary endpoint of all-cause mortality or CV hospitalization was reduced by nebivolol 14% (95% CI: 0.72–1.04) in pts with HF&lt;sub&gt;rEF&lt;/sub&gt; and 19% (95% CI: 0.63, 1.04) in pts with HF&lt;sub&gt;pEF&lt;/sub&gt;</td>
<td><strong>Relevant 2nd Endpoint:</strong> HR for reduction of all-cause mortality by nebivolol: 0.84 (95% CI: 0.66–1.08) for HF&lt;sub&gt;rEF&lt;/sub&gt; and 0.91 (95% CI: 0.62–1.33) for HF&lt;sub&gt;pEF&lt;/sub&gt;</td>
</tr>
<tr>
<td>Yusuf et al. 2003 (78) 13678871</td>
<td><strong>Aim:</strong> To determine the effects of candesartan vs. placebo in pts with HF&lt;sub&gt;pEF&lt;/sub&gt;</td>
<td><strong>Inclusion criteria:</strong> 3,023 pts, mean age 67 y, with HF&lt;sub&gt;pEF&lt;/sub&gt; and NYHA class II-IV HF</td>
<td><strong>Intervention/Comparator:</strong> 3,023 pts were randomized to candesartan or placebo</td>
<td><strong>1st endpoint:</strong> At 36.6 m follow-up, the primary outcome of CV death or hospitalization for HF was reduced 11% (p=0.118) by candesartan</td>
<td><strong>Relevant 2nd Endpoint:</strong> Hospitalization was reduced 16% (p=0.047) by candesartan</td>
</tr>
<tr>
<td>Massie et al. 2008 (80) 19001508</td>
<td><strong>Aim:</strong> To determine the effect of irbesartan vs. placebo on all-cause mortality or hospitalization for a CV cause in pts with HF&lt;sub&gt;pEF&lt;/sub&gt;</td>
<td><strong>Inclusion criteria:</strong> Pts 60 y and older with HF&lt;sub&gt;pEF&lt;/sub&gt; and NYHA class II, III, or IV HF</td>
<td><strong>Intervention/Comparator:</strong> 4,128 pts were randomized to irbesartan or placebo</td>
<td><strong>1st endpoint:</strong> At 49.5-mo follow-up, the primary outcome of all-cause mortality or hospitalization for CV cause was reduced 5% by irbesartan (p=0.35)</td>
<td><strong>Relevant 2nd Endpoint:</strong> Irbesartan did not significantly reduce the secondary outcomes of death from HF or hospitalization for HF, death from any cause and from CV causes, and quality of life</td>
</tr>
</tbody>
</table>

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### Data Supplement F. Nonrandomized Trials for Hypertension (Section 9.5)

<table>
<thead>
<tr>
<th>Study Acronym; Author; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Primary Endpoint and Results (P values, OR or RR &amp; 95% CI)</th>
<th>Summary / Conclusion / Comments</th>
</tr>
</thead>
</table>
| Thomopoulos et al. 2016 (96) 26848994 | Meta-analysis of RCT’s of more versus less intense BP control | 16 trials (52,235 pts) compared more vs. less intense treatment 34 (138,127 pts) active vs. placebo | More intense BP  
  - Stroke RR: 0.71; 95% CI: 0.60–0.84  
  - Coronary heart disease RR: 0.80; 95% CI: 0.68–0.95  
  - Major CV events RR: 0.75; 95% CI: 0.68–0.85  
  - CV mortality RR: 0.79; 95% CI: 0.63–0.97  
  Stratification of SBP cutoffs (150, 140 and 130) | • Intensive BP reduction improves CV outcomes compared to less intense  
  • Achieved BP of <130/80 mm Hg may be associated with CV benefit. |

Date: Chairs selected trials in October 2016.
Data Supplement G. RCTs Comparing Treatment of Sleep Disorders (CPAP makers) (Section 9.6)

<table>
<thead>
<tr>
<th>Study Acronym; Year Published</th>
<th>Aim of Study; Study Type; Study Size (N)</th>
<th>Patient Population</th>
<th>Study Intervention (# patients) / Study Comparator (# patients)</th>
<th>Endpoint Results (Absolute Event Rates, P values; OR or RR; &amp; 95% CI)</th>
<th>Relevant 2° Endpoint; Study Limitations; Adverse Events</th>
</tr>
</thead>
</table>
| SAVE McEvoy et al. 2016 (97) 27571048 | Aim: To whether treatment with CPAP prevents major CV events. Study type: RCT with 1 wk run-in on sham CPAP Size: n=2,717 | Inclusion criteria:  
- Adults 45 - 75 y of age  
- Moderate-to-severe OSA  
- Coronary or cerebrovascular disease  
Exclusion criteria: | Intervention: CPAP treatment plus usual care (CPAP group) Comparator: Usual care alone (usual-care group) | 1° endpoint:  
Composite of death from CVD, MI, stroke, or hospitalization for UA, HF, or TIA Results:  
- Duration of CPAP=3.3 h/night;  
AHI events/h decreased from baseline to end of follow up at 3.7 y, 29.0–3.7 events/h  
- Primary endpoint – no significant difference in CPAP vs usual-care group (n=229, 17.0% vs. n=207; 15.4%; HR: 1.10 with CPAP; 95% CI: 0.91–1.32; p=0.34).  
- No significant difference in any individual or other composite CV end point.  
- CPAP significantly reduced snoring and daytime sleepiness and improved health-related quality of life and mood. | Secondary end points:  
- Other CV outcomes  
- Health-related quality of life  
- Snoring symptoms  
- Daytime sleepiness  
- Mood  
Study Limitations:  
- Primarily men with moderate-to-severe OSA and minimal sleepiness  
Adverse Events: |
| ORBIT-AF Holmqvist et al. 2015 (98) 25965712 | Aim: 1) Define frequency of diagnosed | Inclusion criteria:  
- ≥18 years of age  
- Electrocardiographic evidence of AF  
Comparat or: N/A | Intervention: N/A Comparator: N/A | 1° endpoint:  
- All-cause mortality;  
- First all-cause hospitalization;  
- Composite of first event of CV | Secondary end points: N/A  
Study Limitations: |
### OSA among nationwide AF population;
2) Determine whether OSA is associated w/:
   a) Worse outcomes;
   b) Arrhythmic AF progression; &
3) Determine whether CPAP treatment is associated w/ outcomes in patients w/ AF & OSA.

