30-Day Outcomes in Medicare Patients with Heart Failure at Heart Transplant Centers

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ABSTRACT

Background: Heart transplant centers are generally considered ‘centers of excellence’ for HF care. However, their overall performance has not previously been evaluated in a broad population of elderly HF patients, many of whom are not transplant candidates.

Methods and Results: We identified over 1 million elderly Medicare beneficiaries who were hospitalized for HF between 2004 and 2006 at over 4500 hospitals. We calculated 30-day risk-standardized mortality rates and standardized mortality ratios as well as 30-day risk-standardized readmission rates and standardized readmission ratios at heart transplant centers and non-heart transplant hospitals using risk-standardization models employed by the Centers for Medicare & Medicaid Services for public reporting. The 30-day risk-standardized mortality rates were lower at heart transplant centers than non-heart transplant hospitals nationally (10.6% versus 11.5%, p<0.001), but similar at peer institutions offering coronary artery bypass grafting within the same geographical region (10.6% versus 10.6%, p=0.96). The mean standardized mortality ratio for heart transplant centers was 0.9 (standard deviation [SD], 0.1; range 0.7 to 1.3). No differences were noted in 30-day risk-standardized readmission rates between heart transplant centers and non-heart transplant hospitals nationally (23.6% versus 23.8%, p=0.55). The mean standardized readmission ratio for heart transplant centers was 1.0 (SD, 0.1; range 0.8 to 1.2).

Conclusions: In elderly Medicare HF patients, heart transplant centers have lower 30-day risk-standardized mortality rates than non-heart transplant hospitals nationally; however, this difference is not present in comparison with peer institutions or for 30-day risk-standardized readmission rates.

Key words: heart failure; morbidity; mortality; hospitals; outcomes
INTRODUCTION

Specialist-directed care can improve outcomes across a wide range of medical conditions including heart failure (HF).\(^1\)-\(^4\) Hospitals performing heart transplants require dedicated infrastructure to evaluate and treat the sickest HF patients and, in many ways, represent the ultimate in specialist-directed care for this condition. However, HF outcomes at heart transplant centers have not previously been reported across a broad population of elderly patients, most of whom are not transplant candidates.

Elderly patients who are hospitalized for HF have a high risk for death and suffer frequent readmissions after discharge,\(^5\) and the risk for these outcomes varies markedly across hospitals.\(^1\),\(^6\)-\(^8\) This observation is not entirely explained by patient characteristics,\(^1\),\(^6\)-\(^8\) but little is known about the hospital-level factors that contribute to outcomes in the elderly HF population. It is plausible that the expertise at heart transplant centers improves outcomes for HF patients hospitalized there, even those not eligible for transplantation. If this is the case, adopting some of the related processes of care at the much larger number of non-transplant hospitals might improve HF outcomes in elderly patients.

Accordingly, we used recently-developed and validated risk-adjustment models to assess short-term HF outcomes in Medicare HF patients hospitalized at heart transplant centers. We hypothesized that heart transplant centers would have lower risk-standardized 30-day mortality and readmission rates when compared with hospitals that did not perform transplantation.

METHODS

Study Sample

We used 100% of the Medicare Provider Analysis and Review (MEDPAR) Part-A inpatient files between 2004 and 2006 obtained from the Centers for Medicare & Medicaid Services (CMS). These files included patient-level demographic information, principal and secondary ICD-9CM diagnosis codes, and procedure codes on each hospitalization for the
Medicare population. The study population included Medicare patients 65 years or older hospitalized with a principal discharge diagnosis of HF by International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic codes (ICD-9CM codes 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, or 428.xx).

We included discharges in patients enrolled in Medicare fee-for-service for at least one year, as we used 12 months of prior utilization data to obtain information on comorbidities (see below). We excluded all discharges in patients who were discharged alive, not against medical advice, and within the first day of admission as we deemed them unlikely to have had truly decompensated HF (6% of total discharges for mortality cohort). As we sought to focus on outcomes in “routine” HF patients, we also excluded discharges in patients with a prior history of heart transplantation (ICD-9CM procedure code 37.51) or mechanical circulatory support (ICD-9CM procedure codes 37.52-37.54, 37.62-37.68) (n=799 for the mortality analysis; n=1110 for the readmission analysis). We also excluded discharges from hospitals with 10 or fewer HF cases during the study period (n=1050 for the mortality analysis and n=823 for the readmission analysis).

