Original Article

Angiotensin Receptor Neprilysin Inhibition Compared With Enalapril on the Risk of Clinical Progression in Surviving Patients With Heart Failure

Milton Packer, MD*; John J.V. McMurray, MD*; Akshay S. Desai, MD, MPH; Jianjian Gong, PhD; Martin P. Lefkowitz, MD; Adel R. Rizkala, PharmD; Jean L. Rouleau, MD; Victor C. Shi, MD; Scott D. Solomon, MD; Karl Swedberg, MD, PhD; Michael Zile, MD; Karl Andersen, MD, PhD; Juan L. Arango, MD; J. Malcolm Arnold, MD; Jan Bělohlávek, MD, PhD; Michael Böhm, MD; Sergey Boytsov, MD; Lesley J. Burgess, MBCh, PhD; Walter Cabrera, MD; Carlos Calvo, MD; Chen-Huan Chen, MD; Andrej Dukat, MD; Yan Carlos Duarte, MD; Andrejs Erglis, MD, PhD; Michael Fu, MD; Efrain Gomez, MD; Angel González-Medina, MD; Albert A. Hagège, MD, PhD; Jun Huang, MD; Tzvetana Katova, PhD; Songsak Kiatchoosakun, MD; Kee-Sik Kim, MD, PhD; Ömer Kozan, Prof Dr; Edmund Bayram Llamas, MD; Felipe Martinez, MD; Bela Merkely, MD; Iván Mendoza, MD; Arend Mosterd, MD, PhD; Marta Negrus-Kawecka, MD, PhD; Keijo Peuhkurinen, MD; Felix J.A. Ramires, MD, PhD; Jens Refsgaard, MD, PhD; Arvo Rosenthal, MD, PhD; Michele Senni, MD; Antonio S. Sibulo Jr, MD; José Silva-Cardoso, MD, PhD; Iain B. Squire, MD; Randall C. Starling, MPH; John R. Teerlink, MD; Johan Vanhaecke, MD, PhD; Dragos Vinereanu, MD, PhD; Raymond Ching-Chiew Wong; MBBS on behalf of the PARADIGM-HF Investigators and Coordinators†

Received October 11, 2014; accepted October 20, 2014.

