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Temporal Trends and Prognosis of Physical Examination Findings in Patients with Acute Decompensated Heart Failure: The ARIC Study Community Surveillance

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Abstract

Introduction: Bedside evaluation of congestion is a mainstay of heart failure (HF) management. Whether detected physical examination signs have changed over time as obesity prevalence has increased in HF populations, or if the associated prognosis differs for HF with reduced or preserved ejection fraction (HFrEF or HFpEF) is uncertain.

Methods: From 2005–2014, the Atherosclerosis Risk in Communities (ARIC) Study conducted adjudicated hospital surveillance of acute decompensated heart failure (ADHF). We analyzed trends in physical examination findings, imaging signs, and symptoms related to congestion, both over time and by obesity class, and associated 28-day mortality risks.

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Results: Of 24,937 weighted hospitalizations for ADHF (mean age 75 years, 53% women, 32% Black), 47% had HFpEF. The prevalence of obesity increased from 2005–2014 for both HF types. With increasing obesity category, detected edema increased, while jugular venous distension (JVD) decreased, and rales remained stable. Detected edema also increased over time, for both HF types. Associations between 28-day mortality and individual signs and symptoms of congestion were similar for HFpEF and HFrEF; however, the adjusted mortality risk with all 3 (edema, rales, and JVD) vs. <3 physical examination findings was higher for patients with HFpEF (OR = 2.41, 95% CI: 1.53 – 3.79) than HFrEF (OR = 1.30; 95% CI: 0.87 – 1.93); *P* for interaction by HF type = 0.02.

Conclusion: In patients hospitalized with ADHF, detected physical examination findings differ both temporally and by obesity. Combined findings from the physical examination are more prognostic of 28-day mortality for patients with HFpEF than HFrEF.

Keywords

Acute decompensated heart failure; obesity; physical examination; congestion; surveillance

Introduction

Heart failure (HF) is a leading cause of morbidity and mortality globally,[1] and can be categorized into subtypes with reduced ejection fraction (HFrEF) or preserved ejection fraction (HFpEF).[2] Although demographics, comorbidities, etiology, and pathology differ for patients with HFpEF and HFrEF,[3] both groups present with similar features of hypervolemia and pulmonary congestion on physical examination. Survival has significantly improved over the past decades for HFrEF, but has not substantially changed over the same time period for patients with HFpEF.[4] Prevalence of obesity has also increased in recent years for patients hospitalized with acute decompensated heart failure (ADHF), particularly among those with HFpEF,[5,6] with the potential to confound recognition of HF signs and symptoms and adversely influence HF management.[7,8] In post-hoc analyses of clinical trials, the cardiovascular physical examination has demonstrated independent prognostic value for patients with chronic HF, both with HFrEF and HFpEF.[9,10] However, HF clinical trials often exclude patients with extreme obesity, either directly or by requiring natriuretic peptide levels above a specified cutpoint.[11,12] The prognostic value of the cardiovascular physical examination in patients admitted with ADHF has not been previously examined in population-based settings, nor is it known whether the prognostic value has diminished in recent years as obesity has increased among patients with HF.

Methods

The Atherosclerosis Risk in Communities (ARIC) study's data are owned by the National Heart Lung and Blood Institute (NHLBI). The data are publicly available to qualified investigators with an approved data use agreement and manuscript proposal.

The ARIC Study Community Surveillance

The ARIC study includes a cohort population and several community surveillance populations.[13] The present study is based on the HF community surveillance population.

Since 2005, the ARIC study has conducted population-based retrospective surveillance of hospitalized events in Forsyth County, North Carolina; Washington County, Maryland; Jackson, Mississippi; and 8 northwest suburbs of Minneapolis, Minnesota. Surveillance eligibility is restricted to residents 55 years of age or older, with a hospitalization spanning at least one day and, for the purposes of our analysis, a discharge date between January 1, 2005 – December 31, 2014. Hospitalizations with any discharge codes for congestive HF, rheumatic heart disease, hypertensive heart disease, acute cor pulmonale, chronic pulmonary heart disease, cardiomyopathies, acute edema of lung, or dyspnea were randomly sampled, using pre-specified sampling fractions within strata of ARIC communities, ICD-9 code (428.x or all other eligible codes), age (55–74, 75–84, or ≥85), sex, and race (Black or White).[14] All surveillance activities were approved by local Institutional Review Boards. Informed consent was not required for surveillance, because personal identifiers were redacted from the analytic dataset.

Event adjudication

Hospitalized medical records indicating signs or symptoms of HF were fully abstracted and reviewed by ARIC physicians, as previously described.[14] Using standardized criteria, hospitalizations were classified as definite ADHF, probable ADHF, stable chronic HF, not HF, or unclassifiable; based on diagnostic reports from the hospital record, physician notes, and discharge summaries. ADHF was differentiated from stable, chronic HF by evidence of new onset or worsening paroxysmal nocturnal dyspnea, orthopnea, hypoxia, edema, or shortness of breath.[14]

Data abstraction

Demographic, clinical, imaging, and laboratory data were abstracted from the medical record by certified study personnel following a standardized protocol. Signs and symptoms of congestion were abstracted from the medical record if noted at any time during the hospitalization. Abstracted HF symptoms included shortness of breath at rest, paroxysmal nocturnal dyspnea, and orthopnea. Abstracted physical examination findings included lower extremity edema, pulmonary rales, jugular venous distension (JVD), hepatojugular reflux, and s3 gallop. Lower extremity edema was abstracted from the medical record as a single category if any of the following conditions were noted during the physical examination: lower extremity edema, peripheral edema, sacral edema, scrotal edema, generalized edema, swollen ankles, 1+, 2+, 3+, 4+ pitting (edema), nonpitting edema, or anasarca. Edema that was described as “trace” was not considered evidence of lower extremity edema. Rales were subdivided into “basilar” and “more than basilar”, based on the extent of presentation in the lung field. For the purposes of this analysis, rales were considered present if exceeding the basilar portion of the lung field, consistent with the Modified Boston and NHANES classification algorithms for HF.[15,16] Tachycardia was derived from the admission vitals and was defined by a heart rate ≥ 110 beats per minute.[15,16] Radiographic signs of pulmonary congestion were abstracted from the imaging reports and included diagnoses of pulmonary edema (either interstitial or aveolar) and bilateral pleural effusion. Echocardiographic signs suggestive of congestion were abstracted from the imaging report and included pulmonary hypertension and moderate to severe right ventricular dilation. Obesity was defined by the abstracted height at admission and weight at hospital discharge (defining obesity by a body mass index ≥ 30 kg/m^2). Class I, II, and III obesity were categorized by a body mass index of 30 to <35, 35 to <40, and ≥40 kg/m^2, respectively.

