Ultrafiltration in Heart Failure with Preserved Ejection Fraction: Comparison with Systolic Heart Failure Patients

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Abstract

Background—Ultrafiltration (UF) is a widely used technology for inpatient management of acute decompensated heart failure (ADHF) in patients with volume overload. However, the safety and efficacy of UF in patients with heart failure and preserved left ventricular ejection fraction (LVEF, HFPEF) need further clarification. We hypothesized that UF could be used in this population with outcomes similar to ADHF patients with low LVEF (HFLEF).

Methods and Results—Prospective evaluation was performed on two patient cohorts admitted to a single institution for ADHF and treated with UF: HFLEF (LVEF ≤ 40%, n=87) and HFPEF (LVEF > 40%, n=97). Selected demographic and clinical data were compared including clinical and serologic information as well as in-hospital and 90 day post discharge mortality. HFPEF patients were more likely to be female, have higher blood pressures, and less likely to have ischemic heart disease. There were no significant differences in total weight loss (7.7% in HFLEF and 7.0% in HFPEF), electrolyte and renal disturbances, or in-hospital mortality (3.4% in HFLEF and 3.3% in HFPEF) between the two groups. Mortality at 90 days tended to be greater in HELEF (24.1%) than in HFPEF (15.5%).

Conclusions—Therapeutic responses in patients with HFPEF meeting current indication for UF are similar to those with HFLEF. Larger studies are warranted to better characterize acute HF management with UF in this population.

Key Words: heart failure, diastolic heart failure, registry, ultrafiltration
There are over 1,000,000 hospitalizations for the primary diagnosis of acute decompensated heart failure (ADHF) in the United States, associated with an estimated cost of 29 billion dollars annually.\(^1\)\(^2\) Beyond loop diuretic therapy, proven treatment options are limited, with unsatisfactory results using inotropic support,\(^3\)\(^4\) vasodilation,\(^5\) vasopressin\(^6\) and endothelin inhibition.\(^7\) A recent addition to the in-hospital treatment algorithm for HF is ultrafiltration (UF), a mechanical method of volume removal with several potential advantages over usual care. Putative benefits of UF include more effective sodium (Na) removal\(^8\) and less neurohormonal stimulation.\(^9\) While conclusive data on the overall benefit and identification of potential sub-populations most likely to benefit from UF remain unclear, there is a suggestion that ADHF with preserved LVEF (HFPEF) might be effectively managed with UF. Indeed, in the Ultrafiltration Versus Intravenous Diuretics for Patients Hospitalized for Acute Decompensated Heart Failure (UNLOAD) trial that showed superior volume and weight reduction with UF compared with usual care,\(^10\) some patients (59 of 200, 30%) had an LVEF > 40%. Furthermore, established indication for UF does not distinguish patients based on LVEF. While the treatment goal of symptom relief through volume removal remains similar to heart failure patients with low LVEF (HFLEF),\(^11\) pathophysiologic differences embodied by higher end systolic and arterial elastances\(^12\)\(^13\)\(^14\) are manifested by a greater drop in blood pressure with similar changes in central volume.\(^12\) The downstream effects of UF on these pathophysiologic differences between HFPEF and HFLEF patients, specifically on renal function, are not well known. Consequently, the need to study acutely decompensated HFPEF patients treated with UF remains valid.