From the Department of Clinical Sciences, University of Texas Southwestern Medical Center, Dallas, TX (M.P.); BHF Cardiovascular Research Centre, University of Glasgow, Glasgow, Scotland, UK (J.J.V.M.); Brigham and Women’s Hospital, Cardiovascular Medicine, MA (A.S.D., S.D.S.); Novartis Pharmaceutical Corporation, East Hanover, NJ (J.G., M.P.L., A.R.R., V.C.S.); Université de Montréal, Institut de Cardiologie, Montréal, Canada (J.J.R.); Department of Molecular and Clinical Medicine, Gothenburg, Sweden (K.S.); The Medical University of South Carolina and RHJ Department of Veterans Administration Medical Center, Charleston, SC (M.Z.); School of Health Sciences, Faculty of Medicine, University of Iceland, Reykjavik, Iceland (K.A.); Unidad de Cirugía Cardiovascular de Guatemala, Guatemala City, Guatemala (J.A.); Western University, Department of Medicine and Physiology, Ontario, Canada (J.M.A.); 2nd Department of Medicine, Cardiovascular Medicine, General University Hospital and 1st Medical School, Charles University in Prague, Prague, Czech Republic (J.B.); Department of Cardiology, University of the Saarland, Homburg/Saar, Germany (M.B.); National Research Center for Preventive Medicine, Moscow, Russia (S.B.); TREASUR Study, Cardiology Unit, Department of Internal Medicine, Stellenbosch University and Tygerberg Hospital, Parow, South Africa (J.J.B.); Clinica Vasalio, Lima, Peru (W.C.); Unidad de Hipertensión Arterial y Riesgo Vascular, Hospital Clínico Universitario, Santiago de Compostela, A Coruña, Spain (C.C.); Department of Medicine, National Yang-Ming University, Taiwan, Republic of China (C.-H.C.); Second Department of Internal Medicine, Comenius University in Bratislava, Bratislava, Slovakia (A.D.); Luis Vernaza Hospital, Guayaquil, Ecuador (Y.C.D.); Faculty of Medicine, Institute of Cardiology, University of Latvia, Riga, Latvia (A.E.); Department of Medicine, Sahlgrenska University Hospital/Ostra Hospital, Göteborg, Sweden (M.F.); Clinica Shaio, Bogota, Colombia (E.G.); Hospital San Domingo, Universidad Autónoma de Santo Domingo, Santo Domingo, Dominican Republic (A.G.-M.); Assistance Publique Hôpitaux de Paris, Hôpital Européen Georges Pompidou, Département de Cardiologie; Paris Descartes University, Sorbonne Paris Cité; INSERM U970, Paris Cardiovascular Research Center, Paris, France (A.A.H.); First Affiliated Hospital with Nanjing Medical University, China (J.H.J.); National Hospital of Cardiology, Sofia, Bulgaria (T.K.); Cardiology, Medicine, Khon Kaen University, Thailand (S.K.); Daegu Catholic University Hospital, Daegu, Korea (K.-S.K.); Dokuz Eylül University Med. Fac., İzmir, Turkey (O.K.); Fundación Cardiovascular de Aguascalientes A.C., Hidalgo, Mexico (E.B.L.); Titular de Medicina Interna, Universidad Nacional de Córdoba, Instituto DAMIC/Fundacion Ruscalleda, Cordoba, Argentina (F.M.); Heart and Vascular Center Semmelweis University, Budapest, Hungary (B.M.); Venezuela Instituto Tropical Medicine Universidad Central Venezuela, Caracas, Venezuela (I.M.); Department of Cardiology, Meander Medical Centre, Amersfoort and WCN Dutch Network for Cardiovascular Research, Utrecht, The Netherlands (A.M.); Department and Clinic of Cardiology, Wroclaw Medical University, Poland (M.N.-K.); Department of Medicine, Kuopio University Hospital, Kuopio, Finland (K.P.); Heart Institute (InCor) – University of São Paulo, Medical School, Brazil (F.J.A.R.); Department of Cardiology, Viborg Hospital, Viborg, Denmark (J.R.); Dr. Arvo Rosenthal LLC, Estonia (A.R.); Azienda Ospedaliera Papa Giovanni XXIII, Cardiologia I – Scompenso e Trapianti di Cuore, Bergamo, Italy (M.S.); St. Luke’s Heart Institute, Quezon City, Philippines (A.S.S.); Center for Health Technology and Services Research (CINTESIS), Porto Medical School, University of Porto, Portugal (J.S.-C.); Department of Cardiovascular Sciences, University of Leicester, and NIHR Cardiovascular Biomedical Research Unit, Glenfield Hospital, Leicester, UK (J.B.S.); Heart & Vascular Institute, Cleveland Clinic, Cleveland, OH, USA (R.C.S.); San Francisco Veterans Affairs Medical Center and University of California San Francisco, San Francisco, CA (I.R.T.); Department of Cardiovascular Diseases, University Hospitals KU Leuven, Leuven, Belgium (J.V.); University of Medicine and Pharmacy Carol Davila – University and Emergency Hospital, Bucharest, Romania (D.V.); and Department of Cardiology, National University Heart Centre, Singapore (R.C.-C.W.).

© 2014 American Heart Association, Inc.

*Correspondence to Milton Packer, MD, Department of Clinical Sciences, University of Texas Southwestern Medical Center, 5323 Harry Hines Blvd, Dallas, TX 75390. E-mail milton.packer@utsouthwestern.edu; or John J.V. McMurray, MD, BHF Cardiovascular Research Centre, University PI, University of Glasgow, Glasgow, Scotland G12 8QQ, United Kingdom. E-mail john.mcmmurray@glasgow.ac.uk

© 2014 American Heart Association, Inc. All rights reserved.

Circulation is available at http://circ.ahajournals.org DOI: 10.1161/CIRCULATIONAHA.114.013748

The online-only Data Supplement is available with this article at http://circ.ahajournals.org/lookup/suppl/10.1161/CIRCULATIONAHA.114.013748/-/DC1.
Background—Clinical trials in heart failure have focused on the improvement in symptoms or decreases in the risk of death and other cardiovascular events. Little is known about the effect of drugs on the risk of clinical deterioration in surviving patients.