Using publicly-available data from the United Network of Organ Sharing, we identified 110 heart transplant centers that operated during the study period. This included 14 small-volume (<10 transplants per year) heart transplant programs that were not approved by Medicare for heart transplant-related care, but provided inpatient services for elderly Medicare HF patients. We included these facilities as we judged them likely to have HF-related infrastructure similar to that at other heart transplant centers. We then identified all other non-heart transplant centers that cared for Medicare HF patients during the study period. These were further stratified into ‘non-peer’ or ‘peer’ institutions, with the latter defined as those with ≥300 beds and providing coronary artery bypass grafting (CABG).

For hospitalizations that involved inter-hospital transfer during an admission, we linked both hospitalizations into a single episode of care. For analyses related to mortality, outcomes were attributed to the initial admitting hospital; for analyses related to
readmission, outcomes were attributed to the discharging hospital. In all cases, co-
morbidities were identified from data collected at the initial admitting hospital to avoid
classifying in-hospital complications as co-morbidities. For analyses related to mortality, if a
patient had multiple HF hospitalizations within a single calendar year, one admission was
randomly selected for the analysis. For readmission analyses, one discharge was randomly
selected if the multiple HF hospitalizations occurred within a 30-day period and at the same
hospital. This selection process led to different sample sizes between mortality and
readmission (See Tables 1 and 2).

Outcome Variables and Risk-Standardization Models

Our primary outcomes were: (1) all-cause mortality within 30 days from the date of
the index HF admission and (2) all-cause hospital readmission within 30 days of the date of
discharge from the index HF hospitalization for in-hospital survivors. For each outcome,
separate study populations were constructed as described above. We used risk-
standardization models that are currently employed by the CMS for public reporting. Details
of the mortality6 and readmission7 risk-standardization models have been previously
published. In summary, these models are two level (patient and hospital) hierarchical
random intercept models with patient characteristics as fixed effects at the patient-level and
random effects at the hospital-level. No hospital characteristics were adjusted for random
effects9. Importantly, these administrative data-based models perform well when compared
with models that use abstracted clinical chart data, and have been endorsed by the National
Quality Forum.

In brief, the risk-standardization models utilized patient-level administrative data in
two demographic, 12 cardiovascular, and 29 co-morbidity categories (Tables 1 and 2),
obtained from Medicare Part A (i.e., inpatient and hospital outpatient data) and B (i.e.,
physician office outpatient data) files. These files include facility claims for inpatient care,
ambulatory surgery, surgical or diagnostic procedures, and outpatient provider encounters.
We used data on co-morbidities from the index admission and utilization over the 12 months prior to the index admission to adjust for patient-specific risk. We obtained mortality data through the Medicare enrollment database.

**Statistical Analysis**

We compared baseline characteristics of patients by hospital type – heart transplant centers and non-heart transplant hospitals (including both non-peer and peer institutions) – using χ² tests for categorical variables and analysis of variance for continuous variables. Using data from all hospitals included in the present study, we then calculated a 30-day standardized mortality ratio (SMR) for each hospital using hierarchical generalized linear models. This technique accounts for patient characteristics and addresses the potential effects of patient clustering within hospitals. The SMR was calculated as the predicted mortality in each hospital, given its patient mix and estimated hospital-specific effect, divided by the expected mortality in that hospital given the same patient mix and the average hospital-specific effect. We used a bootstrapping algorithm within each institution to generate the 95% confidence interval (CI) estimates of SMRs and their variances. To investigate hospital performance at heart transplant centers and non-transplant hospitals, each hospital was categorized on the basis of the 95% interval estimates of the SMRs into 1 of 3 groups: predicted mortality significantly better than expected mortality (i.e. SMR significantly < 1.0), predicted mortality no different than expected, or predicted mortality significantly worse than expected (i.e. SMR significantly > 1.0).

We calculated hospital-specific risk-standardized mortality rates (RSMRs) by multiplying each hospital’s SMR by the national unadjusted rate. This form of indirect standardization allowed for assessments of overall quality in HF patients at a hospital for the type of patients it treats, although direct hospital-to-hospital comparisons may be limited. To further examine hospital performance at heart transplant and non-heart transplant hospitals nationwide, we categorized each hospital based on their RSMR into one of three
groups (RSMRs below the 25th percentile, RSMRs between the 25th to 75th percentiles, and RSMRs above the 75th percentile). We then calculated the numbers of heart transplant and non-heart transplant hospitals within these three categories. For non-heart transplant hospitals, we separately calculated the numbers of non-peer and peer institutions (as defined above) within each category. To further account for potential differences in patients across healthcare markets, we repeated these analyses after limiting the study population to patients at non-heart transplant hospitals that were located in the same hospital referral regions (HRR) as a heart transplant center using the *Dartmouth Atlas of Health Care*.