**Study type:**
- Prospective descriptive, correlational / comparative, time-series design
- Data collection at enrollment & 6-month intervals for minimum of 2 years

**Size:** Nationally representative

### Exclusion criteria:
- Life expectancy of <6 months or AF secondary to reversible conditions

### Multicenter, ambulatory-based registry

### Results:
**Frequency of diagnosed OSA among nationwide AF population**
- 18% (n = 1,841)

**OSA associations w/ outcomes**
- Higher risk of:
  - Hospitalization (43 vs 35 events/100 patient-years among patients without OSA [adjusted hazard ratio (HR), 1.12; 95% confidence interval (CI), 1.03-1.22; p = .0078])
- No higher risk of:
  - Death (HR, 0.94; 95% CI, 0.77-1.15; p = .54);
  - Composite of CV death, stroke/non–central nervous system embolism, TIA, or MI (HR, 1.07; 95% CI, 0.85-1.34; p = .57);
  - First major bleeding (HR, 1.18; 95% CI, 0.96-1.46; p = .11)

**OSA associations w/ AF progression**
- Not associated w/ higher risk of AF progression (HR, 1.06; 95% CI, 0.89-1.28; p = .51).

**CPAP treatment association w/ outcomes in patients w/ AF & OSA**
- Less likely to progress to more permanent forms of AF versus patients w/out CPAP (HR, 0.66; 95% CI, 0.46-0.94; p = .021).

**Adverse Events:**
- N/A
sample enrolled consecutively
- n=10,132 w/ AF
  - n=1,841 w/ AF & OSA
  - n=1,837 patients w/ OSA & complete CPAP data
- n=1,763 patients w/ OSA & 2-year outcomes data
- n=937 patients w/ AF, OSA, & CPAP treatment

Sites: 176 national sites that w/ provider & geographic heterogeneity

SERVE-HF
Cowie et al. 2015 (99) 26323938
- ResMed
- The Clinical Research Institute GmbH

<table>
<thead>
<tr>
<th>Aim:</th>
<th>Inclusion criteria:</th>
<th>Intervention:</th>
<th>1&lt;sup&gt;o&lt;/sup&gt; endpoint:</th>
<th>2&lt;sup&gt;o&lt;/sup&gt; Endpoint</th>
</tr>
</thead>
</table>
| Effects of adaptive servo-ventilation in HF pts with reduced EF and CSA | - Chronic HF (defined as ≥12 wk since diagnosis) according to current ESC guidelines  
- LVEF ≤45%  
- Hypopnea index of ≥10/h  
- Stable, GDMT  
- NYHA class III or IV, or NYHA class II with ≥1 hospitalization for HF in the last 24 mo  
- No hospitalization for HF in 4 wk prior to enrolment | Adaptive servo-ventilation use ≥5h/night, 7d/wk. (n=666) | - Death from any cause  
- Lifesaving CV intervention (cardiac transplantation, implantation of a ventricular assist device, resuscitation after sudden cardiac arrest, or appropriate lifesaving shock) or  
- Unplanned hospitalization for HF | - CV death  
- Unplanned hospitalization from any cause  
- Time to death from CV causes  
- Change in NYHA class  
- Change in 6-MWT (both at follow-up visits).  
- General QoL (EuroQOL)  
- HF-specific QoL (MLWHF)  
- Daytime sleepiness |

Comparator: GDMT (n=659)
1,325

- Optimized GDMT
- No new class of disease-modifying drug for prior ≥4 wk
- AHI >15/h with ≥50% central events and a central AHI ≥10/h

Exclusion criteria:
- Significant COPD with a forced expiratory volume in 1 s in 4 wk before randomization
- O₂ saturation ≤90% at rest during d
- Currently receiving PAP therapy
- Cardiac surgery, PCI, MI or UA within the previous 6 mo
- Cardiac resynchronization therapy implantation scheduled or performed within 6 mo prior to randomization
- TIA or stroke within the previous 3 mo
- 1° hemodynamically-significant uncorrected VHD (obstructive or regurgitant) or any valvular disease expected to require surgery during the trial;
- Acute myocarditis/pericarditis within the previous 6 mo
- Untreated or therapy-refractory restless legs syndrome
- Contraindication to the use of AutoSet CS2 because of symptomatic hypotension or significant intravascular volume depletion or pneumothorax or pneumomediastinum
- Pregnancy

- Control (29.3%; HR: 1.28; 95% CI: 1.06–1.55; p=0.01).
- CV mortality was higher with the intervention (29.9%) than control (24.0%; HR: 1.34; 95% CI: 1.09–1.65; p=0.006).
- 6MWT decreased over time and were significantly lower with the intervention than with the control (p=0.02).
- Daytime sleepiness decreased over time and was significantly lower with the intervention than with the control (p<0.001).

Non-Significant Results
- Unplanned hospitalization for HF was not significantly higher with the intervention (43.1%) than control (41.3%; HR: 1.13; 95% CI: 0.95–1.33; p=0.16)
- Of the lifesaving CV interventions, none were significantly higher with the intervention than control (p=0.08–0.61)
- Unplanned hospitalization for any cause was not significantly lower with the intervention (67.9%) than control (68.0%; HR: 1.05; 95% CI: 0.92–1.20; p=0.47)
- The NYHA class change was not significantly different with the intervention than with the control (p=0.46)
- General QoL trends were not significantly higher with the intervention than with the control (p=0.09).
- HF-specific QoL trends were not significantly higher with the

Limitations:
- Unblinded study - more likely to favor treatment group, particularly for QOL, but no QOL improvement seen
- HF pts with reduced EF only
- HF pts with predominantly CSA not obstructive sleep apnea.
- Sample had very limited # of women but reflects epidemiology of CSA with HF/EF

© 2017 American College of Cardiology Foundation, the American Heart Association, Inc., and the Heart Failure Society of America.
Aim: Investigate whether suppression of CSA below threshold by CPAP would LVEF & ht tx–free survival.

Study type: Post hoc analysis of RCT

Size: 100

Inclusion criteria:
- Age 18 to 79 y
- NYHA II-IV
- HF due to ischemic, hypertensive, or idiopathic DCM
- Stabilized w/ optimal medical therapy for ≥1 mo
- LVEF <40%
- CSA

Exclusion criteria:
- Pregnancy
- MI
- Unstable angina
- Cardiac surgery w/in 3 mo of enrollment
- OSA

Intervention:
- CPAP=CSA suppressed, n=57
- CPAP=CSA suppressed, n=43

Comparator:
Control, n=110:

1º endpoint:
- Transplant free survival - Combined rate of all-cause mortality & ht tx

Significant Results
1º endpoint:
- Significantly different between 3 groups (p=0.016)
- Significantly higher in CPAP-suppressed vs. control group (p<0.043)
- No difference between CPAP-unsuppressed vs. control group (p<0.26)

2º endpoint:
- AHI
  - AHI significantly > reduction in both CPAP-suppressed (p<0.001) and CPAP-unsuppressed (p<0.001) groups
  - AHI significantly > reduction in CPAP-suppressed (p<0.001) and CPAP-unsuppressed (p<0.002) than control groups

Mean nocturnal SaO2
- Mean nocturnal SaO2 significantly > increased in CPAP-suppressed vs. control group (p<0.001)
- No significant difference between CPAP-unsuppressed and control group