Methods and Results—We compared the angiotensin-neprilysin inhibitor LCZ696 (400 mg daily) with the angiotensin-converting enzyme inhibitor enalapril (20 mg daily) in 8399 patients with heart failure and reduced ejection fraction in a double-blind trial. The analyses focused on prespecified measures of nonfatal clinical deterioration. In comparison with the enalapril group, fewer LCZ696-treated patients required intensification of medical treatment for heart failure (520 versus 604; hazard ratio, 0.84; 95% confidence interval, 0.74–0.94; \( P = 0.003 \)) or an emergency department visit for worsening heart failure (hazard ratio, 0.66; 95% confidence interval, 0.52–0.85; \( P = 0.001 \)). The patients in the LCZ696 group had 23% fewer hospitalizations for worsening heart failure (851 versus 1079; \( P < 0.001 \)) and were less likely to require intensive care (768 versus 879; 18% rate reduction, \( P = 0.005 \)), to receive intravenous positive inotropic agents (31% risk reduction, \( P < 0.001 \)), and to have implantation of a heart failure device or cardiac transplantation (22% risk reduction, \( P = 0.07 \)). The reduction in heart failure hospitalization with LCZ696 was evident within the first 30 days after randomization. Worsening of symptom scores in surviving patients was consistently more common in the enalapril group. LCZ696 led to an early and sustained reduction in biomarkers of myocardial wall stress and injury (N-terminal pro-B-type natriuretic peptide and troponin) versus enalapril.

Conclusions—Angiotensin-neprilysin inhibition prevents the clinical progression of surviving patients with heart failure more effectively than angiotensin-converting enzyme inhibition.

Clinical Trial Registration—URL: http://www.clinicaltrials.gov. Unique identifier: NCT01035255. (Circulation. 2015;131:xxx–xxx.)

Key Words: heart failure • neprilysin • receptors, angiotensin
considered for enrollment, but were required to tolerate the equivalent of enalapril 10 mg daily for at least 4 weeks before screening along with stable doses of a β-blocker (unless contraindicated or not tolerated) and a mineralocorticoid antagonist (if indicated). Among the exclusion criteria,12 patients were not eligible for the trial if they had a history of intolerance of ACE inhibitors or angiotensin receptor blockers.

**Study Procedures**

On trial entry, ongoing therapy with an ACE inhibitor or angiotensin receptor blocker was stopped, but other treatments for heart failure were continued. Patients first received enalapril 10 mg twice daily for 2 weeks (single-blind) and then LCZ696 (single-blind) for an additional 4 to 6 weeks, initially at 100 mg twice daily and then 200 mg twice daily. To minimize the potential for angioedema, enalapril was withhold a day before starting LCZ696, and LCZ696 was withheld a day before starting randomized therapy. Patients tolerating both drugs at target doses were randomly assigned in a 1:1 ratio to double-blind treatment with either enalapril 10 mg twice daily or LCZ696 200 mg twice daily. The dose of enalapril was selected based on its effect to reduce the risk of death in the Studies of Left Ventricular Dysfunction (SOLVD) Treatment Trial19; higher doses have not been more effective or well tolerated during long-term treatment.20–22 Following randomization, patients were maintained on the highest tolerated doses of the study medication. Surviving patients underwent periodic evaluation of NYHA functional class, symptoms of heart failure (measured by using the Kansas City Cardiomyopathy Questionnaire [KCCQ]),23 and, in approximately 27% of randomized patients, biomarkers of neprilysin inhibition and heart failure progression. Worsening heart failure was treated by adjusting the doses of any concomitant drug and using any interventions that were clinically indicated.

**Statistical Analysis**

The trial was designed to recruit ≈8000 patients and continue until the occurrence of 1229 cardiovascular deaths and 2410 cardiovascular deaths or first hospitalizations for heart failure. However, an independent Data and Safety Monitoring Board recommended early termination of the study (approximately 50 months after the first patient was randomized) when the boundary for overwhelming benefit for cardiovascular mortality had been crossed.

The principal analyses for this article focused on (1) worsening NYHA functional class, as assessed by the physician; (2) worsening KCCQ total symptom score, as assessed by the patient; (3) worsening heart failure requiring an increase in the dose of diuretic for >1 month, the addition of a new drug for heart failure, or the use of intravenous therapy (prospectively defined in the protocol as a treatment failure); (4) worsening heart failure leading to an emergency department visit (without subsequent hospitalization); (5) worsening heart failure requiring hospitalization, with a prespecified analysis at 30 days after randomization; (6) the use of interventions for advancing heart failure; and (7) changes in biomarkers reflecting cardiac injury, wall stress, and the effects of neprilysin inhibition. All deaths and all hospitalizations possibly related to heart failure were adjudicated blindly according to prespecified criteria by a clinical-events committee, which had no knowledge of the patient’s drug assignment. Of the 4 biomarkers of interest, plasma NTproBNP and troponin T were measured by using the Roche Elecsys proBNP and high-sensitivity Troponin T assays (Roche Diagnostics GmbH, Germany); plasma BNP was measured by using the Advia Centaur assay (Siemens, USA); and cGMP was measured in first-morning-void urine samples by using an enzyme-linked immunosorbent assay (R & D Systems, USA). Data on all outcome measures were collected prospectively, and their analyses were prespecified as end points of interest.