Accordingly, we sought to expand on the UNLOAD trial findings by analysis of a prospective registry of UF patients which were stratified by LVEF. We hypothesized that UF could be used in the HFPEF population with outcomes similar to those with HFLEF.
Methods

Patients

The database and its design were approved by the Institutional Review Board of The Christ Hospital, Cincinnati, OH. All patients admitted to The Christ Hospital inpatient HF service for ADHF who were treated with UF, regardless of LVEF, were entered into a prospective database. Selection of UF as the primary treatment method was the choice of the involved HF specialist; generally, patients with more than 10 lbs of estimated volume overload or evidence of inadequate response to IV diuretic administration (UOP < 125 ml/hour) were referred for UF. Otherwise, there was no explicit protocol guidance for patient selection. Patients had to be able to tolerate insertion of a brachial or internal jugular venous line for access, as well as heparin infusion. LVEF was recorded in the database based on the most recent available value prior to admission; these values are available in the chart as part of the HF core measures set. The time between the last LVEF determination and admission was not recorded in the registry. Nonetheless, the vast majority of these values were obtained from echocardiograms performed in our institution’s laboratories (accredited by the Intersocietal Commission for the Accreditation of Echocardiography Laboratories-ICAEL) and read by board certified cardiologists as part of routine clinical practice. As part of the ICAEL certification, routine technologist and physician education and correlations are performed. Only those patients with recorded weights on admission, UF initiation, UF cessation, and discharge were included in the current analysis; patients were divided into those with HFLEF (LVEF < 40%) and HFPEF (LVEF > 40%).
Protocol

Ultrafiltration was performed for each patient using the Aquadex 100 system (CHF Solutions, Inc, now Gambro) on a telemetry unit, specially dedicated to heart failure treatment, with patient to nurse ratio of no more than two to one. Sixty-nine % of patients in HFLEF and 57% in HFPEF were treated via brachial vein extended length catheter (ELC) and the rest via internal jugular access. The ELC is a 6 F, 15 cm, dual lumen catheter provided by the makers of the Aquadex system, inserted by the peripherally inserted central catheter (PICC) team. All UF patients received intravenous heparin to keep activated partial thromboplastin time between 70-90 seconds (after July 2009, anti Factor X levels between 0.3 and 0.7 IU/ml). While loop and thiazide diuretics were discontinued, spironolactone was continued. None of the patients received concurrent intravenous vasodilator or inotropic therapies. The in-line hematocrit sensor was not used routinely, and did not figure into clinical decisions. Discontinuation of treatment and fitness for discharge were made by the treating HF physician based on clinically assessed volume status, symptoms, and objective data such as laboratory values.

Death rates at ninety days post discharge were obtained through examination of the social security database.

Statistical Analysis

The Chi square test was used to test categorical variables, while continuous variables with a normal distribution were tested with the Student’s t-test. The paired t-test was used to compare values pre- and post- UF. Non-normally distributed variables were analyzed with Wilcoxon Rank Sum test and presented as the median with interquartile range. A p-value ≤ 0.05 was considered to be significant. All data were analyzed using R 2.15.1 statistical package.
For 90 day survival, we fit the data using a Cox Proportional Hazards model. Of the covariates in question, a modest correlation was found between total weight loss for the admission and the total UF run time as well as between length of stay and time to UF initiation. It was decided to not include total UF run time and time to UF initiation in the Cox model. The first model considered the effects of covariates that were most likely to influence survival: EF group, age, gender, change in creatinine after UF, length of stay, and total weight loss for the admission. While the full model gave a p-value of 0.0076, many of the covariates did not reach significance. Covariates were removed from the model using backward elimination until a final model was obtained with remaining covariates (except for our main effect, EF Group) reaching significance level ≤ 0.05. The final Cox model adjusts for age on EF group and has a p-value of 0.0084. EF group was found to have a β coefficient = -0.58, translating to the HFPEF group trending toward a better chance of survival than the HFLEF group (p=0.0885). Age (β coefficient = 0.03) had a positive effect on survival in the model (p=0.0167).

**Results**

We analyzed 87 patients in the HFLEF group and 97 in HFPEF. As shown in Table 1, the HFPEF patients were more likely female (52.6 % vs. 26.4), less likely to have ischemic etiology (44.3 % vs. 65.5), heavier (259 lbs vs. 220.6), with higher systolic blood pressure (128.5 mmHg vs. 112.3), and lower B-type natuiriuretic peptide (BNP) levels (347 pg/ml vs. 1125). Based on a limited number of patients for whom data were available, median daily furosemide dose before initiation of UF for HFLEF was 206.5 mg (IQR:10-240, n=26) and for HFPEF, 210 mg (IQR: 40-288, n=57).