LVEF

Limitations:
- Post hoc analysis
- Stratification of CPAP-treated pts based on polysomnogram performed 3 mo after randomization.
- Because suppressed and unsuppressed status could not be ascertained until completion of PSG, events that occurred during the first 3 mo could not be included
- The CPAP-CSA–suppressed group was younger, had a lower AHI, and had a slightly lower proportion of central events than the CPAP CSA–unsuppressed group
### CPAP for CSA & HF (CANPAP)
Bradley et al. 2005 (101) 16282177

<table>
<thead>
<tr>
<th>CPAP for CSA &amp; HF (CANPAP)</th>
<th>Aim: Test long-term treatment of CSA w/ CPAP in HF pts receiving optimal medical therapy on combined rates of death &amp; ht tx.</th>
<th>Inclusion criteria:</th>
</tr>
</thead>
</table>
| **Study type:** 11 center RCT | **Intervention:** CPAP n=128 Comparator: No CPAP n=130 | **1° endpoint:** Transplant free survival
**Comparator:** No CPAP n=130 |
| **Size:** 258 | **Exclusion criteria:** |
| | *18-79 y*
*NYHA II-IV*
*HF due to ischemia*
*HTN, Idiopathic DCM*
*Stable condition*
*Optimal medical therapy for 1+ mon*
*LVEF <40%*
*CSA w/ ≥15 AHI >50% of AHI had to be central.* |

#### Limitations:
- Underpowered because trial stopped early for low enrollment

<table>
<thead>
<tr>
<th><strong>2° endpoints:</strong></th>
</tr>
</thead>
</table>
| *Hospitalizations*
*EF*
*Frequency of apnea and hypopnea episodes*
*Mean nocturnal SaO2*
*6MWT*
*QoL*
*Neurohormones – norepinephrine and atrial NP* |

#### 1° endpoints:
- No significant difference in transplant free survival between CPAP and control groups (p=0.54)

#### 2° endpoints:
- No significant difference in transplant free survival between CPAP-suppressed and control group (p=0.984)
- LVEF significantly increased over time in CPAP-suppressed group (p<0.001)
- LVEF significantly increased in CPAP-suppressed vs. CPAP-unsuppressed (p=0.006) and vs. control (p<0.001) groups.
- No significant difference between CPAP-unsuppressed and control group (p=0.984)
### Ruttanaumpawan et al. 2009
**Aim:** To determine whether attenuation of CSA by CPAP in pts w/ HF reduces the frequency of arousals from sleep or improves sleep structure.

**Study type:** RCT

**Size:** 205

**Inclusion criteria:**
- Age 18 - 79 y of age;
- NYHA II - IV
- HF due to ischemic, hypertensive, or idiopathic DCM, stabilized on optimal medical therapy ≥1 mo
- LVEF <40% by radionuclide angiography
- CSA defined as an AHI ≥15, w/ >50% central apneas & hypopneas

**Exclusion criteria:**
- Pregnancy
- MI
- UA
- Cardiac surgery within 3 mo of enrollment
- OSA

**Intervention:** CPAP n=97
**Comparator:** Control n=108

1° endpoint:
- AHI (central and obstructive)
- Mean and lowest SaO2

#### Significant Results
- Central and obstructive AHI decreased significantly over BL and vs. the control group (p<0.001)
- Mean and lowest SaO2 improved in both the CPAP (p<0.001) and control (p<0.04) but the improvement was significantly better in the CPAP vs. the control group (p<0.001).

2° endpoints:
- No significant improvement in arousals from sleep or sleep structure within or between groups (p=0.14–0.99)

**Limitations:**
- 2° analysis of CANPAP data
- Did not classify arousals as being respiratory or non-respiratory related, and did not examine their timing.

### Kaneko et al. 2003
**Aim:** To determine the effect of CPAP on LVEF when awake and daytime BP in pts with HF and OSA

**Study type:** RCT

**Intervention:** CPAP n=12
**Comparator:** Control n=12

1° endpoint:
- LVEF when awake
- LVEDD
- LVESD
- Heart rate
- Daytime BP

#### Significant Results
- LVEF when awake

2° endpoint:
- BMI
- Episodes of apnea and hypopnea
- Total
- Obstructive
- Central
- Desaturation index (# hr of sleep)
- Lowest oxyhemoglobin saturation (%)
<table>
<thead>
<tr>
<th><strong>Size:</strong> 24</th>
<th>OSA defined as ≥20 episodes of apnea and hypopnea/h of sleep of which &gt;50% were obstructive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exclusion criteria:</strong></td>
<td></td>
</tr>
<tr>
<td>• 1° valvular heart disease;</td>
<td></td>
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<tr>
<td>• Presence of implanted cardiac pacemaker;</td>
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<tr>
<td>• UA;</td>
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<tr>
<td>• MI;</td>
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<tr>
<td>• Cardiac surgery within 3 mo of enrollment</td>
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<tr>
<td></td>
<td><strong>Significant increase in CPAP</strong> (p&lt;0.001) but not control group and difference between groups was significant (p=0.009)</td>
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<tr>
<td></td>
<td><strong>LVEDD</strong></td>
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<tr>
<td></td>
<td>• No significant difference for either group or between groups</td>
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<tr>
<td></td>
<td><strong>LVESD</strong></td>
</tr>
<tr>
<td></td>
<td>• Significant reduction in CPAP (p=0.009) but not control group and difference between groups was significant (p=0.02)</td>
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<td></td>
<td><strong>Heart Rate</strong></td>
</tr>
<tr>
<td></td>
<td>• Significant decrease in CPAP (p=0.007) but not control group and difference between groups was significant (p=0.02)</td>
</tr>
<tr>
<td></td>
<td><strong>Daytime BP</strong></td>
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<tr>
<td></td>
<td>• Significant decrease in systolic BP in CPAP (p=0.02) but not control group and difference between groups was significant (p=0.008)</td>
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<tr>
<td></td>
<td>• No significant difference in diastolic BP for either group or between groups</td>
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<tr>
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<td><strong>2° endpoint:</strong></td>
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<tr>
<td></td>
<td>BMI</td>
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<tr>
<td></td>
<td>• No significant difference for either group or between groups</td>
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<tr>
<td></td>
<td><strong>Episodes of apnea and hypopnea</strong></td>
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<td></td>
<td><strong>Total</strong></td>
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<tr>
<td></td>
<td><strong>BMI</strong></td>
</tr>
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<td></td>
<td>• No significant difference for either group or between groups</td>
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<tr>
<td></td>
<td><strong>Total sleep time</strong></td>
</tr>
<tr>
<td></td>
<td>• Stage I and II sleep (% of total sleep time)</td>
</tr>
<tr>
<td></td>
<td>• Stage III and IV sleep (% of total sleep time)</td>
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<tr>
<td></td>
<td>• REM sleep (% of total sleep time)</td>
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<tr>
<td></td>
<td>• Arousals/hr of sleep</td>
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<td></td>
<td><strong>Limitations:</strong></td>
</tr>
<tr>
<td></td>
<td>• No placebo</td>
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<tr>
<td></td>
<td>• Small sample size</td>
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<td>• Pts unblinded to group</td>
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</tbody>
</table>
was significant (p=0.002)