Cox proportional hazards regression models (with treatment and region as fixed-effect factors) were used to evaluate between-group differences in time-to-event end points and to estimate hazard ratios, 95% confidence intervals, and P values. Negative binomial models (with treatment and region as fixed factors and logarithm of the duration of follow-up as the offset),24 Wilcoxon rank-sum test, and Fisher exact test were used to assess the significance of differences in the number, rate and duration of hospital admissions and emergency department visits; of the use of medical and device interventions for advancing heart failure; and of clinical worsening by ≥1 NYHA functional class and ≥5 points in the KCCQ total symptom score (based on the magnitude of change considered to be clinically relevant).25

The rate of total hospitalizations for heart failure was calculated by the Nelson-Aalen estimator,26 ignoring death as a potential informative dropout. Ignoring death as a potential informative dropout may lead to underestimation of the magnitude of the treatment effects in our analysis, because heart failure morbidity and mortality are strongly associated, and thus, the censoring of patients at the time of death can be expected to minimize estimates of the rate of worsening heart failure events in the group with a poorer survival.27 Nevertheless, all analyses were performed on data available at each time point; no imputation was applied to patients who died or had missing data.

**Results**

**Study Patients and Study Drug Administration**

A total of 10521 patients at 1043 centers in 47 countries entered the run-in period, of whom 8399 patients were randomly assigned and prospectively included in the intention-to-treat analysis (4187 to LCZ696 and 4212 or enalapril). As previously reported,12 the 2 groups comprised primarily patients with mild-to-moderate symptoms who were well treated with diuretics, β-blockers, and mineralocorticoid receptor antagonists and were balanced with respect to baseline characteristics. Excluding patients who died, 87% of both the LCZ696 and enalapril groups were receiving the target dose of the study drug at 8 months; and 76% and 75%, respectively, were maintained at the target dose at the end of the study.

**Effect on Death or Hospitalization for Any Reason**

There were 835 patients in the enalapril group and 711 in the LCZ696 group who died for any reason, corresponding to annualized rates of 7.5% and 6.0%, respectively. These differences reflected a 16% incremental reduction in the risk of death (hazard ratio, 0.84; 95% confidence interval [CI], 0.76–0.93; P=0.0009). There were 2093 patients who died or who were hospitalized for any reason in the enalapril group and 1892 such patients in the LCZ696 group, corresponding to annualized rates of 30.3% and 26.3%, respectively. These differences reflected a 12.6% lower risk as a result of treatment with LCZ696 instead of enalapril (hazard ratio, 0.87; 95% CI, 0.82–0.93; P<0.0001).