Heart failure type

Heart failure type was determined by the abstracted ejection fraction (EF), from either inpatient diagnostic tests, or when absent, pre-admission imaging studies. HFrEF was identified by reported EF <50% and HFpEF was identified by EF ≥50%.

Mortality

All-cause mortality within 28-days of admission was ascertained by the ARIC study by linking hospital records with the National Death Index.

Statistical Analysis

Each hospitalization was considered statistically independent. Statistical tests and models accounted for the stratified sampling design (which oversampled minority groups) and were weighted by the inverse of the sampling probability,[17] which was based on demographic distributions of the underlying population. Baseline characteristics of the study population were compared with stratification by HF type and half-decade of admission (2005–2009 and 2010–2014). Continuous variables were compared using the difference in least square means from weighted linear regression and categorical variables were compared using Rao-Scott χ^2 tests. Temporal trends in the annual prevalence of signs and symptoms of congestion were plotted across 2005–2014, with trend lines fit by 2nd order polynomials. Significance of temporal trends was analyzed using logistic regression and the Cochran-Armitage test for trend, constructing separate models for each sign or symptom and regressing on year of admission. Differences in temporal trends were compared between patients with HFrEF vs. HFpEF by testing the multiplicative interaction of HF type with year of admission. Trends in the reported presence of signs and symptoms by increasing severity of obesity were analyzed using logistic regression models stratified by HF type, regressing on increasing obesity category as an ordinal variable.

Associations between individual and combined signs of congestion with all-cause, 28-day mortality were analyzed using logistic regression, with stratification by HF type and obesity status. Because hepatojugular reflux and s3 gallop were rarely detected, combined physical examination findings were analyzed as a composite of lower extremity edema, JVD, and rales, both by number of findings present (0, 1, 2, or 3) and by presence of all 3 versus < 3 findings. All mortality models for individual or combined signs of congestion were adjusted for age, race, sex, year of admission, geographic region, and length of stay (as a surrogate of hospitalization acuity). To examine whether congestion, as indicated by combined physical examination findings, had any prognostic utility beyond indications of congestion by patient symptoms and imaging signs, models were additionally adjusted for symptoms (dyspnea, paroxysmal nocturnal dyspnea, and orthopnea), and imaging signs (pulmonary edema, bilateral pleural effusion, pulmonary hypertension, and right ventricular dilation). To examine whether mortality outcomes associated with 3 vs. <3 physical examination signs may be modified by HF type, half-decade of admission, or obesity, we constructed stratified models and tested the multiplicative interaction of potential modifiers with 3 vs. <3 physical examination findings. A *P* <0.10 was considered suggestive of statistical interaction, to account for the diminished power inherent with stratification.[18] All analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC)

Results

From 2005 – 2014, a total of 22,805 hospitalizations were sampled among patients identified as White or Black. Of these, 8914 were classified as definite or probable ADHF. After excluding patients lacking an abstracted ejection fraction, 5460 remained. This sample size corresponded to 24,937 weighted hospitalizations after applying the sampling weights. All subsequent results are presented with statistical weighting.

Detectable Signs of Congestion: Aggregated Across the 10-Year Interval

Approximately half (53%) of the patients were women, a third (32%) were Black, and the average age at admission was 75 years. The prevalence of HFrEF (53%) and HFpEF (47%) was nearly equal. When aggregated across 2005–2014, patients with HFpEF were older, more often women, and more frequently had obesity than patients with HFrEF, but were less often Black (Table 1). Paroxysmal nocturnal dyspnea and orthopnea were more often noted in patients with HFrEF, as was JVD, tachycardia, and s3 gallop. Patients with HFrEF also had higher B-type natriuretic peptides levels than those with HFpEF. On the other hand, lower extremity edema, bilateral pleural effusion, and pulmonary hypertension were more often reported for patients with HFpEF.

Detectable Signs of Congestion: Temporal Trends and Changes Over Time

Dyspnea was common and an increasingly reported symptom from 2005–2009 to 2010–2014, for both HF types (HFrEF: 79% to 91%; HFpEF: 80% to 91%), while symptoms of paroxysmal nocturnal dyspnea declined (HFrEF: 22% to 18%; HFpEF: 16% to 12%). Symptoms of orthopnea also declined, but the annual trend was significant only for HFpEF, with a rate of decline that did not differ significantly from HFrEF (*P* for interaction by HF type = 0.2). On physical examination, lower extremity edema was increasingly noted from 2005–2009 to 2010–2014, both for HFrEF (62% to 67%) and HFpEF (66% to 72%), Table 1 and Figure 1. However, the noted presence of rales, JVD, hepatojugular reflux, and tachycardia on physical examination did not change over time, for either HF type. S3 gallop was rarely detected, but the noted presence declined from 2005–2009 to 2010–2014, both for HFrEF (7% to 5%) and HFpEF (3% to 2%). On echocardiography, right ventricular dilation was increasingly detected from 2005–2009 to 2010–2014, both for HFrEF (18% to 26%) and HFpEF (18% to 24%). Pulmonary hypertension was also increasingly detected, but the annual trend was significant only for HFpEF, with a rate of increase that did not significantly differ from HFrEF (*P* for interaction = 0.2). Diagnoses of pulmonary edema and bilateral pleural effusion from chest radiography did not significantly change over time for either HF type; nor did levels of B-type natriuretic peptide (Table 1 and Figure 1).

Detectable Signs of Congestion: Obesity Trends and Changes with Increasing Obesity

Obesity (body mass index ≥30 kg/m^2) increased in prevalence from 2005–2009 to 2010–2014, both for HFrEF (28% to 33%) and HFpEF (42% to 49%), Table 1 and Supplemental

Figure 1. Mean patient age declined with increasing severity of obesity, while the percentage of women and Black patients increased; a pattern observed for both HF types (Tables 2 and 3). Orthopnea and lower extremity edema were increasingly reported with worsening severity of obesity, for both HF types. Conversely, the presence of JVD, bilateral pleural effusion, and pulmonary edema declined with increasing obesity categories for both HF types, as did B-type natriuretic peptide levels, Tables 2 and 3.

Mortality Associated with Individual Signs of Congestion

Within 28 days of admission, there were 1470 deaths (11%) among patients with HFrEF and 1106 (10%) among those with HFpEF. Associations between mortality and individual signs of congestion on physical examination, radiography, and echocardiography were largely comparable by HF type, after adjustments for age, race, sex, year of admission, geographic region, and hospitalization acuity (length of stay), Table 4. The adjusted mortality risk associated with jugular venous distention tended to be higher for patients with HFpEF (*P* for interaction by HF type = 0.08); however, rales, pulmonary edema, and bilateral pulmonary effusion had the highest mortality odds ratios, with no interaction by HF type. When stratified by obesity, rales and radiography signs remained associated with higher mortality odds ratios, both for patients with and without obesity (Table 5). Among those with obesity, bilateral pleural effusion was particularly prognostic of 28-day mortality for patients with HFpEF (OR = 2.52) but was not significantly associated with mortality for patients with HFrEF (*P* for interaction by HF type = 0.04).