In terms of the UF protocol, therapy was started at median of 40.6 (21.2-66.6) hours after presentation to the hospital in HFLEF and 30.5 (17.5-77.1) hours in HFPEF. (Table 2) Average
UF rate was approximately 180 ml per hour for both groups. In terms of unintended UF interruptions during the course of therapy for technical reasons, approximately 73% of HFLEF patients and 60% of HFPEF experienced at least one interruption (p=0.14). In both groups, the vast majority of these interruptions were for clotting of the filter. There were no reported interruptions for symptomatic hypotension, bleeding or thrombosis.

In both groups, weight loss between admission and initiation of UF was minimal (0.4 lbs in HFLEF, 1.2 in HFPEF). (Table 2) During UF treatment, weight loss in the two groups were similar (16.7 lbs in HFLEF and 14.1 lbs in HFPEF); however, HFLEF did not lose further weight in the period between UF cessation to discharge (203.5 lbs to 203.7, p=0.72) while HFPEF group lost on average 2.7 lbs more (243.7 lbs to 241.0, p=0.07). These changes in weight by stages are represented in Figure 1.

In totality, the two groups responded similarly to UF treatment. Both groups lost significant amount of weight (7.7 % of baseline weight in HFLEF and 7.0 % in HFPEF, between group comparison p = 0.73). (Table 2) Systolic blood pressure decreased in both groups by 5-6 mmHg and both manifested signs of volume contraction, with tendency for higher blood urea nitrogen and creatinine levels at end of UF treatment. (Table 3) However, we did observe that creatinine levels were unchanged from UF cessation to discharge in HFLEF (1.82(1.3-2.7) to 1.84 (1.3-2.6), p = 0.89) and in HFPEF (1.65 (1.2-2.6) to 1.82 (1.2-2.7), p = 0.65), p = 0.5 for intergroup difference. There was no evidence of hemoconcentration in terms of hematocrit elevation, drawn with routine morning laboratories. In both groups, Na levels were lower at discharge, although importantly, potassium levels were higher (Tables 3).

Hospital lengths of stay were the same, with 8 days (5-11.5) for HFLEF and 8 days (6-13) for HFPEF. (Table 4) In hospital mortality rates were 3 of 87 (3.4%) in HFLEF and 2 of 97
(3.3%) in HFPEF. Number of deaths at 90 days post discharge tended to be greater in HFLEF, 21 (24.1%) compared with HFPEF, 15 (15.5%). Cox Proportional Hazard plot of age-adjusted mortality is shown in Figure 2.

**Discussion**

Our findings based on a large cohort of HFPEF patients treated with UF suggest that this population responds similarly to patients with reduced LVEF. Between group comparisons of changes in weights and other clinical parameters show no significant difference between HFLEF and HFPEF.

The HFPEF patient characteristics of our cohort are consistent with other databases of such patients, with a preponderance of female patients and a greater likelihood of hypertensive, non-ischemic etiology of HF. The findings of this study are reassuring in that UF may be safely applied to the preserved LVEF patients with volume overload with a reasonable expectation of efficacy, similar to the low LVEF population. This is not entirely surprising in that the pathophysiologic mechanisms underlying acute decompensation and volume overload are similar in the two groups of patients. Whether UF represents a superior method of treatment compared with usual care for these patients in the acute setting remains to be seen.