**Obstructive**
- Significant reduction in CPAP (p<0.001) but not control group and difference between groups was significant (p<0.001)
- Central
  - No significant difference for CPAP group or between groups

**Desaturation index (# hr of sleep)**
- Significant reduction in CPAP (p<0.001) but not control group and difference between groups was significant (p=0.008)

**Lowest oxyhemoglobin saturation (%)**
- Significant increase in CPAP (p=0.004) but not control group and difference between groups was significant (p=0.01)

**Total sleep time**
- No significant difference for CPAP group or between groups

**Stage I and II sleep (% of total sleep time)**
- No significant difference for CPAP group or between groups

**Stage III and IV sleep sleep (% of total sleep time)**
- No significant difference for CPAP group or between groups

**REM sleep (% of total sleep time)**
<table>
<thead>
<tr>
<th>Mansfield et al. 2004 (104) 14597482</th>
<th>Aim: To assess long-term effect of OSA treatment with nocturnal CPAP on systolic heart function, sympathetic activity, BP, and QoL in pts with HF</th>
<th>Inclusion criteria:</th>
<th>Intervention: CPAP X 3 mo n=19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study type: RCT</td>
<td>Size: 44</td>
<td>Intervention:</td>
<td>Comparator: Control n=21</td>
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<td>1° endpoint:</td>
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<td>LVEF</td>
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<td>Overnight urinary norepinephrine excretion</td>
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<td>BP</td>
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<td>QoL</td>
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<td>Significant Results 1° endpoint:</td>
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<td>LVEF</td>
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<td>Significant improvement in CPAP group (p&lt;0.001) and vs. control group (p=0.04)</td>
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<td>Overnight urinary norepinephrine excretion</td>
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<td>Significant reduction in CPAP group (p&lt;0.05) and vs. control group (p=0.036)</td>
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<td>BP</td>
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<td>No significant difference in CPAP group or between groups</td>
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<td>QoL</td>
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<td>Significant improvements in most domains within CPAP group</td>
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<td>SF-36</td>
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<td>Significant improvements between groups in 4/8 domains</td>
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<td></td>
<td></td>
<td>o Physical (p=0.03)</td>
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<td>o Vitality (p=0.02)</td>
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<td>o Social (p=0.03)</td>
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<td>o Mental health (p=0.01)</td>
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<td>2° endpoint:</td>
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<td>Peak Vo2</td>
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<td>NYHA class</td>
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<td>Epworth sleepiness scale</td>
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<td>BMI</td>
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<td>AH1 events per h</td>
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<td></td>
<td></td>
<td>Minimum SpO2 saturation</td>
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<td>Limitations:</td>
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<td></td>
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<td>No placebo</td>
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<td>Significant difference between groups in peak Vo2 and mean BP at BL</td>
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<td>Dropout rate = 27%</td>
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<td>Higher than expected death rate</td>
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<td>Higher than expected rate of interventions initiated that may have effected end points</td>
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<td>Small sample size with only 3 females</td>
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</tbody>
</table>
| Chronic HF questionnaire | **Significant improvements between groups in 3/4 domains**  
| | | Fatigue (p=0.01)  
| | | Emotional well-being (p=0.02)  
| | | Disease mastery (p=0.02)  
| **2° endpoint:** | Peak VO₂  
| | No significant difference in CPAP group or between groups  
| NYHA class | No significant difference CPAP group or between groups  
| Epworth sleepiness scale | Significant reduction in CPAP vs. control group (p=0.01)  
| BMI | No significant difference CPAP group or between groups  
| **AHI events per h** | Significant reduction in CPAP group (p<0.001) and vs. control group (p<0.001)  
| **Minimum SpO₂ saturation** | Significant improvement in CPAP group (p<0.001) and vs. control group (p=0.001)  

*Date:* Study selected by the chairs in December 2015 and some trials added by the writing committee.
### 2013 HF Guideline Data Supplement 18. ACE Inhibitors (Section 7.3.2.2)