Mortality Associated with Combined Signs of Congestion from the Physical Examination

When signs of congestion from the physical examination (lower extremity edema, JVD, and rales) were grouped into <3 or 3 signs, all 3 signs were comparably present for patients with HFrEF (11%) and HFpEF (9%), Figure 2. The 28-day mortality increased only slightly with increasing number of physical examination findings in patients with HFrEF (8%, 12%, 11%, and 13% for patients with 0, 1, 2, or 3 findings). In contrast, among patients with HFpEF, 28-day mortality was comparable for patients with 0, 1, or 2 findings (9%, 8%, and 9%, respectively), but doubled with 3 physical exam findings, amounting to a 19% mortality within 28 days of admission (Figure 2). The unadjusted mortality odds ratio associated with 3 vs. <3 physical examination findings was 1.21 (95% CI: 0.83 – 1.77) for HFrEF and 2.52 (95% CI: 1.66 – 3.83) for HFpEF. Model estimates and interpretations were not largely changed by sequential adjustments for demographics and length of stay, congestive symptoms, or imaging signs suggestive of congestion (Supplemental Table 1). With full adjustment, mortality odds ratios were 1.30 (95% CI: 0.87 – 1.93) and 2.41 (95% CI: 1.53 – 3.79) for HFrEF and HFpEF, respectively.

Modification of the Mortality Associated with Combined Physical Examination Findings

In fully adjusted models, presence of 3 vs. <3 physical examination findings was more strongly associated with 28-day mortality for patients with HFpEF (OR = 2.41, 95% CI: 1.53 – 3.79) than those HFrEF (OR = 1.30; 95% CI: 0.87 – 1.93); *P* for interaction by HF type = 0.02. The mortality odds ratios were not modified by half-decade of admission (2005–2009 vs. 2010–2014), for either HF type (Figure 3). Nor was the association significantly modified by obesity among patients with HFrEF. However, among patients with HFpEF, the odds of mortality associated with 3 vs. <3 physical examination findings was higher for patients without obesity (OR = 4.09; 95% CI: 2.28 – 7.32) than those with obesity (OR = 1.36; 95% CI: 0.62 – 3.00); *P* for interaction by obesity = 0.08.

Discussion

In this decade-long community surveillance of patients hospitalized with ADHF, we investigate temporal trends in the signs and symptoms of congestion among patients with HFpEF and HFrEF and the associated mortality risk. After adjustment for demographics, hospitalization acuity (length of stay), symptoms, and imaging signs, the combined presence of 3 physical examination findings (lower extremity edema, JVD, and rales) was associated with twice the 28-day mortality risk in patients with HFpEF, compared to <3 physical examination findings. Combined physical examination findings had greater prognostic significance in patients with HFpEF than HFrEF and were particularly significant in non-obese patients with HFpEF.

The prognostic significance of physical examination findings in patients with chronic HFrEF has previously been examined in several post-hoc analyses of clinical trials.[9,19,20] Peripheral edema, rales, s3 heart sound, and JVD were associated with a higher reported mortality risk in the AF-CHF (Atrial Fibrillation and Congestive Heart Failure) trial,[20] and were shown to have independent prognostic value over natriuretic peptides and traditional risk scores in the PARADIGM-HF (Prospective Comparison of Angiotensin Receptor-Neprilysin Inhibitor With Angiotensin Converting Enzyme Inhibitor to Determine Impact on Global Mortality and Morbidity in Heart Failure) trial. Similarly, in the TOPCAT (Treatment of Preserved Cardiac Function Heart Failure with an Aldosterone Antagonist) trial, which enrolled patients with chronic HFpEF, peripheral edema, rales, and jugular venous extension had independent prognostic value over traditional risk scores.[10] However, the value of the physical examination in patients hospitalized with ADHF has been less well studied, particularly in population-based settings, or among patients with HFpEF. In a post-hoc analysis from the ASCEND-HF (Acute Study of Clinical Effectiveness of Nesiritide in Decompensated Heart Failure) trial, which primarily enrolled acutely decompensated patients with HFrEF, neither peripheral edema nor JVD was associated with adverse outcomes in isolation, but when both present, these physical examination findings were associated with worse 30-day mortality.[21] A post-hoc analysis from the EVEREST (Efficacy of Vasopressin Antagonism in Heart Failure: Outcome Study with Tolvaptan) trial, which monitored acutely decompensated patients with HFrEF, reported an increased risk of all-cause 30-day mortality in patients with signs and symptoms of residual congestion present at hospital discharge.[22] However, selection bias is a known limitation of randomized controlled trials (RCTs), and many HF RCTs exclude very obese patients, either by BMI limits or by requiring natriuretic peptides above a certain threshold. Unlike an RCT, the ARIC community surveillance did not impose any selection criteria (other than classification of ADHF, white or black race, geographic catchment area, and age >55), and did not require informed consent (*i.e.,* self-selection into the study). Hospitalizations were randomly sampled within their prespecified demographic strata, an approach which was designed to provide a representative study population. Our analysis of patients hospitalized with ADHF suggests the physical examination differs in prognosis of 28-day mortality for patients with HFrEF and HFpEF.

Although the ARIC study used a consistent algorithm to classify ADHF from 2005–2014, temporal changes in detectable signs and symptoms of congestion were noted over time. Among the reported symptoms, dyspnea was nearly ubiquitous and the prevalence increased over time, both for HFrEF and HFpEF. Similarly, lower extremity edema was increasingly reported over time for both HF types, as was prevalence of right ventricular dilation on echocardiography. However, prevalence of pulmonary hypertension on echocardiography increased over time only for patients with HFpEF. Median values for B-type natriuretic peptides did not appreciably change over time, and radiographic signs were also stable over time. Orthopnea had no apparent temporal change in patients with HFrEF, but a slight decline over time for patients with HFpEF. Although hepatojugular reflux and s3 gallop were rarely detected for either HF types, the detection of s3 gallop declined over time both for HFrEF and HFpEF. Surprisingly, symptoms of paroxysmal nocturnal dyspnea were decreasingly reported over time for both HF types.