In the same manner, 30-day standard readmission ratios (SRR) and risk-standardized readmission rates (RSRRs) were calculated for each hospital. We again categorized hospitals based on their SRR (significantly lower than expected, as expected, or significantly worse than expected) and RSRR (lower than 25th percentile, 25th to 75th percentile, and higher than 75th percentile). We conducted all analyses using SAS statistical software (version 9.1.3; SAS Institute Inc, Cary, North Carolina).

**RESULTS**

Between 2004 and 2006, we identified 1,318,899 discharges in Medicare HF patients at 4,570 hospitals in our study sample for assessing 30-day mortality and 1,610,803 discharges in Medicare HF patients at 4,607 hospitals in our study sample for assessing 30-day readmission rates. Among the study sample for 30-day mortality, 73,778 (5.6%) patients were admitted at 110 heart transplant centers, 289,710 (22.0%) were admitted at peer institutions with CABG, and 955,411 (72.4%) were admitted at non-peer institutions. This pattern of admission across hospital types was similar in the study sample for 30-day readmission rates.

For the study samples examining 30-day mortality and readmission, baseline patient characteristics found in each hospital type are summarized in *Tables 1* and *2*, respectively. In general, patients admitted at heart transplant centers were younger, more likely to be...
male, and had higher prevalence of previous heart disease than those at non-transplant hospitals. There was also a higher prevalence of cardiopulmonary-respiratory failure or shock and renal failure in the heart transplant center cohort, but a lower prevalence of chronic obstructive pulmonary disease (COPD), pneumonia, and dementia (Tables 1 and 2).

Patients admitted to peer institutions with CABG were more similar to those at heart transplant centers, but still had slightly lower prevalence of prior heart disease, shock, and renal failure (data available from authors by request).

The observed 30-day mortality rates were 9.9% vs. 11.5% (p<0.001) for Medicare HF patients at heart transplant centers compared with non-heart transplant hospitals nationally. After adjustment for patient differences and hospital-level effects, the 30-day RSMRs remained significantly lower at heart transplant centers (10.6% vs. 11.5% p <0.001). When heart transplant centers were compared with peer institutions with CABG nationally, RSMRs remained significantly lower at heart transplant centers (10.6% versus 11.2%; p=0.015). However, no differences in RSMRs were noted when heart transplant centers were compared with peer institutions with CABG within the same HRR (10.6% versus 10.6%; p=0.96). These findings are summarized in Table 3. The percentage of each hospital type within RSMR categories (below the 25th percentile, between the 25th to 75th percentiles, and above the 75th percentile) is shown in Figure 1.

Inspection of the SMRs for heart transplant centers revealed 25 institutions (22.7%) with SMRs significantly lower than the average expected mortality ratio for all hospitals (defined by 95% CIs with an upper limit excluding 1.0). Of the remaining heart transplant centers, 2 (1.8%) had SMRs significantly greater than 1.0. The mean SMR for heart transplant centers was 0.9 (standard deviation [SD], 0.1), with a range between 0.7 and 1.3 (Figure 2, panel A). In comparison, 197 (4.4%) hospitals without heart transplantation had SMRs significantly less than 1.0 and 187 (4.2%) had SMRs significantly greater than 1.0. The mean SMR for non-heart transplant hospitals was 1.01 (SD=0.1), and ranged from
In the subset of peer institutions with CABG, 110 (11.2%) had SMRs significantly less than 1.0 and 85 (8.6%) had SMRs significantly greater than 1.0.

In contrast to the above findings, observed 30-day readmission rates in Medicare HF patients were no different between heart transplant centers and other non-transplant hospitals nationally (23.8% versus 23.8%, p=0.65). After adjustment for patient differences and hospital-level effects, 30-day RSRRs remained similar between heart transplant centers and other hospitals (23.6% versus 23.8%, p=0.55). These findings are summarized in Table 4. The percentage of each hospital type within RSRR categories (below the 25th percentile, between the 25th to 75th percentiles, and above the 75th percentile) is shown in Figure 3.

Inspection of the SRRs for heart transplant centers revealed 18 (16.4%) hospitals with SRRs significantly lower than the average expected readmission ratio for all hospitals (defined by 95% CIs with an upper limit excluding 1.0). Of the remaining heart transplant centers, 16 (14.5%) had SRRs significantly greater than 1.0. The mean SRR for heart transplant centers was 1.0 (SD, 0.1), with a range between 0.8 and 1.2 (Figure 2, panel B). In comparison, 196 (4.4%) non-heart transplant hospitals had SRRs significantly less than 1.0 while 237 (5.3%) had SRRs significantly greater than 1.0. The mean SRR for non-heart transplant hospitals was 1.0 (SD=0.1), and ranged from 0.7 to 1.4.