**Effect on Occurrence of Clinical Worsening**

In comparison with enalapril-treated patients, there were fewer LCZ696-treated patients who had worsening heart failure requiring the addition of a new drug, intravenous therapy, or an increase in the daily dose of diuretic for >1 month (520 versus 604; hazard ratio, 0.84; 95% CI, 0.74–0.94; P=0.003). Fewer patients in the LCZ696 group than in the enalapril group were evaluated and treated for worsening heart failure in the emergency department but discharged without hospital admission (102 versus 150; hazard ratio, 0.66; 95% CI, 0.52–0.85; P=0.001; Table). When all (including repeat) emergency department evaluations for heart failure were considered, the LCZ696 group had 30% lower rate of such visits than the enalapril group (P=0.017).
A table presenting measures of nonfatal worsening heart failure in the Enalapril and LCZ696 groups.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Enalapril (n=4212)</th>
<th>LCZ696 (n=4187)</th>
<th>Hazard/Rate Ratio (95% CI)</th>
<th>PValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with worsening heart failure leading to intensification of outpatient therapy, n (%)</td>
<td>604 (14.3)</td>
<td>520 (12.4)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.003</td>
</tr>
<tr>
<td>Patients with worsening NYHA functional class (≥1 class)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In patients surviving at 4 mo, n (%)</td>
<td>218 (5.5)</td>
<td>186 (4.7)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.113</td>
</tr>
<tr>
<td>In patients surviving at 8 mo, n (%)</td>
<td>266 (7.0)</td>
<td>205 (5.4)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.004</td>
</tr>
<tr>
<td>In patients surviving at 12 mo, n (%)</td>
<td>271 (7.4)</td>
<td>225 (6.1)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.023</td>
</tr>
<tr>
<td>Patients with worsening KCCQ total symptoms score (≥5 points)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In patients surviving at 4 mo, n (%)</td>
<td>1012 (28.3)</td>
<td>899 (25.1)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.002</td>
</tr>
<tr>
<td>In patients surviving at 8 mo, n (%)</td>
<td>1087 (31.8)</td>
<td>974 (28.2)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.001</td>
</tr>
<tr>
<td>In patients surviving at 12 mo, n (%)</td>
<td>1029 (31.5)</td>
<td>964 (29.0)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.03</td>
</tr>
<tr>
<td>Patients with ED visit for heart failure, n (%)</td>
<td>150 (3.6)</td>
<td>102 (2.4)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.001</td>
</tr>
<tr>
<td>Patients with 1 ED visit for heart failure, n (%)</td>
<td>111 (2.6)</td>
<td>78 (1.9)</td>
<td>0.84 (0.74–0.94)</td>
<td>0.003</td>
</tr>
<tr>
<td>Patients with ≥3 ED visits for heart failure, n (%)</td>
<td>27 (0.6)</td>
<td>15 (0.4)</td>
<td>0.84 (0.74–0.94)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total number of ED visits for heart failure</td>
<td>208</td>
<td>151</td>
<td>0.70 (0.52–0.94)*</td>
<td>0.017</td>
</tr>
<tr>
<td>Patients hospitalized for heart failure, n (%)</td>
<td>658 (15.6)</td>
<td>537 (12.8)</td>
<td>0.79 (0.71–0.89)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients with 1 admission for heart failure, n (%)</td>
<td>418 (9.9)</td>
<td>367 (8.8)</td>
<td>0.79 (0.71–0.89)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients with 2 admissions for heart failure, n (%)</td>
<td>143 (3.4)</td>
<td>110 (2.6)</td>
<td>0.79 (0.71–0.89)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients with 3 admissions for heart failure, n (%)</td>
<td>53 (1.3)</td>
<td>33 (0.8)</td>
<td>0.79 (0.71–0.89)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients with ≥4 admissions for heart failure, n (%)</td>
<td>44 (1.0)</td>
<td>27 (0.6)</td>
<td>0.79 (0.71–0.89)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total number of hospitalizations for heart failure</td>
<td>1079</td>
<td>851</td>
<td>0.77 (0.67–0.89)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of days in the hospital per admission per patient</td>
<td>9.7±9.5</td>
<td>10.8±17.5</td>
<td>0.86</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of patients requiring intensive care</td>
<td>623</td>
<td>549</td>
<td>0.87 (0.78–0.98)</td>
<td>0.019</td>
</tr>
<tr>
<td>Total number of stays in intensive care</td>
<td>879</td>
<td>768</td>
<td>0.82 (0.72–0.94)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients receiving IV positive inotropic drugs, n (%)</td>
<td>229 (5.4)</td>
<td>161 (3.9)</td>
<td>0.69 (0.57–0.85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients requiring cardiac resynchronization, ventricular assist device implantation, or cardiac transplantation, n (%)</td>
<td>119 (2.8)</td>
<td>94 (2.3)</td>
<td>0.69 (0.57–0.85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients hospitalized for cardiovascular reason, n (%)</td>
<td>1344 (31.9)</td>
<td>1210 (28.9)</td>
<td>0.88 (0.81–0.95)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total number of hospitalizations for cardiovascular reason</td>
<td>2537</td>
<td>2216</td>
<td>0.84 (0.76–0.92)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients hospitalized for any reason, n (%)</td>
<td>1827 (43.4)</td>
<td>1660 (39.7)</td>
<td>0.84 (0.76–0.92)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total number of hospitalizations for any reason</td>
<td>4053</td>
<td>3564</td>
<td>0.84 (0.78–0.91)*</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

CI indicates confidence interval; ED, emergency department; IV, intravenous; KCCQ, Kansas City Cardiomyopathy Questionnaire; and NYHA, New York Heart Association.