The detection of congestive signs and symptoms was also observed to be influenced by obesity. Symptoms of dyspnea and orthopnea were increasingly reported for both HF types as obesity increased, as was presence of lower extremity edema. Although plasma volume expansion can be nonspecific and modified by various factors, it can also be related to obesity,[23,24] which is consistent with these trends. We observed that JVD was less often detected as BMI categories increased, possibly reflecting the inherent difficulty in performing an accurate physical exam with increasing obesity.[25,26] It is well-established that natriuretic peptide levels are lower in patients with obesity,[27] and a similar trend was also observed in our analysis. This may be attributed to enhanced natriuretic peptide clearance in fat tissue, alterations in sex hormones or insulin resistance.[28,29] Radiographic diagnoses of bilateral pleural effusion and pulmonary edema declined with increasing BMI categories for both HF types. Although pulmonary artery systolic pressure is known to increase with BMI,[30] diagnoses of pulmonary hypertension on echocardiography also declined with increasing BMI categories for both HF types. The reason for the decrease in imaging signs with increasing obesity severity is unclear, but may be related to technical difficulty due to limitations by body habitus.[31]

Associations between 28-day mortality and individual signs of congestion on physical examination, radiography and echocardiography were fairly comparable by HF type. However, when stratified by obesity status, bilateral pulmonary effusion was far more prognostic of mortality for obese patients with HFpEF compared to obese patients with HFrEF. When considering a composite of congestive signs from the physical examination, presence of all 3 signs (lower extremity edema, JVD and rales) more than doubled the mortality risk for patients with HFpEF, an association which persisted after multivariable adjustment for demographics, hospitalization acuity, symptoms, and imaging signs. In contrast, the presence of all 3 vs <3 physical examination signs was associated with a modest and nonsignificant increase in mortality risk for patients with HFrEF. The reason for the differing prognostic significance by HF type is not entirely clear but could be related to the lack of effective HF pharmacotherapies for patients with HFpEF. Alternatively, the severity of congestion may have been worse for patients with HFpEF and detectable physical examination findings.

HF-specific mortality risks associated with 3 vs. <3 physical examination signs were not substantially modified by half-decade of admission, nor by obesity in patients with HFrEF. However, the presence of all 3 signs had a 4-fold increase in associated mortality risk for non-obese patients with HFpEF, when compared to non-obese patients with < 3 physical examination signs. In contrast, presence of all 3 signs was associated with a modest but nonsignificant increase in mortality risk for obese patients with HFpEF, compared to patients with obesity who had < 3 physical examination signs. One possible explanation for the diminished prognostic significance in patients with obesity may be misclassification of physical examination signs, particularly if obesity complicates the detection of signs of congestion. Consequently, the physical examination had greater prognostic significance in non-obese patients with HFpEF.

Our study has some limitations. This was an observational analysis with data limited to availability in the medical record and longitudinal outcomes limited to all-cause mortality. Our study population was limited to hospitalized patients with ADHF and may not be generalizable to outpatients. It is possible that temporal changes in diagnostic testing or documentation may have influenced reporting over time. We were unable to consider invasive assessments of hemodynamics, as right heart catheterization was rarely conducted in this real-world surveillance of patients hospitalized with ADHF. Kusmaul's signs were not abstracted from the medical record, and we were unable to assess constrictive pericarditis or pericardial restraint due to obesity.[32] Signs and symptoms of congestion may rapidly improve following hospital admission,[22] and we were unable to analyze presence of residual congestion at hospital discharge. Symptoms may be subject to reporting bias, and performance of physical examination was not standardized and may be subject to interobserver variability. Echocardiography and radiography signs were abstracted from qualitative reports and were subject to physician interpretation. However, our analysis reflects clinical practice which increases generalizability of the findings. The ARIC Study provides a large, multi-year surveillance of 4 diverse US communities, allowing an analysis of contemporary trends spanning 10 years. All hospitalizations for ADHF were validated by standardized physician review of the medical record, minimizing misclassification of events, and mortality outcomes were verified by the National Death Index.

Conclusion

In this large epidemiological surveillance of patients hospitalized with ADHF, signs of congestion from the physical examination had differential prognostic significance in patients with HFpEF vs. HFrEF and were particularly prognostic of all-cause 28-day mortality in non-obese patients with HFpEF. Our study highlights the importance of a complete physical examination as no single sign perfectly captures the clinical condition of a patient and hence, no single sign emerged as a strong predictor of mortality. On the other hand, when these signs were considered together, the associated mortality risk doubled for patients with HFpEF, irrespective of demographics, acuity of hospitalization, reported symptoms, and imaging signs of congestion. These data support the importance of a complete physical examination in patients hospitalized with ADHF and its continued clinical relevance in the modern era.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Drs. Kolupoti and Caughey conceptualized the study and wrote the manuscript. Dr. Caughey performed the statistical analysis. Drs. Fudim, Pandey, Kucharska-Newton, Hall, Vaduganathan, and Mentz interpreted the data and revised the manuscript critically. The authors thank the ARIC study staff and participants for their important contributions.

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Abbreviations

ADHF	acute decompensated heart failure
ARIC	Atherosclerosis Risk in Communities Study
BMI	body mass index
EF	ejection fraction
HF	heart failure
HFpEF	heart failure with preserved ejection fraction
HFrEF	heart failure with reduced ejection fraction
JVD	jugular venous distension

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What is New?

- Few studies have analyzed the prognostic significance of physical examination findings in patients admitted with acute decompensated heart failure (ADHF), particularly in population-based settings, or among patients with preserved ejection fraction.
- As the prevalence of obesity continues to increase in heart failure populations, it is also uncertain whether the detection or prognosis of congestive signs from the physical examination has changed over time for hospitalized patients with heart failure.

What are the Clinical Implications?

- In the 10-year surveillance of patients hospitalized with heart failure, the detection of physical examination signs of congestion varied both temporally and by obesity.
- Among patients hospitalized with ADHF, detectable signs of congestion from the physical examination were more prognostic of 28-day mortality for patients with preserved ejection fraction, particularly when noted in patients without obesity.
- The influence of body mass index on detectable of signs of congestion from the physical examination is an important consideration for patients hospitalized with ADHF, especially in the setting of rising obesity.