<table>
<thead>
<tr>
<th>Study Name, Author, Year</th>
<th>Aim of Study</th>
<th>Study Type</th>
<th>Background Therapy</th>
<th>Study Size</th>
<th>Etiology</th>
<th>Patient Population</th>
<th>Endpoints</th>
<th>Mortality</th>
<th>Trial Duration (Years)</th>
<th>Absolute Benefit</th>
<th>P Values &amp; 95% CI:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CONSENSUS 1987 283575 (105)</strong></td>
<td>To Evaluate influence of enalapril on prognosis of NYHA class IV HF</td>
<td>RCT</td>
<td>Diuretics (spironolactone 53%, mean dose 80mg), digitalis (93%), other vasodilators, except ACEI (ie, nitrates 40%)</td>
<td>253; 127;126</td>
<td>Ischemic/Nonischemic</td>
<td>Severe HF/symptoms at rest/NYHA class IV; Increased heart size &gt;600 mL; BP: 120/75; HR: 80; AF 50%</td>
<td>APE; hemodynamically import aortic/MV stenosis; MI w/in prior 2 mo Unstable angina; planned cardiac surgery; right HF b/c of pulm disease; Cr &gt;300 mmol/L</td>
<td>Mortality</td>
<td>Change in NYHA-FC, LV size, Cr level</td>
<td>52% placebo group and 36% enalapril group (6 mo mortality: 26% in enalapril group and 44% in placebo group)</td>
<td>0.51 y</td>
</tr>
<tr>
<td><strong>10 y FU of CONSENSUS 1999 2099910 (106)</strong></td>
<td>Report on the survival at the 10-y follow up of the pts randomized in CONSENSUS. (1st study to show prognostic improvement by an ACEI. Pts in NYHA class IV HF treated with enalapril or placebo. After study completion all pts were offered open-label enalapril therapy).</td>
<td>10-y open-label follow-up study (via completion of a questionnaire) on the survival status of pts in CONSENSUS - a RCT.</td>
<td>All pts were offered open-label enalapril therapy</td>
<td>315; 77; 58</td>
<td>Ischemic Heart disease</td>
<td>253 randomized pts included in analysis of time from randomization to death; Survivors (135) of the double-blind period included in analysis of the time from end of double-blind period to death; Severe, NYHA IV</td>
<td>Mortality</td>
<td>5 pts, all in the enalapril group, were long-term survivors (p=0.004). Averaged over the trial (double-blind plus open-label extension) risk reduction was 30% (p=0.008), 95% CI: 11% - 46%. At end of double-blind study period, mortality considerably higher among pts not receiving open ACEI therapy</td>
<td>10 y</td>
<td>3.45 y</td>
<td></td>
</tr>
<tr>
<td><strong>SOLVD 1991 2067034 (107)</strong></td>
<td>Study the effect of enalapril on mortality and hospitalization in pts with chronic HF and EF &lt;35%</td>
<td>RCT</td>
<td>Diuretics + Digoxin</td>
<td>2569; 1285; 1284</td>
<td>Ischemic heart disease</td>
<td>LVEF &lt;35%; Mild to severe (11% class IV=2% class IV); LVEF &gt;25%; BP: 125/77; HR: 80; AF: 8-12%</td>
<td>Age &gt;80 y; Unstable angina; MI w/in past mo; Cr&gt;2.0 mg/dL</td>
<td>Mortality</td>
<td>Hospitalizations; Incidence of MI; Mortality by specific causes; Combined mortality and morbidity from both SOLVD+SOLVD-</td>
<td>15.70%</td>
<td>Treating 1000 SOLVD+ pts with enalapril for 3 y would save ~50 premature deaths and 350 hospitalizations. Reduced mortality by 18% (95% CI, 5-26%; p=0.0036)</td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Description</td>
<td>Design</td>
<td>No.</td>
<td>History and Treatment</td>
<td>EF &lt;35%</td>
<td>As per SOLVD+</td>
<td>Mortality; Combined mortality and the incidence of HF and rate of hospitalization for HF</td>
<td>Incidence of HF and rate of hospitalization for HF</td>
<td>Duration</td>
<td>Reduced mortality: p=0.30; 95% CI: -9.21%</td>
</tr>
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</tr>
<tr>
<td>SOLVD 1992</td>
<td>146330</td>
<td>Study effect of ACEIs on total mortality and mortality from CV causes, the development of HF, and hospitalization for HF in pts with EF ≤35%</td>
<td>RCT</td>
<td>No drug treatment for HF</td>
<td>4228; 2111; 2117</td>
<td>History of ischemic heart disease 85%</td>
<td>EF &lt;35%; Asymptomatic; NYHA class I (67%) + II; EF: 28%; BP: 126/78; HR: 75; AF: 4%</td>
<td>As per SOLVD+</td>
<td>3.12 y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOLVD F/U 2003</td>
<td>12768569</td>
<td>12-y FU of SOLVD to establish if the mortality reduction with enalapril among pts with HF was sustained, and whether a subsequent reduction in mortality would emerge among those with asymptomatic ventricular dysfunction.</td>
<td>12-y FU of RCTs [SOLVD+ and SOLVD-]</td>
<td>N/A</td>
<td>N/A</td>
<td>Participation in SOLVD+ and SOLVD-: Asymptomatic to severe; NYHA I-V</td>
<td>N/A</td>
<td>Mortality</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>SOLVD F/U 2003</td>
<td>12768569</td>
<td>12-y FU of SOLVD to establish if the mortality reduction with enalapril among pts with HF was sustained, and whether a subsequent reduction in mortality would emerge among those with asymptomatic ventricular dysfunction.</td>
<td>12-y FU of RCTs [SOLVD+ and SOLVD-]</td>
<td>N/A</td>
<td>N/A</td>
<td>Participation in SOLVD+ and SOLVD-: Asymptomatic to severe; NYHA I-V</td>
<td>N/A</td>
<td>Mortality</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>ATLAS 1999</td>
<td>1999</td>
<td>To compare the efficacy and safety of low and high doses of ACEIs on the risk of death and hospitalization in chronic HF, than the large doses that have been shown to reduce morbidity and mortality in pts with HF. AIM: Investigate if low doses and high doses of ACEIs have similar benefits.</td>
<td>RCT</td>
<td>N/A</td>
<td>N/A</td>
<td>CAD 65%</td>
<td>LVEF &lt;30%; NYHA class II, III, or IV, despite treatment with diuretics for ≥2 mo (Treatment for HF in ED or hospital within 6 mo required for pts in class II); Prior use of digitalis, ACEIs, or vasodilators allowed but not mandated; NYHA I-V (mainly class II); LVEF 23%; SBP 128 mmHg; HR 80; NYHA class: II (few II and IV)</td>
<td>Acute coronary ischemic event or revascularization procedure within 2 mo; History of sustained or symptomatic ventricular tachycardia; Intolerant of ACEIs; SCR &gt;2.5 mg/dL</td>
<td>Mortality from all causes</td>
<td>Combined risk of all-cause mortality and hospitalization for any reason; CV mortality, CV hospitalizations; All-cause mortality combined with CV hospitalizations; CV mortality combined with CV hospitalizations; Combined risk of fatal and nonfatal MI plus hospitalization for unstable angina</td>
<td>S y</td>
</tr>
</tbody>
</table>

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Post-MI ACEI Use

© 2017 American College of Cardiology Foundation, the American Heart Association, Inc., and the Heart Failure Society of America.
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Population</th>
<th>Treatment</th>
<th>Comparator</th>
<th>Outcomes</th>
<th>Duration</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAVE, 1992</td>
<td>RCT</td>
<td>To test the hypothesis that the long-term administration of captopril to survivors of acute MI who had baseline LV dysfunction but did not have overt HF requiring vasodilator therapy would reduce mortality, lessen deterioration in cardiac performance, and improve clinical outcome.</td>
<td>Beta-blockers 36%; Diuretics 26%; Nitrates 51%</td>
<td>Alive 3 d after MI: LVEF &lt;40%; &gt;21 y of age, but &lt;80; Killip class I — 80% (&gt;60% of the pts did not have even transient pulmonary congestion at baseline/the time of their acute MI; EF 31%; BP 113/70; HR 78; Failure to undergo randomization within 16 d after the MI; Relative contraindication to the use of an ACEIs or the need for such an agent; SCR &gt; 2.5 mg/dl</td>
<td>Mortality from all causes</td>
<td>3.5 y</td>
<td>Mortality from all causes was significantly reduced in the captopril group (228 deaths, or 20%) as c/w the placebo group (275 deaths, or 25%); the RR: 19% (95% CI: 3-32%; p=0.019). RR:21% (95% CI, 5-35%; p=0.014) for death from CV causes, 37% (95% CI, 20-50%; p=0.014) for the development of severe HF, 22% (95% CI, 4-37%; p=0.019) for CHF requiring hospitalization, and 25% (95% CI, 5-40%; p=0.015) for recurrent MI.</td>
</tr>
<tr>
<td>AIRE 1993</td>
<td>RCT</td>
<td>Investigated the effect of therapy with ACEI ramipril, on survival in pts who had shown clinical evidence of HF at any time after an acute MI. Also, to compare the incidences of progression to severe or resistant HF, nonfatal reinfection and stroke between the 2 groups.</td>
<td>Aged ≥18 y, with a definite acute MI 3-10 d before randomization; Clinical evidence of HF at any time since acute MI</td>
<td>Use of an ACEI considered to be mandatory</td>
<td>Mortality from all causes</td>
<td>1.3 y</td>
<td>Mortality from all causes was significantly lower for pts on ramipril compared to pts on placebo. RR: 27%; 95% CI: 11-40%; p&lt;0.002. Prespecified secondary outcomes: risk reduction of 19% for the 1st validated outcome—namely, death, severe/resistant HF, MI, or stroke (95% CI: 5% - 31%; p=0.008).</td>
</tr>
</tbody>
</table>
To determine whether pts who LV dysfunction soon after MI benefit from long-term oral ACE inhibition.