The recent report of the landmark Cardiorenal Recue Study in Acute Decompensated Heart Failure (CARRESS-HF) study has raised concerns about the safety and utility of UF in the management of patients with ADHF with reduced or preserved LV ejection fraction, complicated persistent congestion and worsening renal function. This direct comparison of 94 patients treated with stepped pharmacologic therapy versus 94 patients treated with UF had a bivariate endpoint of change from baseline in serum creatinine and body weight. There was a
similar amount of weight loss seen in both groups. However, preservation of renal function at 96 hours was superior in the stepped pharmacologic therapy group. Should the findings of CARRESS-HF affect the interpretation of our study? The answer depends on whether the patients in the two studies are comparable. Pre-study furosemide equivalents in CARRESS-HF were 120 mg per day; in our study, furosemide equivalents prior to starting UF were over 210 mg per day. However, due to small number of data available (Table 1), this comparison is suboptimal. Sixty day mortality rate in CARRESS-HF was 17% in the UF arm, compared with 24% 90 day mortality in the HFLEF arm of our study. These rates appear to be fairly similar. Obviously, as an uncontrolled study, our analysis can only comment on the comparison between HFLEF and HFPEF groups, and remain silent on the relative efficacy of UF vs. usual care in either group. We do not extrapolate the findings from CARRESS-HF to HFPEF patients, as the interplay between a more predictable rate of volume removal (UF) and the pressure-volume slope are unknown in the clinical setting.

Does the approximately 10 day length of stay for both groups suggest these patients may not be comparable to the typical patients seen for ADHF? In the ADHERE registry, a large clinical cross section, the average LOS were 5 days for HFLEF (n=25,865) and 4.9 for HFPEF patients (n=26,322). However, our patients were those who by virtue of their selection for UF were likely to be sicker, with greater estimated target volume to be removed and evidence of diuretic resistance. Compared with patients in the ADHERE registry, our patients had lower systolic BP (112.3 mmHg vs. 139 in HFLEF, 128.5 mmHg vs. 153 in HFPEF), higher BUN (49.3 mmHg vs. 30 in HFLEF, 45.3 mg/dl vs. 29 in HFPEF) and creatinine (1.77 mg/dl vs. 1.6 in HFLEF, 1.92 mg/dl vs. 1.7 in HFPEF). This conclusion is supported by the relatively high 90-day mortality rates of 24.1% and 15.5% in HFLEF and HFPEF groups respectively.
The impact of UF on weight change for the entire hospitalization is similar in HFLEF vs. HFPEF, with comparable changes in electrolyte values and renal function. Rises in serum BUN and creatinine levels were seen in both groups; whether these observations represent significant deleterious events or transient markers of decongestion is not clear due to the lack of a diuretic control group or follow up renal function. However, we did observe that creatinine levels were unchanged from UF cessation to discharge in HFLEF (1.82 (1.3-2.7) to 1.84 (1.3-2.6), p = 0.89) and in HFPEF (1.65 (1.2-2.6) to 1.82 (1.2-2.7), p = 0.65), p = 0.5 for intergroup difference. This is not surprising in that typically, a creatinine rise is used in conjunction with clinical status to signal a reasonable time to stop UF, and stability of renal function a requisite for discharge. Nonetheless, 90-day death rates do appear to be higher than expected, and it is possible that UF may have had a deleterious medium term clinical effect which is more pronounced in the HFLEF group.

Changes in weight at various time points are of interest. There is no significant weight loss between admission and UF initiation in these diuretic resistant patients, despite conventional therapy for over significant number of hours. However the relative contribution of UF to the overall weight loss is less in HFPEF than in HFLEF. The HFPEF patients continued to lose weight during the period between UF cessation and discharge; 15% of the total weight loss in HFPEF was achieved in the period between UF cessation and discharge. The exact duration of this time period is not clear because in nearly 35% of the patients, the UF treatment was not continuous. Nonetheless, it seems that compared with HFLEF patients, HFPEF patients’ response to usual care in the period after UF was relatively greater, even if small in magnitude. Mechanisms to explain this observation might include the potential to be more aggressive with diuretic therapy given the higher BP in the HFPEF group as well as a differential effect of UF.
mediated volume removal on cardio-renal physiology and neurohormonal activation between HFLEF and HFPEF.