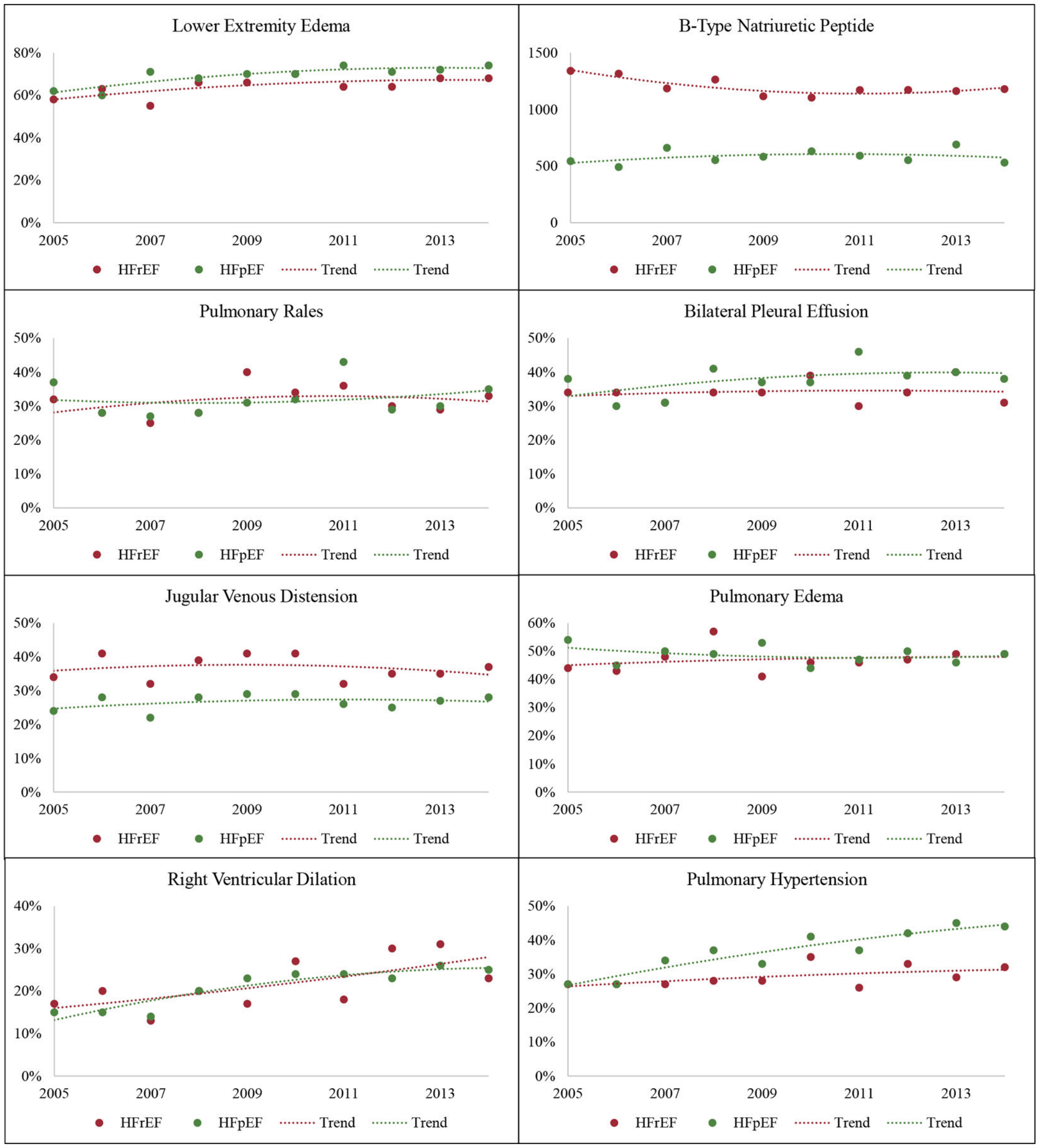

Figure 1:

Annual proportion of patients admitted with acute decompensated heart failure with various signs and symptoms of congestion, stratified by heart failure with reduced and preserved ejection fraction. The community surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014.

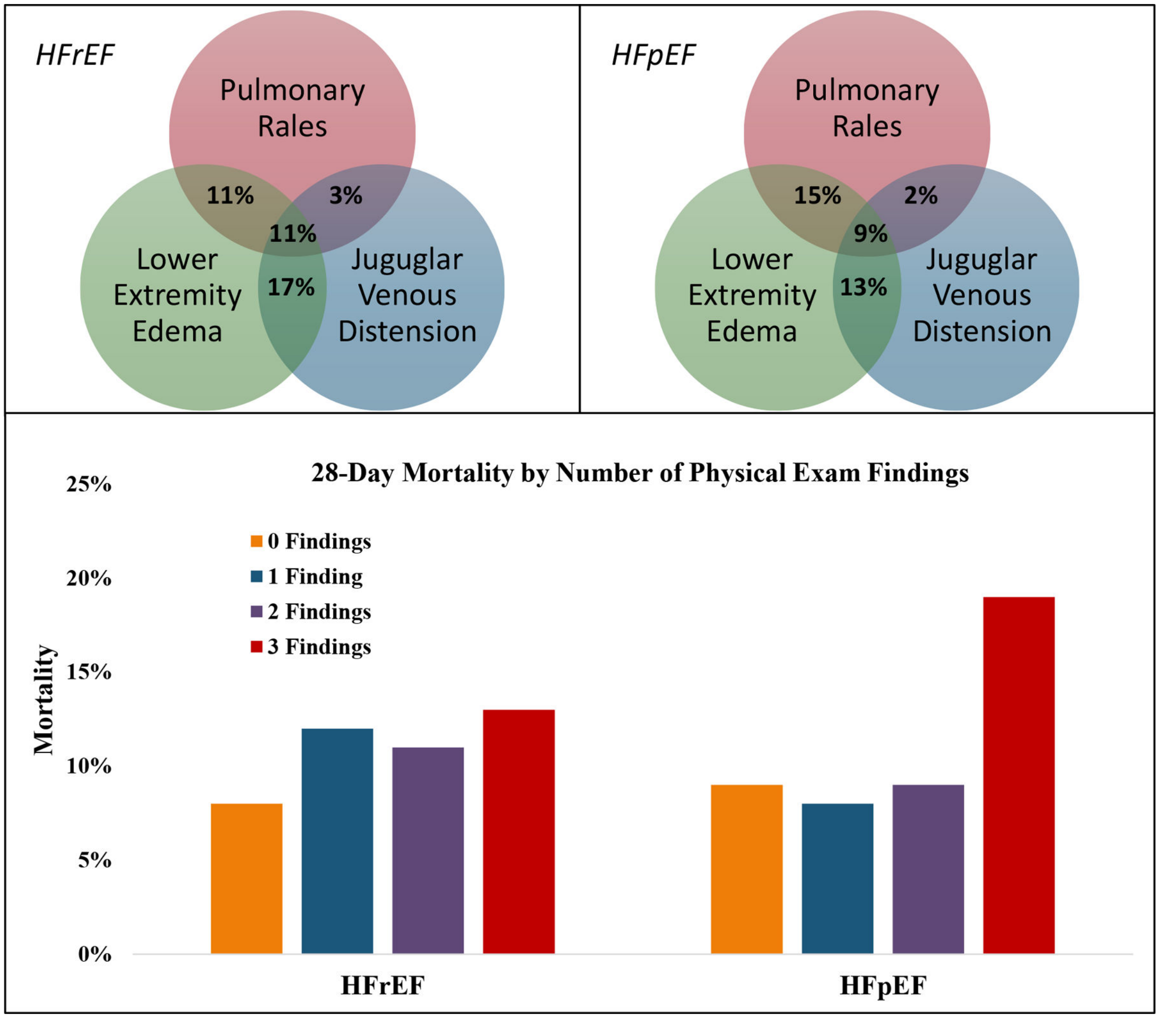

Figure 2:

Prevalence of physical examination findings suggestive of congestion in patients hospitalized with acute decompensated heart failure and associated 28-day mortality by number of physical examination findings, stratified by heart failure with reduced versus preserved ejection fraction. The community surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014.

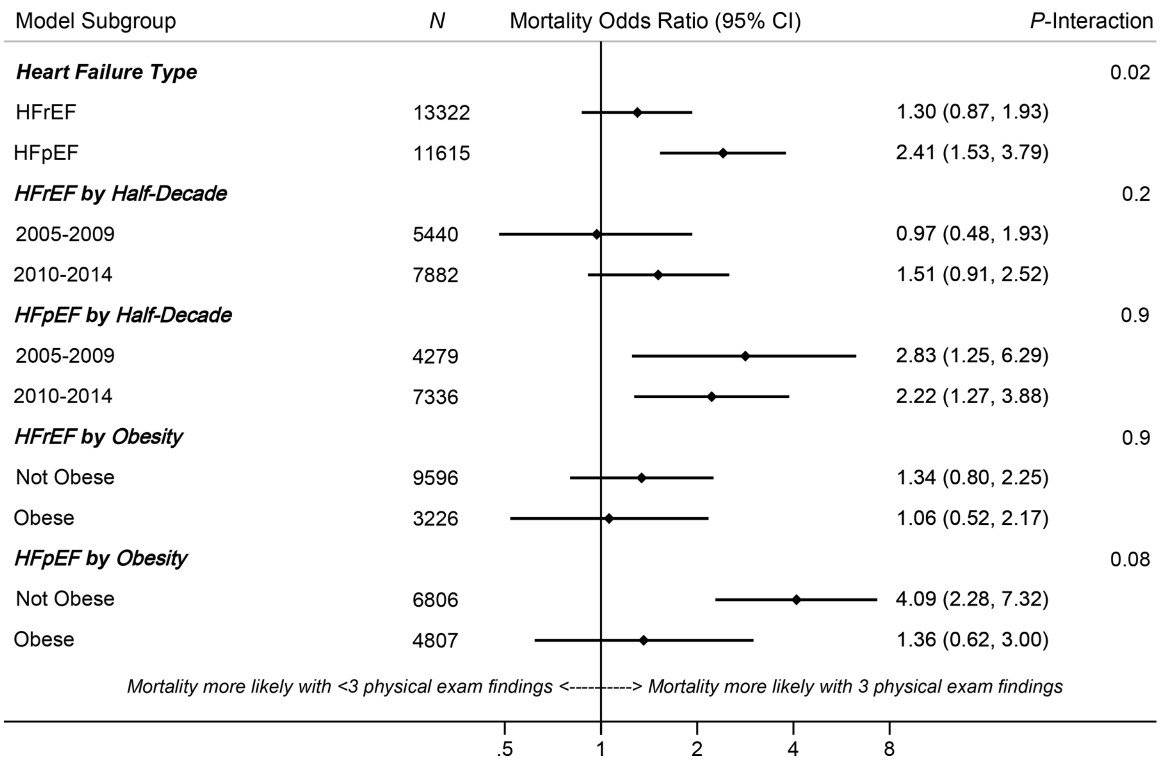

Figure 3:

Adjusted odds ratios* of all-cause 28-day mortality for patients hospitalized with acute decompensated heart failure presenting with 3 vs. <3 physical examination findings. The community surveillance component of the Atherosclerosis Risk in Communities study, 2005–2014.

*Models adjusted for demographics (age, race, sex, year of admission, geographic region), hospitalization acuity (length of stay), symptoms (dyspnea, paroxysmal nocturnal dyspnea, and orthopnea), and imaging signs (pulmonary edema, bilateral pleural effusion, pulmonary hypertension, and right ventricular dilation).

Table 1:

Characteristics of patients admitted with acute decompensated heart failure, stratified by heart failure type and half-decade of hospitalization. The community surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014.

Characteristics	HFrEF			HFpEF			HFrEF vs. HFpEF	
	2005–2009	2010–2014	10-Year Trend	2005–2009	2010–2014	10-Year Trend	Comparison (Aggregate)	Comparison (Trend)
	N = 5440	*N = 7882*	*P-value*	*N = 4279*	*N = 7336*	*P-value*	*P-value*	*P-value*
Patient Population								
Age	74 (65, 82)	74 (64, 83)	0.3	77 (68, 84)	76 (68, 85)	0.06	<0.0001	0.5
Female	2525 (46%)	3106 (39%)	<0.0001	2770 (65%)	4700 (64%)	0.001	<0.0001	0.04
Black	1861 (34%)	2838 (36%)	0.4	1155 (27%)	2157 (29%)	0.0004	<0.0001	0.4
Obese	1362 (28%)	2365 (33%)	0.005	1591 (42%)	3229 (49%)	0.004	<0.0001	0.8
Symptoms								
Dyspnea at rest	4272 (79%)	7201 (91%)	<0.0001	3424 (80%)	6693 (91%)	<0.0001	0.3	0.6
Paroxysmal nocturnal dyspnea	1204 (22%)	1415 (18%)	0.005	667 (16%)	884 (12%)	0.008	<0.0001	0.6
Orthopnea	2089 (38%)	2909 (37%)	0.5	1481 (35%)	2237 (30%)	0.02	0.0002	0.2
Physical Exam Findings								
Lower extremity edema	3389 (62%)	5272 (67%)	0.009	2841 (66%)	5297 (72%)	0.002	0.0004	0.5
Rales (more than basilar)	1701 (31%)	2564 (33%)	0.4	1289 (30%)	2454 (33%)	0.4	0.9	0.9
Jugular venous distension	2074 (38%)	2808 (36%)	0.4	1133 (26%)	1968 (27%)	0.7	<0.0001	0.4
Hepatojugular reflux	106 (2%)	213 (3%)	0.08	110 (3%)	141 (2%)	0.9	0.6	0.3
Tachycardia *	1919 (37%)	2644 (35%)	0.5	1069 (26%)	1683 (24%)	0.2	<0.0001	0.5
s3 gallop	389 (7%)	398 (5%)	0.02	123 (3%)	115 (2%)	0.02	<0.0001	0.5
Systolic blood pressure (mmHg)	136 (114, 160)	136 (116, 159)	0.9	143 (124, 168)	145 (126, 168)	0.5	<0.0001	0.6
Imaging and Laboratories								
Pulmonary edema †	2445 (46%)	3670 (48%)	0.2	2106 (50%)	3395 (47%)	0.6	0.4	0.5
Bilateral pleural effusion †	1779 (33%)	2651 (34%)	0.7	1503 (36%)	2867 (40%)	0.08	0.003	0.3
Pulmonary hypertension ‡	1481 (27%)	2426 (31%)	0.1	1359 (32%)	3069 (42%)	<0.0001	<0.0001	0.2
Right ventricular dilation ‡	965 (18%)	2028 (26%)	<0.0001	766 (18%)	1788 (24%)	<0.0001	0.7	0.9
B-type natriuretic peptide §	1185 (572, 2326)	1133 (554, 2211)	0.1	570 (312, 1159)	590 (304, 1160)	0.6	<0.0001	0.1