*Asterisk denotes rate ratio estimated from a negative binomial model; ratios without an asterisk are hazard ratios derived by using the Cox proportional hazards model.

Fewer patients in the LCZ696 group than in the enalapril group were hospitalized for heart failure (hazard ratio, 0.79; 95% CI, 0.71–0.89; P<0.001), for a cardiovascular reason (hazard ratio, 0.88; 95% CI, 0.81–0.95; P<0.001) or for any reason (hazard ratio, 0.88; 95% CI, 0.82–0.94; P<0.001; Table). The between-group difference in the risk of hospitalization for heart failure was statistically significant as early as 30 days following randomization (hazard ratio at 30 days, 0.60; 95% CI, 0.38–0.94; P=0.027; Figure 1).

In comparison with enalapril, patients treated with LCZ696 were not only less likely to be hospitalized for heart failure at least once, but were also less likely to be hospitalized multiple times; 240 patients in the enalapril group but only 170 patients in the LCZ696 group were hospitalized...
Higher during treatment with LCZ696 than with enalapril

Effect on Biomarkers of Heart Failure Progression
Levels of urinary cyclic GMP and plasma BNP were higher during treatment with LCZ696 than with enalapril

Not only was LCZ696 superior to enalapril in reducing the risk of a first emergency department visit or hospitalization for heart failure, but the drug was also more effective than ACE inhibition alone in decreasing the need for repeated emergency visits and hospitalizations for heart failure. These advantages were apparent even though (1) the enalapril group had a meaningfully higher mortality rate throughout the trial, leading to the preferential exclusion of high-risk enalapril-treated patients with progressing symptoms from our analyses; and (2) the enalapril group had greater intensification of background therapy, which would have been expected to ameliorate deleterious changes in clinical status. Therefore, the observed effect sizes reported in our analyses may underestimate the true magnitude of the treatment difference. Despite the biases against the drug, LCZ696 was superior to enalapril in reducing the risk of symptom progression and exerting a favorable effect on the clinical course of surviving patients with mild-to-moderate heart failure.

Few trials have focused on the ability of new drugs to prevent worsening of clinical status in patients with mild-to-moderate heart failure. Previous studies in such patients...
have primarily reported improvements in exercise tolerance or functional class or decreases in the risk of hospitalization for heart failure. In the few trials that have reported on exercise, the LCZ696 group showed higher 6-minute walk distances than the enalapril group, with statistically significant differences in favor of LCZ696 at 4 weeks and 8 months. However, these differences were small, even very low levels of troponin release are believed to reflect ongoing myocardial injury (possibly related to increased wall stress), and even small increases in the levels of troponin reflect a higher risk of disease progression in heart failure.

In conclusion, in comparison with guideline-recommended doses of an ACE inhibitor, combined inhibition of both the angiotensin receptor and neprilysin was more effective not only in reducing all-cause and cardiovascular mortality, but also in reducing the risks and rates of multiple manifestations of clinical deterioration of surviving patients with heart failure. The effect of LCZ696 to stabilize the course of heart failure is likely to have important ramifications for both quality of life and resource utilization in this disorder.

Sources of Funding
The study was funded by Novartis.

Disclosures
All authors have consulted for or received research support from Novartis, sponsor of the PARADIGM-HF trial. Dr Packer has consulted for Novartis, Pfizer, Sanofi, CytoKinetics, Cardiokinetics, BioControl, Janssen, Amgen, CardioMEMS, and Cardiorentis. Prof McMurray’s employer, University of Glasgow, was paid by Novartis for Prof McMurray’s time spent as chairman of the PARADIGM-HF trial. Dr Desai consulted for Novartis, Relypsa, and St. Jude Medical. Drs Gong, LeKowitz, Rizkala, and Shi are employees of Novartis. Drs Böhm, Hagege, Schwedberg, and Zile have received honoraria from Novartis for sponsored lectures. Drs Chen and Martinez are on the speaker’s bureau of Novartis. Dr Bélohlavék received honoraria from AstraZeneca for sponsored lectures and consulting for AstraZeneca and Servier. Dr Erglis is on the speakers’ bureau of Pfizer, Abbott Laboratories, Merck, and Sanofi. Dr Gomez consulted for Biotoscana. Drs Moster and Squire received honoraria from Novartis for participating in various activities. Dr Vinereanu received research support and honoraria from and consulted for Novartis and honoraria from Servier, Pfizer, BMS, and AstraZeneca. An immediate family member of Dr Negrusz-Kawecka received research support from Novartis, and her institution received institutional fees from Novartis.
Angiotensin Nephrilysin Inhibition in Heart Failure

in patients with chronic systolic heart failure: rationale for and design of the Prospective comparison of ARNI with ACEI to Determine Impact on Global Mortality and morbidity in Heart Failure trial (PARADIGM-HF).