Despite similar amounts of weight loss, the change in BNP is relatively greater in HFPEF. The reasons for this finding are not clear, as clinically, both groups appeared improved and ready for discharge. It is possible that similar amounts of volume removed represents a more complete decongestive treatment in the HFPEF, as it is known that through a steeper pressure volume relationship, patients with HFPEF require smaller volume changes to achieve comparable filling pressure drops, and that doses of diuretics required are generally less in HFPEF patients compared with HFLEF patients.20

There are operational challenges to UF that apply to most patients receiving this treatment, regardless of whether they have decreased or preserved systolic function. In most patients in the current study, UF was not begun early, particularly as diuretic resistance is the typical indication for UF initiation. However further delay may be reflective of the associated patient flow limitations that exist in many tertiary care hospitals from point of contact in the emergency department until transfer to an inpatient unit and initiation of more definitive therapy under the heart failure team’s guidance. This uncontrolled pre-treatment period may have impacted our observations, as HFLEF and HFPEF patients may have been subject to potential disparity in diagnosis and treatment of acute heart failure based on LVEF. However similar lack of weight loss in the period between presentation and UF initiation minimizes the effect of this potential confounder.
**Limitations**

This study is not a randomized clinical trial, but rather a cohort study. As such, it cannot evaluate UF’s relative effectiveness or safety compared with usual care. The database elements are also limited, without extensive baseline clinical and pharmacological data, urine output, input and output information, and adequate follow up post discharge. In future study designs, these limitations should be addressed.

**Conclusions**

In a non-randomized, prospective observational study comparing ADHF patients stratified by LVEF, we observed in both HFLEF and HFPEF a similar mild drop in BP, rise in BUN and creatinine, as well as a drop in serum Na and rise in serum K. Overall LOS, weight loss, and in-hospital mortality are similar between HFLEF and HFPEF. Therefore, UF may be a viable treatment option in those ADHF patients with preserved LVEF. Further investigation is required to better define the potential advantages of the more prescribed, accurate and predictable degree of volume removal with ultrafiltration in this population.

**Acknowledgments**

We wish to thank Dr. Eileen King of Cincinnati Children’s Hospital for her invaluable assistance with data analysis.

**Disclosures**

Dr. Menon: speaker’s bureau for Gambro.
References


Table 1. Patient data on admission

<table>
<thead>
<tr>
<th></th>
<th>HFLEF (n=87)</th>
<th>HFPEF (n= 97)</th>
<th>P value</th>
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</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>65 ± 15.9</td>
<td>67 ± 13.1</td>
<td>0.43</td>
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<tr>
<td>Male gender, n (%)</td>
<td>64 (73.6)</td>
<td>46 (47.4)</td>
<td>0.0005</td>
</tr>
<tr>
<td>Black race, n (%)</td>
<td>15 (17.2)</td>
<td>12 (12.3)</td>
<td>0.48</td>
</tr>
<tr>
<td>Ischemic etiology, n (%)</td>
<td>57 (65.5)</td>
<td>43 (44.3)</td>
<td>0.0063</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>22.6 ± 8.4</td>
<td>55.7 ± 6.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Admission weight (lbs)</td>
<td>220.6 ± 66.3</td>
<td>259.0 ± 77.7</td>
<td>0.0004</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>112.3 ± 18.0</td>
<td>128.5 ± 23.2</td>
<td>0.0002</td>
</tr>
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<td>Median daily furosemide dose</td>
<td>206.5 (10-240)</td>
<td>210 (40-288)</td>
<td>0.499</td>
</tr>
<tr>
<td>BNP (pg/ml)</td>
<td>1125 (546-1933)</td>
<td>347 (130-689)</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Na (mmol/l)</td>
<td>135.7 ± 5.1</td>
<td>137.8 ± 4.1*</td>
<td>0.0023</td>
</tr>
<tr>
<td>K (mmlol/l)</td>
<td>4.04 ± 0.62</td>
<td>4.05 ± 0.59</td>
<td>0.96</td>
</tr>
<tr>
<td>BUN (mg/dl)</td>
<td>44 (26-64.5)</td>
<td>41 (26-61.5)</td>
<td>0.48</td>
</tr>
<tr>
<td>Creatinine (mg/dl)</td>
<td>1.6 (1.31-2.1)</td>
<td>1.56 (1.1-2.24)</td>
<td>0.56</td>
</tr>
<tr>
<td>Hct (%)</td>
<td>34.1 ± 5.6</td>
<td>31.7 ± 5.2*</td>
<td>0.0089</td>
</tr>
</tbody>
</table>