Abbreviations: HFrEF = heart failure with reduced ejection fraction. HFpEF = heart failure with preserved ejection fraction

Continuous variables (age, systolic blood pressure, B-type natriuretic peptides) presented by median (quartile 1, quartile 3).

P-values for temporal increase or decrease in annual prevalence assessed by logistic regression, regressing on year of admission and using the Cochran-Armitage test for trend. *P*-values for temporal increase or decrease in annual mean values tested by linear regression regressing on year of admission.

P-values for aggregate comparisons between HFpEF vs. HFrEF analyzed by aggregating data across 2005–2014, with mean values tested by least square means from linear regression, and prevalence values tested by Rao-Scott χ^2 tests.

P-values comparing differences in temporal trends between HFpEF vs. HFrEF tested by the linear or logistic regression, regressing on heart failure type and year of admission, and testing the multiplicative interaction of heart failure type by year of admission

[*] Tachycardia indicates heart rate at admission exceeding 110 beats per minute, missing for 809.

[†] Pulmonary edema and bilateral pleural effusion identified by chest x-ray, missing for 583. Pulmonary edema indicates presence of either aveolar or interstitial pulmonary edema.

[‡] Pulmonary hypertension and right ventricular dilation identified by echocardiography

[§] B-type natriuretic peptide assayed for 17,319 (69%) hospitalizations

Table 2:

Characteristics of patients admitted with acute decompensated heart failure with reduced ejection fraction, stratified by obesity categories*. The community surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014.

Characteristic	**Not Obese** *(N = 9596)*	**Obese Class I** *(N=1976)*	**Obese Class II** *(N=848)*	**Obese Class III** *(N=902)*	**Trend** *P-value*
Demographics					
Age	**77** (68, 84)	71 (63, 76)	69 (62, 76)	67 (61, 73)	<0.0001
Female	3830 (40%)	834 (42%)	441 (52%)	526 (58%)	<0.0001
Black	3174 (33%)	751 (38%)	387 (46%)	386 (43%)	<0.0001
Symptoms					
Dyspnea at rest	8282 (86%)	1720 (87%)	700 (83%)	770 (85%)	0.5
Paroxysmal nocturnal dyspnea	1815 (19%)	420 (21%)	169 (20%)	215 (24%)	0.1
Orthopnea	3484 (36%)	759 (38%)	362 (43%)	394 (44%)	0.02
Physical Exam Findings					
Lower extremity edema	5859 (61%)	1451 (73%)	633 (75%)	718 (80%)	<0.0001
Hepatojugular reflux	211 (2%)	78 (4%)	27 (3%)	3 (0.2%)	0.7
Jugular venous distension	3629 (38%)	728 (37%)	241 (28%)	284 (32%)	0.02
Pulmonary rales (>basilar)	3117 (32%)	627 (32%)	266 (31%)	255 (28%)	0.3
s3 heart sound	591 (6%)	135 (7%)	35 (4%)	25 (3%)	0.06
Tachycardia	3268 (35%)	694 (36%)	290 (36%)	312 (37%)	0.7
Systolic blood pressure (mmHg)	135 (114, 159)	139 (118, 160)	139 (118, 161)	139 (116, 160)	<0.0001
Chest Radiography					
Bilateral pleural effusion	3551 (38%)	517 (27%)	175 (21%)	187 (21%)	<0.0001
Pulmonary edema	4511 (48%)	902 (47%)	351 (43%)	349 (39%)	0.01
Echocardiography					
Diastolic dysfunction	2355 (25%)	505 (26%)	205 (24%)	198 (22%)	0.6
RV dilation	2098 (22%)	451 (23%)	188 (22%)	256 (28%)	0.1
Pulmonary hypertension	2960 (31%)	509 (26%)	214 (25%)	223 (25%)	0.06
Laboratory					
B-type natriuretic peptide (pg/mL)	1305 (676, 2516)	876 (438, 1804)	639 (337, 1364)	565 (247, 1039)	<0.0001

*Obesity class I = body mass index of 30 to <35 kg/m^2, class II = 35 to <40 kg/m^2, class III ≥40 kg/m^2

Continuous variables (age, B-type natriuretic peptides) presented by median (quartile 1, quartile 3)

Table 3:

Characteristics of patients admitted with acute decompensated heart failure with preserved ejection fraction, stratified by obesity categories. The community surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014.