CLINICAL PERSPECTIVES

The PARADIGM-HF (Prospective comparison of ARNI with ACEI to Determine Impact on Global Mortality and morbidity in Heart Failure) trial compared the angiotensin receptor-neprilysin inhibitor LCZ696 (400 mg daily) with the angiotensin-converting enzyme inhibitor enalapril (20 mg daily) in 8399 patients with heart failure and reduced ejection fraction in a double-blind trial. In a previous report, patients in the LCZ696 group had a 20% lower risk of cardiovascular death and a 16% lower risk of death for any reason (both P<0.0001). This article reports on the effect of treatment on the clinical progression of heart failure in surviving patients. When compared with enalapril, fewer LCZ696-treated patients required intensification of medical treatment for heart failure (P=0.003) or an emergency department visit for worsening heart failure (P=0.001). The patients in the LCZ696 group also had 23% fewer hospitalizations for worsening heart failure (P<0.001) and were 18% less likely to require intensive care (P=0.005), 31% less likely to receive intravenous positive inotropic agents (P<0.001), and 22% less likely to have implantation of a heart failure device or cardiac transplantation (P=0.07). The reduction in heart failure hospitalization with LCZ696 was evident within the first 30 days after randomization. Worsening symptoms of heart failure were consistently more common in the enalapril group. LCZ696 led to an early and sustained reduction in biomarkers of myocardial wall stress and injury (N-terminal pro–B-type natriuretic peptide and troponin) versus enalapril. These findings demonstrate that LCZ696 prevents the clinical progression of surviving patients more effectively than enalapril and provides further support for the use of this new approach to replace the current use of inhibitors of the renin-angiotensin system in chronic heart failure.
Angiotensin Receptor Neprilysin Inhibition Compared With Enalapril on the Risk of Clinical Progression in Surviving Patients With Heart Failure


Circulation. published online November 17, 2014;

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2014 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/early/2014/11/17/CIRCULATIONAHA.114.013748

Data Supplement (unedited) at:
http://circ.ahajournals.org/content/suppl/2014/11/18/CIRCULATIONAHA.114.013748.DC1
http://circ.ahajournals.org/content/suppl/2014/11/18/CIRCULATIONAHA.114.013748.DC2

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/
Correction

In the article by Packer et al, “Angiotensin Receptor Neprilysin Inhibition Compared With Enalapril on the Risk of Clinical Progression in Surviving Patients with Heart Failure,” which published ahead of print on November 17, 2014 (doi:10.1161/CIRCULATIONAHA.114.013748), incorrect labels were displayed on the y-axis of Figure 2. The correct labeled increments indicated on the y-axis should be 0, 20, 40, and 60. The correct figure is below:

![Corrected Figure](image-url)
SUPPLEMENTAL MATERIAL

PARADIGM-HF Trial Investigators and Committees

Executive Committee
J McMurray, co-chair; M Packer, co-chair; J Rouleau, S Solomon, K Swedberg, M Zile

Endpoint and Angioedema Adjudication
S Solomon, co-chair; A Desai, co-chair; A Kaplan, N Brown, B Zuraw

Data Monitoring Committee
H Dargie, chair; R Foley, G Francis, M Komajda, S Pocock

Investigators by Country (National Leaders Listed First)
ARGENTINA
BELGIUM

BRAZIL

BULGARIA

CANADA
CHILE
F Albornoz, P Avendaño, L Cobos, E Escobar, M Fernandez, J Jalil, F Lanas, P Sepulveda, B Stockins, P Yovaniniz

CHINA
J Huang, M Gui, HD Hu, YN Ke, LG Li, XD Li, XL Li, WM Li, SW Liu, XH Liu, GS Ma, NL Sun, G Xu, K Yang, ZY Yuan, J Zhang, RP Zhao

COLOMBIA

CZECH REPUBLIC

DENMARK
O Lederballe, J Refsgaard, H Andersen, K Egstrup, H Elming, N Eske, O Gøtzsche, J Jensen, L Køber, O May, O Pedersen, H Rickers, F Steffensen