GFR: glomerular filtration rate. LVEF: left ventricular ejection fraction. BNP: brain natriuretic peptide. Na: sodium. K: potassium. BUN: blood urea nitrogen. Hct: hematocrit. Numbers of patients with available data for median daily furosemide dose were 26 in HFLEF, 57 in HFPEF. Mean ± SD, except BNP. Median daily furosemide dose. BUN, creatinine are presented as the median with 25th and 75th interquartile ranges.
Table 2. Ultrafiltration specific data

<table>
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<th>HFLEF (n=87)</th>
<th>HFPEF (n= 97)</th>
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<tr>
<td>Time to UF start, (hours)</td>
<td>40.6(21.2-66.6)</td>
<td>30.5(17.5-77.1)</td>
<td>0.93</td>
</tr>
<tr>
<td>Total UF run time (hours)</td>
<td>59.3 (36.8-87.8)</td>
<td>59 (40.6-89)</td>
<td>0.62</td>
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<tr>
<td>Initial UF run rate (ml/hour)</td>
<td>187.9 ± 60.7</td>
<td>179.7 ± 58.2</td>
<td>0.39</td>
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<tr>
<td>Weight on admission (lbs)</td>
<td>220.6 ± 66.3</td>
<td>259.0 ± 77.7</td>
<td>0.0004</td>
</tr>
<tr>
<td>Weight on UF initiation (lbs)</td>
<td>220.2 ± 67.0</td>
<td>257.8 ± 76.3</td>
<td>0.0005</td>
</tr>
<tr>
<td>Weight on UF cessation (lbs)</td>
<td>203.5 ± 62.2</td>
<td>243.7 ± 77.4</td>
<td>0.0001</td>
</tr>
<tr>
<td>Weight on discharge (lbs)</td>
<td>203.7 ± 62.1</td>
<td>241.0 ± 77.0</td>
<td>0.0004</td>
</tr>
<tr>
<td>Weight change with UF (lbs)</td>
<td>16.7 ± 11.2</td>
<td>14.1 ± 16.3</td>
<td>0.21</td>
</tr>
<tr>
<td>Total weight change (lbs)</td>
<td>16.9 ± 11.9</td>
<td>18.0 ± 15.0</td>
<td>0.60</td>
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<tr>
<td>Total weight change (% of baseline)</td>
<td>7.7</td>
<td>7.0</td>
<td>0.73</td>
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</table>

Mean ± SD, except Time to UF start and Total UF run time are presented as the median with 25th and 75th interquartile ranges.
Table 3. Effect of UF