	Not Obese *(N=6806)*	**Obese Class I** *(N=2017)*	**Obese Class II** *(N=1180)*	**Obese Class III** *(N=1610)*	**Trend** ***P-value***
Demographics					
Age	81 (72, 87)	76 (70, 83)	73 (65, 81)	68 (61, 75)	<0.0001
Female	4273 (63%)	1215 (60%)	779 (66%)	1202 (75%)	0.0002
Black	1767 (26%)	521 (26%)	377 (32%)	647 (40%)	<0.0001
Symptoms					
Dyspnea at rest	5767 (85%)	1836 (91%)	1064 (90%)	1449 (90%)	0.002
Paroxysmal nocturnal dyspnea	872 (13%)	290 (14%)	149 (13%)	240 (15%)	0.4
Orthopnea	1994 (29%)	637 (32%)	377 (32%)	708 (44%)	<0.0001
P/E Findings					
Lower extremity edema	4295 (63%)	1503 (75%)	966 (82%)	1375 (85%)	<0.0001
Hepatojugular reflux	168 (2%)	39 (2%)	21 (2%)	23 (1%)	0.3
Jugular venous distension	1887 (28%)	560 (28%)	357 (30%)	297 (18%)	0.01
Pulmonary rales (>basilar)	2252 (33%)	637 (32%)	409 (35%)	445 (28%)	0.2
S3 heart sound	158 (2%)	18 (1%)	25 (2%)	37 (2%)	0.8
Tachycardia	1718 (26%)	402 (21%)	258 (23%)	374 (24%)	0.2
Systolic blood pressure (mmHg)	144 (124, 168)	146 (127, 170)	147 (124, 174)	142 (125, 163)	0.9
Chest Radiography					
Bilateral pleural effusion	2973 (45%)	650 (33%)	368 (31%)	379 (24%)	<0.0001
Pulmonary edema	3376 (51%)	880 (44%)	532 (45%)	714 (46%)	0.04
Echocardiography					
Diastolic dysfunction	1846 (27%)	549 (27%)	390 (33%)	416 (26%)	0.7
Right ventricular dilation	1453 (21%)	465 (23%)	247 (21%)	389 (24%)	0.4
Pulmonary hypertension	2693 (40%)	748 (37%)	444 (38%)	543 (34%)	0.06
Laboratory					
B-type natriuretic peptide (pg/mL)	718 (388, 1344)	513 (305, 1002)	465 (251, 906)	313 (183, 594)	<0.0001

*Obesity class I = body mass index of 30 to <35 kg/m^2, class II = 35 to <40 kg/m^2, class III ≥40 kg/m^2

Continuous variables (age, systolic blood pressure, B-type natriuretic peptides) presented by median (quartile 1, quartile 3)

Table 4:

Adjusted odds ratios* of 28-day mortality associated with various signs of hypervolemia / pulmonary congestion among patients hospitalized with acute decompensated heart failure, stratified by heart failure type. The Community Surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014.

	HFrEF		HFpEF		Interaction
	Present	**OR (95% CI)**	**Present**	**OR (95% CI)**	***P*-value†**
Physical Examination					
Jugular venous distension	37%	0.92 (0.71 – 1.20)	27%	1.38 (0.99 – 1.92)	0.08
Pulmonary rales	32%	1.65 (1.28 – 2.12)	32%	1.63 (1.20 – 2.22)	0.9
Lower extremity edema	65%	1.01 (0.77 – 1.31)	70%	0.99 (0.70 – 1.40)	0.9
S3 heart sound	6%	0.93 (0.52 – 1.67)	2%	0.74 (0.23 – 2.42)	0.8
Hepatojugular reflux	2%	1.07 (0.52 – 2.24)	2%	0.83 (0.25 – 2.75)	0.8
Tachycardia	22%	1.14 (0.82 – 1.56)	14%	1.45 (0.98 – 2.15)	0.4
Radiography					
Pulmonary edema	47%	1.46 (1.13 – 1.89)	48%	1.37 (0.98 – 1.91)	0.7
Bilateral pleural effusion	34%	1.46 (1.12 – 1.89)	38%	1.97 (1.41 – 2.74)	0.2
Echocardiography					
Right ventricular dilation	22%	1.20 (0.90 – 1.61)	22%	1.44 (1.00 – 2.06)	0.5
Pulmonary hypertension	29%	1.15 (0.87 – 1.54)	38%	1.14 (0.83 – 1.57)	0.8

*Models adjusted for demographics (age, race, sex, year of admission, geographic region), and hospitalization acuity (length of stay).

†Mutliplicative interaction tests modification of the associated mortality odds ratio by heart failure type

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Table 5:

Adjusted odds ratios* of 28-day mortality associated with various signs of hypervolemia / pulmonary congestion among patients hospitalized with acute decompensated heart failure, stratified by obesity. The Community Surveillance component of the Atherosclerosis Risk in Communities Study, 2005–2014.

	Without Obesity				With Obesity			
Congestive Signs	**HFrEF**		**HFpEF**		**HFrEF**		**HFpEF**	
	Present	**OR (95% CI)**	**Present**	**OR (95% CI)**	**Present**	**OR (95% CI)**	**Present**	**OR (95% CI)**
Physical Exam								
Jugular venous distension	38%	1.02 (0.73 – 1.40)	28%	1.35 (0.86 – 2.11)	34%	1.02 (0.64 – 1.62)	25%	1.22 (0.72 – 2.05)
Pulmonary rales	32%	1.43 (1.03 – 1.98)	34%	1.92 (1.23 – 2.96)	31%	1.80 (1.17 – 2.78)	31%	1.44 (0.88 – 2.37)
Lower extremity edema	61%	0.82 (0.59 – 1.12)	63%	0.91 (0.58 – 1.44)	75%	2.24 (1.19 – 4.22)	80%	1.19 (0.66 – 2.14)
S3 heart sound	6%	0.98 (0.48 – 1.98)	3%	0.72 (0.14 – 3.85)	5%	0.97 (0.39 – 2.39)	2%	1.16 (0.22 – 6.23)
Hepatojugular reflux†	2%	0.58 (0.14 – 2.53)	3%	1.41 (0.40 – 4.98)	3%	0.92 (0.20 – 4.20)	2%	---
Tachycardia	22%	1.38 (0.92 – 2.06)	15%	1.49 (0.88 – 2.54)	25%	1.05 (0.64 – 1.73)	13%	1.71 (0.89 – 3.27)
Radiography								
Pulmonary edema	48%	1.41 (1.03 – 1.95)	48%	1.52 (0.92 – 2.49)	44%	1.67 (1.06 – 2.63)	45%	1.10 (0.68 – 1.79)
Bilateral pleural effusion	39%	1.75 (1.26 – 2.42)	45%	1.63 (1.01 – 2.63)	24%	1.11 (0.66 – 1.87)	30%	2.52 (1.54 – 4.13)
Echocardiography								
RV dilation	22%	0.98 (0.67 – 1.42)	22%	1.14 (0.66 – 1.98)	24%	1.39 (0.82 – 2.35)	23%	1.71 (0.99 – 2.96)
Pulmonary hypertension	31%	1.17 (0.82 – 1.66)	41%	0.95 (0.61 – 1.49)	25%	1.15 (0.67 – 1.96)	36%	1.15 (0.67 – 1.94)

Abbreviations: HFrEF = heart failure with reduced ejection fraction, HFpEF = heart failure with preserved ejection fraction

*Models adjusted for demographics (age, race, sex, year of admission, geographic region), and hospitalization acuity (length of stay).

†Sample size of patients with HFpEF and hepatojugular reflux with 28-day fatality event too low to calculate mortality odds ratio