DISCUSSION

Across a broad population of elderly Medicare HF patients, we found that heart transplant centers had lower 30-day mortality rates than non-heart transplant hospitals nationally. This difference diminished after adjusting for patient characteristics and between-hospital variance across facilities. We noted no significant differences in 30-day risk-adjusted mortality between heart transplant centers and peer institutions providing CABG surgery in the same geographic area. Finally, 30-day risk-adjusted readmission rates were similar in Medicare HF patients discharged from heart transplant centers and non-transplant hospitals.
Within 30 days of hospital discharge for HF, 10 to 15% of elderly Medicare patients are readmitted to an acute-care hospital and 10% have died. In our national sample of elderly Medicare HF patients, we observed large between-hospital variations in 30-day risk-standardized mortality and readmission rates. Prior work by our group and others suggests that much of this variation is due to hospital-level characteristics rather than patient characteristics or guideline adherence. Despite the lack of clinical trial evidence guiding the management of acutely decompensated HF, a significant number of short-term deaths and rehospitalizations appear to be preventable. Understanding the hospital-level factors that contribute to early mortality and readmission is critical to improving outcomes in the elderly HF population.

The main findings of our study are somewhat unexpected. Heart transplant centers are generally considered “centers of excellence” for HF care, due to the dedicated infrastructure needed to evaluate and treat complex and often critically ill HF patients. We anticipated that the expertise present within successful heart transplant programs would also translate into better short-term outcomes in the general elderly HF population. Indeed, we did find lower 30-day mortality rates at heart transplant centers when compared with all non-transplant hospitals. However, large, comparably-resourced peer institutions offering CABG surgery in the same geographic area had similar mortality outcomes to heart transplant centers. This suggests that the lower mortality rates in elderly Medicare HF patients at heart transplant centers are unrelated to the presence of a transplant program, and may be due to more traditional hospital-level factors. These characteristics could include better adherence to guideline-based performance measures, higher hospital HF case volumes, and increased likelihood of cardiologist-directed HF care, none of which are specific to heart transplant centers.

When we evaluated 30-day readmission rates, the results suggested even more equivalence between heart transplant centers and non-heart transplant hospitals. This could be because short-term hospital readmission in elderly HF patients is often multifactorial, and
may depend in part on issues that are only indirectly related to disease severity or inpatient HF management.\textsuperscript{14, 19, 20} The administrative risk-standardization model we used for for 30-day readmission is less predictive than that for 30-day mortality,\textsuperscript{6, 7} which could limit the ability of heart transplant centers to demonstrate improved readmission outcomes. Nonetheless, the overlap of the point estimates for SRR and RSRR at heart transplant centers and non-transplant hospitals is striking.

Transplant-eligible HF patients are generally younger and have fewer co-morbidities than the population we studied. Accordingly, these patients may have different predictors of outcomes or responses to interventions. However, it is likely that heart transplant centers employ specific resources in this group that could potentially benefit elderly HF patients, who often present with multiple medical co-morbidities, polypharmacy, functional limitations, and suboptimal social support systems. As others have noted,\textsuperscript{14, 19} up to half of rehospitalizations in this population are related to failures in HF self-care measures and/or post-discharge care coordination. All CMS-approved solid-organ transplant programs (including heart transplant programs) currently are required to provide multidisciplinary care and hospital discharge planning for pre- and post-transplant patients. The physician-led team must include a care coordinator and representatives from nursing, social work, nutritional services, and pharmacology.\textsuperscript{21} Such a care model would seem ideally suited for elderly HF patients, as several studies show that multidisciplinary hospital discharge education, care transition planning, and outpatient management can improve outcomes in this population.\textsuperscript{22-24}

Promoting such “spill-over” effects into non-transplant candidates is not currently required by CMS for heart transplant centers. Kidney transplant centers that provide outpatient dialysis provide an interesting contrast, as multidisciplinary care plans are mandated for all end-stage renal disease patients at these centers whether or not they are listed for transplantation.\textsuperscript{21} We speculate that many heart transplant centers apply their extensive expertise and infrastructure for HF care primarily in patients who may be
transplant candidates, and less so in the general population of HF patients. If the specialized resources available at heart transplant centers are indeed focused only on the small number of transplant evaluations, an important opportunity to understand and improve post-discharge outcomes in the larger elderly HF population may be missed.