<table>
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<tr>
<th></th>
<th>HFLEF (n=87)</th>
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<th>HFPEF (n= 97)</th>
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<tr>
<td></td>
<td>Before UF</td>
<td>After UF</td>
<td>Before UF</td>
<td>After UF</td>
<td></td>
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<tr>
<td>Systolic BP (mmHg)</td>
<td>111.2 ± 18.3</td>
<td>106.2 ± 16.0</td>
<td>122.9 ± 17.9*</td>
<td>117.3 ± 15.1*</td>
<td>0.69</td>
</tr>
<tr>
<td>Na (mmol/l)</td>
<td>135.7 ± 5.1</td>
<td>133.3 ± 5.7†</td>
<td>137.8 ± 4.1*</td>
<td>135.6 ± 4.9*†</td>
<td>0.94</td>
</tr>
<tr>
<td>K (mmol/l)</td>
<td>4.04 ± 0.62</td>
<td>4.5 ± 0.67†</td>
<td>4.05 ± 0.59</td>
<td>4.60 ± 0.8†</td>
<td>0.37</td>
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<tr>
<td>BUN (mg/dl)</td>
<td>44(26-64.5)</td>
<td>53.5(33-80.75)†</td>
<td>41(26-61.5)</td>
<td>48(31-76)†</td>
<td>0.40</td>
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<tr>
<td>Creatinine (mg/dl)</td>
<td>1.6(1.32-2.1)</td>
<td>1.82(1.3-2.7)†</td>
<td>1.56(1.1-2.2)</td>
<td>1.65(1.2-2.6)</td>
<td>0.27</td>
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<td>BNP (pg/ml)</td>
<td>1125(546-1933)</td>
<td>914(430-1880)</td>
<td>347(130-689)*</td>
<td>259(86-518)*</td>
<td>0.50</td>
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<td>Hct (%)</td>
<td>34.1 ± 5.6</td>
<td>31.7 ± 5.8†</td>
<td>31.7 ± 5.2*</td>
<td>30.7 ± 5.4</td>
<td>0.21</td>
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* p < 0.05 vs. corresponding HFLEF value, † p< 0.05 vs. Before UF. Between group p values refer to between group comparisons of changes. Na: sodium, K: potassium, BUN: blood urea nitrogen, BNP: brain natriuretic peptide, Hct: hematocrit. Mean ± SD, except BUN, creatinine, BNP are presented as the median with 25th and 75th interquartile ranges.
Table 4. Clinical data

<table>
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<th>HFPEF (n= 97)</th>
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<tr>
<td>Length of stay (days)</td>
<td>8 (5-11.5)</td>
<td>8 (6-13)</td>
<td>0.46</td>
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<tr>
<td>In hospital death, n (%)</td>
<td>3 (3.4%)</td>
<td>2 (3.3%)</td>
<td>0.90</td>
</tr>
<tr>
<td>90 day death, n (%)</td>
<td>21 (24.1%)</td>
<td>15 (15.5%)</td>
<td>0.20</td>
</tr>
</tbody>
</table>

LOS presented as the median with 25th and 75th interquartile ranges.
Figure Legends

Figure 1. Weights at various stages of hospitalization relative to ultrafiltration are displayed. There is minimal change in weight before UF initiation in both groups. However after UF cessation, the HFPEF group continues to lose a modest amount of weight, while HFLEF does not. Nonetheless, the overall trend and magnitude of weight changes in the two groups are similar. *P<0.05 compared with previous stage of hospitalization.

Figure 2. Adjusted mortality with Cox proportional hazards model.
Weights at various stages of hospitalization for HFLEF and HFPEF patients

- **Weight on admission (lbs)**
- **Weight on UF initiation (lbs)**
- **Weight on UF cessation (lbs)**
- **Weight on discharge (lbs)**

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**Circulation**

Heart Failure

Journal of the American Heart Association
Age Adjusted Survival of Ultrafiltration Patients by EF Group

Survival Probability

Survival in Days

p = 0.0885

Circulation
Heart Failure
JOURNAL OF THE AMERICAN HEART ASSOCIATION
Ultrafiltration in Heart Failure with Preserved Ejection Fraction: Comparison with Systolic Heart Failure Patients
John L. Jefferies, Cheryl Bartone, Santosh Menon, Gregory F. Egnaczyk, Thomas M. O'Brien and Eugene S. Chung

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