RCT

Beta blocker 16%; Calcium antagonist 28%; Diuretic 66%; Nitrates 53%; Digoxin 28%.

Ischemic 100%

Consecutive pts >18 y hospitalized with MI; Criteria for MI: chest pain or electrocardiographi
c changes, accompanied by >2X increase in 1 cardiac enzymes: LV dysfunction (EF <35%);
NYHA class 1 - 41%; BP 121/76; HR 81

Contraindication to ACEI or a definite need for them; Severe, uncontrolled DM; Hyponatremia (<125
mmol/L); Elevated SCr level (2.3 mg/dL)

Death from any cause

Death from a CV cause, sudden death, Progression to severe HF (hospital admission for HF, death due to progressive HF, or HF necessitating open-
label ACEI); Recurrent infarction (fatal or nonfatal); Change in the wall-
motion index (EF)

The mortality from all causes at 1 y was 24%.

The mortality from all causes at 1 y was 24%.

24 lives were saved after 1 mo of treating 1,000 pts

During the study period, 304 pts in the trandolapril group died (34.7%), as did 369 in the placebo group (42.3%). RR: 0.78 (95% CI, 0.67 - 0.91; p=0.001)

In every subgroup, treatment with trandolapril was associated with a reduction in risk.

ACEI indicates angiotensin-converting-enzyme inhibitor; AF, atrial fibrillation; AIRE, Acute Infarction Ramipril Efficacy; APE, acute pulmonary embolism; ATLAS, Assessment of Treatment with Lisinopril and Survival; BP, blood pressure; CAD, coronary artery disease; CHD, chronic heart disease; CHF, congestive heart failure; CONSENSUS Cooperative North Scandinavian Enalapril Survival Study; Cr, creatinine; CV, cardiovascular; CW, compared with; DM, diabetes mellitus; ED, emergency department; FU, follow-up; HF, heart failure.

<table>
<thead>
<tr>
<th>Study Name, Author, Year</th>
<th>Aim of Study</th>
<th>Study Type</th>
<th>Background Therapy</th>
<th>Study Size</th>
<th>Etiology</th>
<th>Patient Population</th>
<th>Severity</th>
<th>Endpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHARM-Alternative; Granger et al; (2003) 13678870 (T14)</td>
<td>Discover whether ARB could improve outcome in pts not taking an ACEI (intolerant)</td>
<td>RCT</td>
<td>Diuretics, Beta-blockers (55%); spironolactone 24%, Digoxin 45-46%</td>
<td>2028; 1013; 1015</td>
<td>Ischemic 67-70%</td>
<td>NYHA II-IV; EF &lt;40%; no ACEI (b/c of intolerance)</td>
<td>NYHA II-IV; mild to severe (&lt;4% class IV); EF: 30%; BP: 130/75; HR: 74-75; AF: 25-26%</td>
<td>Composite of CV death or hospital admission for CHF</td>
</tr>
<tr>
<td>CHARM-ADDED; McMurray et al; (2003) 13678889 (T15)</td>
<td>To investigate if ARB + ACEI in pts with chronic HF improve clinical outcomes</td>
<td>RCT</td>
<td>Beta blocker - 55%; spironolactone 17%; Digoxin 58-59%</td>
<td>2548; 1276; 1272</td>
<td>Ischemic 62-63%</td>
<td>Symptomatic HF, EF &lt;40%; Treatment with ACEI; Age &gt;18 y</td>
<td>NYHA class II-IV; mild to severe (&lt;3% class IV); EF 28%; BP 125/75; HR 74; AF 27%</td>
<td>Composite of CV death or hospital admission for CHF</td>
</tr>
</tbody>
</table>
VALIANT; Pleffer et al. (2003) 14601650 (116) 

Compared the effect of an ARB, ACEI, and the combination of the 2 on mortality 

Randomized double blind multicenter trial 

Beta-blockers: ASA 

14,703 

Valsartan: 490 

9 Captopril: 

4909 

VAL + CAP: 4885 

Ischemic 100% (MI inclusion criteria) 

Age >18 y 

Acute MI complicated by HF, LV systolic dysfunction (EF <35%), (<40% on radionuclide ventriculography); SBP >100 mmHg; Cr <2.5 mg/dL 

Prior intolerance or contra-indication to ACEV ARB 

NYHA II–IV 

asymptomatic-severe, EF: 35%; BP: 123/72; HR: 76 

Death from any cause 

12.5% VAL 

12.3% VAL–CAP 

2.1 y 

VAL and CAP: 1.9 (97.5% CI: 0.90-1.11) 

p=0.98; 

VAL+CAP and CAP: 0.98 (97.5% CI: 0.89-1.09); p=0.73 

Val-HeFT; Cohn et al. (2001) 11758645 (17) 

Evaluate long term effects of adding ARB to standard therapy for HF 

RCT 

Diovan; Digoxin 67%; Beta blocker 35%; ACEI 93% 

5010; 2511; 2469 

Ischemic 57% 

Age >18 y; NYHA II–III, IV (only 3% class IV); At least 2 wk of background meds including ACEIs; EF <40% and LVID >2.9 cm/BSA 

NYHA II–III, IV (only <2% class IV); Mild to severe; EF 27%; BP 123/76; AF: 12% 

Mortality; Combined endpoint of mortality and morbidity 

Change in EF; NYHA class; QoL scores; Signs and symptoms of HF 

2.1 y 

Mortality similar for the 2 treatment groups. For the combined endpoint: RR: 0.87, 97.5% CI, 0.77-0.97; p=0.009 

HEAAL study; Lancet 2009; 374: 1840-48. 19922995 (178) 

Compared the effects of high-dose vs low-dose losartan on clinical outcomes in pts with HF. 

RCT 

Diovan drugs (77%), beta blockers (72%), and ARBs (38%). 

3846 

(n=1927) or 50 mg daily (n=1919). 