DOMINICAN REPUBLIC
A González, A Paulino, P Martinez

ECUADOR

YC Duarte, C Delgado, Y Duarte, FL Hidalgo, C Mariscal, R Marmol

ESTONIA

A Rosenthal, A Kaasik, J Kaik, E Laane

FINLAND

K Peuhkurinen, T Jääskeläinen, K Kiilavuori, J Taurio

FRANCE


GERMANY


GUATEMALA
JL Arango, J Arriola, V Corona, S Leal, E López, R Muñoz, A Ovando, A Paniagua, D Rodríguez, L Velasquez, F Wyss

HONG KONG
HF Tse, SK Li, B Yan, G Yip

HUNGARY

ICELAND
K Andersen, T Gudnason, A Sigurdsson, G Thorgeirsson
INDIA

ISRAEL
D Aronson, T Ben Gal, S Goland, A Katz, A Keren, B Lewis, A Marmor, S Mayler, M Shochat

ITALY

LATVIA
A Erglis, G Dormidontova, R Eglite, T Lvova, G Rancane, I Sime
LITHUANIA
Z Petrulioniene, D Luksiene, T Maleckas, R Mazutavicius, R Miliuniene, Z Petrulioniene, R Slapikas

MALAYSIA
W Ahmad, D Chew, O Ismail, T Ong

MEXICO
EB Llamas, M Aguilera, J Arenas, J Carrillo, J González, S Leon, G Llamas, A Macias, A Meaney, O Orihuela, A Pavía, I Rodríguez, T Rodríguez, E Salcido, G Solache, R Velasco

NETHERLANDS
A Mosterd, D Basart, L Bellersen, A Derks, R Dijkgraaf, P Dunselman, J van Eck, C Gurlek, F den Hartog, G Hoedemaker, R Kaplan, J Koolen, L Liem, J Milhous, C de Nooijer, A Pronk, H Brunner- la Rocca, E Ronner, H Swart, G Tjeerdsma, F Willems

PANAMA
E Avilés, G Frago, B González, R Nieto

PERU
W Cabrera, R Alegre, R Azañero, JH García, A Godoy, J Heredia, L Lu, B Orihuela, A Rodriguez, Y Roldan, P Torres, J Urquiaga
PHILIPPINES


POLAND


PORTUGAL

JS Cardoso, F Almeida, A Andrade, N Braganca, S Carvalho, C. Fonseca, L Oliveira, F Padua, I Silvestre, R Soares

ROMANIA

D Vinereanu, M Andor, D Bartos, G Basarab, I Coman, I Copaci, M Cristea, Stefan Dragulescu, D Enache, A Fruntealata, L Iliescu, O Istratoaie, D Lighezan, C Militaru, T Nanea, C Nechita, M Puschita, M Tomescu, M Tudoran,

RUSSIA


SINGAPORE
R Wong, C Lee, H Ong, D Yeo

SLOVAKIA

SOUTH AFRICA
L Burgess, F Ahmed, L. Baben, A Badat, D Basson, F Bester, A Bruning, E Delport, F Dindar, J Foccart, M Gani, T Gertholtz, E Hellstrom, A Horak, S Ismail, L Jamjam, C Kapp, G Latiff, T Lerumo, J Lombard, P Manga, N van der Merwe, M Mkhwanazi, Z Mohamed, M Mpe, D
Naidoo, T Padayachee, N Ranjith, D Jansen van Rensburg, J Saaiman, B. Sebopa, M Tayob, H Theron, M Thomas, T Vally, T Venter, H Wellmann, L van Zyl

**SOUTH KOREA**


**SPAIN**


**SWEDEN**

M Fu, P Ahlström, I Hagerman, A Hajimirsadeghi, A Hansson, A Kempe, C Thorsén, M Zethson-Halldén

**TAIWAN**

CH Chen, CP Chen, PS Chen, KL Hsu, LY Lin, PY Pai, HM Tsao, BH Tzeng

**THAILAND**

S Kiatchoosakun, K Hengruessamee, D Piyayotai, S Sanguanwong, T Thongsri
Turkey

O Kozan, M Aktoz, C Barcin, A Birdane, A Camsari, C Ermis, Y Guray, H Kudat, D Ural, O Yavuzgil, M Yenigun, Z Yigit, MB Yilmaz, M Yokusoglu

UK


USA


**VENEZUELA**

I Mendoza, A Avendaño, M Alvarez, E Silva, G Vergara