**Limitations**

Our findings should be considered in the context of the following study design issues and limitations. The risk-standardization models we used in the present study rely on administrative data and may not fully account for all factors that affect mortality and readmission. However, the models have been extensively validated using clinical data from chart review and are supported by CMS for comparison and public reporting of hospital performance. Another related concern is the potential for referral to heart transplant centers for acute-care hospitalization and with follow-up care provided locally. This could lead to challenges in attributing overall performance in HF outcomes to a single facility. Our focus on 30-day events was meant to minimize this possibility, since these short-term outcomes are most likely to be influenced by immediate care provided during the inpatient setting. While the CMS models and public outcomes reporting are based on this timeframe, it is conceivable that a longer duration of follow-up could reveal further outcome differences between heart transplant centers and non-transplant hospitals.

The administrative data sources we used did not allow us to directly assess the quality of heart failure care delivered at heart transplant centers and non-transplant hospitals. Future work will need to focus on these areas since it could provide details that better explain our findings. In addition, it will be important in subsequent analyses to understand what type of resources at heart transplant centers may be available to a broad population of heart failure patients. Finally, it is important to note that the results of our study cannot be extrapolated to other populations, in particular younger and potentially transplant-eligible HF patients.
Conclusions

Heart transplant centers offer extensive and highly-specialized infrastructure designed to care for the sickest and most complex HF patients. However, in elderly Medicare HF patients we found little evidence that short-term outcomes are consistently better at these centers in comparison to other non-transplant hospitals – particularly, peer institutions within the same geographic area. Precise reasons for these findings are unclear, but may be related to heart transplant centers specifically targeting their specialized resources to the transplant-eligible HF population. Additional studies are needed to better understand which hospital characteristics are associated with improved inpatient and post-discharge HF outcomes.
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DISCLOSURES

Drs. Pauli. Wang, Chen, and Nallamothu report no relevant conflicts of interest. Dr. Krumholz reports receiving funding from CMS contracts, including the contract funding this work, and also serves as the chair of the United Health Care Scientific Advisory Board. Dr. Normand serves on the advisory boards for Blue Cross/Blue Shield, Kaiser Permanente, and Medicare. Dr. Hummel is a transplant cardiologist employed at a heart transplant center.
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**FIGURE LEGENDS**

**Figure 1.** Percentage of facilities in RSMR percentile groups, by hospital type

Abbreviations used: CABG, coronary artery bypass grafting; HRR, hospital referral region; RSMR, risk-standardized 30-day mortality rate. This figure reflects aggregate information by hospital type, and no significant differences between individual hospitals of each type should be assumed. ‘All HRR’ indicates national comparisons, and ‘Heart transplant center HRR’ comparisons between hospital types among facilities located in the same geographic area as a heart transplant center.

**Figure 2.** Distributions of standardized mortality ratios (SMR; panel A) and standardized readmission ratios (SRR; panel B) at heart transplant centers

Note: Heart transplant center number (1-110, denoted on x-axis) is consistent across both panels to enable graphical comparison of mortality and readmission ratios at each individual center.

**Figure 3.** Percentage of facilities in RSRR percentile groups, by hospital type

Abbreviations used: CABG, coronary artery bypass grafting; HRR, hospital referral region; RSRR, risk-standardized 30-day readmission rate. This figure reflects aggregate information by hospital type, and no significant differences between individual hospitals of each type should be assumed. ‘All HRR’ indicates national comparisons, and ‘Heart transplant center HRR’ comparisons between hospital types among facilities located in the same geographic area as a heart transplant center.
Hospital Type

Heart Transplant Center (N=110) | All HRR: Large teaching hospital with CABG (N=431) | All HRR: Other (N=4,029) | Heart Transplant Center HRR: Large teaching hospital with CABG (N=196) | Heart Transplant Center HRR: Other (N=1,788)

- <25th percentile
- 25-75th percentile
- >75th percentile

- Heart Transplant Center (N=110)
  - 12.7%
- All HRR: Large teaching hospital with CABG (N=431)
  - 25.5%
  - 39.0%
- All HRR: Other (N=4,029)
  - 25.3%
  - 51.3%
- Heart Transplant Center HRR: Large teaching hospital with CABG (N=196)
  - 15.3%
  - 38.8%
- Heart Transplant Center HRR: Other (N=1,788)
  - 22.0%
  - 50.3%
Heart Transplant Center (N=110)
All HRR: Large teaching hospital with CABG (N=432)
All HRR: Other (N=4,065)
Heart Transplant Center HRR: Large teaching hospital with CABG (N=197)
Heart Transplant Center HRR: Other (N=1,806)

Hospital Type
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