IHD 64% 

 Age >18 y; NYHA class II–IV; LVEF <40%, with stable CV medical therapy for at least 2 wk; Intolerance to ACEI; Investigators encouraged to start beta blocker and titrate to a maximum, whenever possible 

Pregnancy or lactation; known intolerance to ARBs; Active myocarditis; active pericarditis; Planned heart surgery; EF <40% and LVID >2.9 cm/BSA 

NYHA II–IV (70% II); EF: 33%; BP: 124/77; HR: 71%; AF: 28% 

Death or admission for HF 

Composite endpoint of death or CV admission. Additional prespecified outcomes included: death, death or all-cause admission, CV death, all-cause admission, CV death, all-cause admission, CV death, all-cause admission, CHF death or hospital admission for HF, and changes in the severity of heart disease 

4.7 y median fu 

Treat pts with 150 mg dose instead of 50 mg dose would result in 1 additional pt w/out the primary event at 4 y for every 31 pts treated. Composite: 828 (43%) pts in 150 mg group vs. 895 (46%) in 50 mg group died or admitted for HF (RR: 0.90; 95% CI: 0.82-0.99; p=0.027) 

Components: 635 pts in 150 mg group vs. 665 in 50 mg group died (HR: 0.94, 95% CI: 0.84-1.04; p=0.24), and 450 vs. 503 pts admitted for HF (0.87, 0.78-0.98; p=0.025) 

CHARM-Overall 13378895 (178) 

Aim to find out whether the use of an ARB could reduce mortality and morbidity. 

RCT- parallel randomized double-blind, 

Diovan 83% 

Beta blockers 55% ACEI 43% Spironolactone 17% Digoxin 43% 

7601 pts 

(7699 with data) 3803 3796 

Age >18 y; NYHA class II–IV for at least 4 wk; 3 distinct populations: pts with LVEF <40% who were not receiving ACEIs (previous intolerance) or who were currently receiving ACE and pts with LVEF >40% 

SCR > 265 mcmol /L, serum potassium >5.5 mmol/L Bilateral renal artery stenosis; Symptomatic hypotension Women with childbearing potential not using adequate contraception; Critical aortic or mitral stenosis; MI, stroke, or open-heart surgery in the previous 4 wk; Use of an ARB in the previous 2 wk 

NYHA II–IV 

Only 3% class IV 

The primary outcome of the overall program: all-cause mortality; For all the component trials: CV death or hospital admission for CHF. 

The annual CV death rate among the placebo group who had reduced LVEF was around 9% and was only 4% in the placebo group of CHARM-Preserved. 

3.1 y 

886 (23%) pts in candesartan and 945 (25%) in placebo group died (unadjusted RR: 0.91; 95% CI: 0.83-1.00; p=0.055; covariate aHR: 0.89; 95% CI: 0.82-0.96; p=0.032) 

• Fewer CV deaths (691 [15% vs 769 [20%], p=0.012; covariate aHR: 0.88; 95% CI: 0.79–0.96; p=0.006) 

• Hospital admissions for CHF (757 [20%] vs 518 [24%], p=0.0001) 

ACEI indicates angiotensin-converting-enzyme inhibitor; AF, atrial fibrillation; ARB, angiotensin receptor blockers; ASA, aspirin; BP, blood pressure; BSA, body surface area; CABG, coronary artery bypass graft; CHARM, Candesartan in Heart Failure: Assessment of Reduction in Mortality and Morbidity; CHD, chronic heart disease; CHF, congestive heart failure; Cr, creatinine; CV, cardiovascular; DM, diabetes mellitus; EF, ejection fraction; FU, follow-up; HEAAL study, effects of high-dose versus low-dose losartan on clinical outcomes in patients with heart failure; HF, heart failure; HR, heart rate; IHD, ischemic heart disease; LV, left ventricular; LVOD, left ventricular dilatation; MI, myocardial infarction; NYHA, New York Heart Association; QoL, quality of life; pts, patients; SBP, systolic blood pressure; RCT, randomized control trial; SCR, serum creatinine; TIA, transient ischemic attack; UA, unstable angina; Val-HeFT, Valsartan Heart Failure Trial; and VALIANT, Valsartan in Acute Myocardial Infarction. 

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Investigate the efficacy of bisoprolol in decreasing all-cause mortality in chronic HF

RCT - multicenter double-blind randomised placebo controlled trial (Europe)

Duretics + ACEI; [amiodarone allowed-14-16%]

2647; 1327; 1320

Documented ischemic 50%

NYHA class II or IV EF: <35%

Uncontrolled HTN, MI/UA w/in previous 3 mo; PTCA/CABG w/in previous 6 mo; AV-block >1st degree w/o PPM; Heart rate >65 bpm; resting SBP <100mmHg; renal failure; Reversible obstruct lung disease; Use of beta blocker

Moderate to severe. Mean BP: 130/60; Mean HR: 80; Mean EF: 25%; Mean LVEDD: 6.7 cm; AF: 20%

All-cause mortality

All-cause hospital admissions

13.2% Placebo group

8.6% Treatment group

1.3 y

0.54-0.81; p=0.0001

Investigate whether Metoprolol CR/XL lowered mortality in pts with decreased EF and symptoms of HF

RCT - multicenter double-blind randomised placebo controlled trial (Europe + USA)

Duretics + ACEI

[Amiodarone NOT allowed]

3691; 1991; 2001

Ischemic 65%

NYHA IV; 40-80 y old; LVEF <40% (36-40 if 6-min walk <450m); heart rate >68 bpm

MUGA w/in 28 d; Contraindication or current use of beta blocker; Planned transplant or ICD; Heart block >11 degree w/o PPM; SBP <100mmHg

Mild to severe. Mean BP: 130/78; Mean HR: 78; Mean EF 28%; AF 16-17%

All-cause mortality

All-cause mortality in combination with all-cause admission to hospital

N/A

11.0% Placebo group

7.2% Treatment group

1 y

Treatment of 27 pt for 1 y can prevent 1 death. 0.68 (95% CI: 0.53-0.81); p=0.00009

Investigate whether Carvedilol is beneficial in severe HF

RCT - double blind

Duretics (PO or IV) + ACEI (or ARB); [Amiodarone allowed 17-18%]

2289; 1156; 1133

Ischemic 67%

Euvolumic NYHA class IV; LVEF <25%; No positive inotropes or vasodilators w/in 4 d

Pt requiring hospitalized intensive care; Use of positive inotropes or IV; vasodilators w/in 4 d; Coronary revascularization/MICVA/ sign VT or IV w/in 2 mo; SBP < 85 mmHg; Heart rate < 60 bpm; No PPM; SBP < 100 mmHg

Severe

Mean BP: 123/70; Mean HR: 83; Mean EF 20%

All-cause mortality

Combined risk of death or hospitalization-any reason; Combined risk of death or hospitalization-CV reason; Combined risk of death or hospitalization-HF reason; Pt global assessment

19.7% placebo

24.0% in pts with recent or recurrent cardiac decompensations

18.5% in placebo group

11.4% in Carvedilol group

10.4 mo

Treated 1000 pt for 1 y led to savings of 70 premature deaths p=0.0014

Assess effects of the beta blocker Nebivolol in pts >70 y regardless of EF.

RCT

Duretics + ACEI (aldosterone antagonist in 29%)

2128; 1067; 1061

Prior h/o CAD in 69%

Age >70 CHF with 1 of the following: hospitalization with CHF w/in a year or EF <35% w/in the past 6 mo

New HF Therapy w/in 6 wk or change in drug therapy w/in 2 wk

Contradiction to beta blockers, current use of beta blockers Significant renal dysfunction CVA w/in 3 mo.

Mild to severe

Mean BP: 139/81; Mean HR: 79; Mean EF 36% (13 with EF >35%)

Composite of all-cause mortality or CV hospital admission

All-cause mortality

Composite of all-cause mortality or hospital admissions

All cause hospital admissions CV hospital admissions CV mortality Composite of CV mortality or CV hospital admissions NYHA class assessment; 6 MWT

N/A

N/A

1.75 y

Absolute risk reduction 4.2%; 24 pts would need to be treated for 21 mo to avoid one event RR: 0.86; 95% CI: 0.74-0.98; p=0.039

A Trial of the Beta-Blocker Bucindolol In Pt With Advanced Chronic HF The Beta-Blocker Evaluation of Survival Trial Investigators

11386264

Designed to determine whether bucindolol hydrochloride, a nonselective beta- adrenergic blocker and mild vasodilator, would reduce the rate of death from any cause among pts with advanced HF

RCT

ACEIs (if tolerated) [91% ACE; 7% ARB], for at least 1 mo. Before the publication of the results of the DIG trial, 12 digoxin therapies were

2708; 1554; 1534

Ischemic 59%

NYHA class III or IV HF LVEF <35% >15 y

Reversible cause of HF present Candidates for heart transplantation Cardiac revascularization procedure within the previous 60 d UA Heart rate <50 bpm, SBP <80mmHg Decompensated HF.

NYHA class III or IV (52% class II) EF 23%; HR 82; BP 11771; AF 12%

Death from any cause

Death from CV causes (death due to pump failure or an ischemic event or sudden death) Hospitalization for any reason Hospitalization because of HF Composite of death or heart transplantation LVEF at 3 and 12 mo MI, QL, and any change in

For pt in NYHA functional class III, the annual mortality rate was 16% in the placebo group; For pt with NYHA class IV, the annual mortality rate in the placebo group was 28%

Overall: annual mortality of 17% in placebo group c/w

N/A

<2 y

449 pt in placebo group (33%) died, 411 pt in the bucindolol group (30%; HR: 0.90; 95% CI, 0.78-1.02; unadjusted p=0.10; adjusted p=0.13)
and to assess its effect in various subgroups defined by ethnic background and demographic criteria—specifically women and members of minority groups.

<table>
<thead>
<tr>
<th>COMET: Poole-Wilson et al; (2003) 12853193 (124)</th>
<th>To compare the effects of carvedilol and metoprolol on clinical outcome in pts with HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT</td>
<td>Diuretics, ACEIs</td>
</tr>
<tr>
<td>3026: 1511 carvedilol; 1518 metoprolol tartrate</td>
<td>NYHA class III/ IV EF &lt;35% Previous CV admission</td>
</tr>
<tr>
<td>N/A</td>
<td>Mild to severe</td>
</tr>
<tr>
<td>N/A</td>
<td>All-cause mortality</td>
</tr>
<tr>
<td>N/A</td>
<td>Composite endpoint of all-cause mortality, or all-cause admission</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>(CIBIS) III; 2005: 16143696 (125)</th>
<th>Sufficient data do not currently exist to establish the optimum order of initiating chronic HF therapy (ACEI vs. beta blocker). This was the objective of the CIBIS III trial— it compared the effect on mortality and hospitalization of initial monotherapy with either bisoprolol or enalapril for 6 mo, followed by their combination for 6 to 24 mo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multicenter, prospective, randomized, open-label, blinded endpoint evaluation (PROBE) trial, 24 with 2 parallel groups.</td>
<td>Treatment with an ACEI, an ARB, or a beta blocker for &gt;7 d during the 3 mo before randomization Heart rate at rest &lt;60 bpm without a functioning pacemaker Supine SBP &lt;100 mm Hg at rest SCr ≥ 220 mmol/L AV block 1° without a functioning pacemaker Obstructive lung disease contraindicating bisoprolol treatment</td>
</tr>
<tr>
<td>Diuretics 84%; Digoxin 32%</td>
<td>NYHA class II or III, LVEF &lt;35% (By echo within the 3 mo)</td>
</tr>
<tr>
<td>CAD 62%</td>
<td>Clinically stable HF (without clinically relevant fluid retention or diuretic adjustment within 7 d)</td>
</tr>
<tr>
<td>1010 Bisoprolol 505; Enalapril 505</td>
<td>Treatment with an ACEI, an ARB, or a beta blocker for &gt;7 d during the 3 mo before randomization Heart rate at rest &lt;60 bpm without a functioning pacemaker Supine SBP &lt;100 mm Hg at rest SCr ≥ 220 mmol/L AV block 1° without a functioning pacemaker Obstructive lung disease contraindicating bisoprolol treatment</td>
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<td>The primary endpoint was time-to-the-first-event of combined all-cause mortality or all-cause hospitalization</td>
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<td>Combined endpoint at the end of the monotherapy phase and the individual components of the primary endpoint, at study end and at the end of the monotherapy phase. CV death CV hospitalization</td>
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</tr>
</tbody>
</table>

ACEI indicates angiotensin-converting-enzyme inhibitor; AF, atrial fibrillation; ARB, angiotensin receptor blocker; AV, atrioventricular; BP, blood pressure; CABG, coronary artery bypass graft; CHF, congestive heart failure; CIBIS II, Cardiac Insufficiency Bisoprolol Study II; COMET, Carvedilol Or Metoprolol European Trial; COPERNICUS, carvedilol prospective randomized cumulative survival; Cr, creatinine; CR/XL, controlled release/extended release; CV, cardiovascular; CVA, cerebrovascular accident; c/w, compared with; DIS, Digitalis Investigation Group; EF, ejection fraction; HF, heart failure; h/o, history of; HR, hazard ratio; ICD, ICD, implantable cardioverter defibrillator; ITT, intent to treat; MERIT-HF, Metoprolol CR/XL Randomised Intervention Trial in Congestive Heart Failure; MI, myocardial infarction; MWT, minute walk test; NYHA, New York Heart Association; PPM, permanent pacemaker; PTCA, percutaneous transluminal coronary angioplasty; Pts, patients; QoL, quality of life; RCT, randomized control trial; RR, relative risk; SBP, systolic blood pressure; SCR, serum creatinine; UA, unstable angina; USA, United States of America; VF, ventricular fibrillation; VT, ventricular tachycardia; and w/o, without.
References


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125. Willenheimer R, van Veldhuizen DJ, Silke B, et al. Effect on survival and hospitalization of initiating treatment for chronic heart failure with bisoprolol followed by enalapril, as compared with the opposite sequence: results of the randomized Cardiac Insufficiency Bisoprolol Study (CIBIS) III. Circulation. 2005; 112:2426-35.