

BRIEF RESEARCH REPORT

Cardiology

Emergency department use and hospital admissions among adult orthotopic heart transplant patients

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Abstract

Objective: To study the demographics, clinical presentations, and outcomes of emergency department (ED) visits of patients with heart transplantation (HT) in the United States.

Methods: We performed a secondary analysis of the National Emergency Department Sample database from 2016 to 2018. All ED visits of patients with HT aged ≥ 18 years were identified using International Classification of Diseases, Tenth Revision codes.

Results: Out of a total 308,182,495 national ED visits, 55,583 were HT-related visits. The median age was 61.07 years (interquartile range [IQR]: 46.91–69.38) and 69.44% were males. The hospital admission rate was 54.3% and median inpatient length of stay was 3.19 days (IQR: 1.63–5.92). The mortality rate during inpatient stay was 1.16%. Median inpatient and ED charges among admitted patients were \$37,911 (IQR: \$21,487–\$71,262). The most common primary diagnosis of HT-related ED visits was sepsis (4.3%) followed by acute kidney injury (3.57%) and chest pain (3%).

Conclusion: More than half of total ED visits among HT patients resulted in hospital admission. The most common cause for ED visit in these patients was sepsis followed by acute kidney injury and chest pain.

KEYWORDS

cardiac transplantation, emergency department, health care use, heart transplantation, in-hospital mortality, organ transplantation, outcomes

1 | INTRODUCTION**1.1 | Background**

Heart transplantation (HT) is a treatment option for patients with end-stage heart failure.¹ The total number of heart transplants performed annually in the United States has been increasing over the past

decade.² According to a recent International Society for Heart and Lung Transplantation report, the current median posttransplant survival is 12.5 years.² With the improvement in posttransplant survival, it can be expected that more patients will be presenting for acute care to the emergency department (ED) for routine as well as specialized care. Solid organ transplant recipients are at increased risk of infections due to use of immunosuppressants.³ Previous research studies on ED visits among solid organ transplant patients reported hospital admission rates between 48% and 62%.^{4,5} Analysis of ED visits among kidney

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transplant recipients reported that complication of the graft was the most common reason for ED visit, whereas a study on ED visits among lung transplant recipients showed the infection was the most common primary diagnosis.^{4,6} To the best of our knowledge, there are no population studies published to date on ED use for adult HT recipients.

1.2 | Importance

It is important for physicians to be familiar with the anticipated spectrum of presenting complaints in HT patients presenting to the ED.

1.3 | Goals of this investigation

To analyze national rates of HT-related ED visits and describe demographic, clinical, and outcomes profiles. We hypothesized that a significant proportion of patients with HT who present to the ED are admitted to the hospital, thus leading to higher resource use compared to non-HT patients.

2 | METHODS

2.1 | Study design and setting

This study is a retrospective cohort study using the National Emergency Department Sample (NEDS), the largest all-payer database of ED visits in the United States. NEDS is a publicly available database that contains information from approximately 30 million ED visits from 990 hospitals located in 36 states and represents an approximately 20% stratified sample of US hospital-based ED visits.⁷ The NEDS database is maintained by the Healthcare Cost and Utilization Project sponsored by Agency for Healthcare Quality and Research. The NEDS database includes information on ED visits that result in admission to the same hospital, transfer to the other hospital, or discharge. NEDS captures commonly used International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10 CM) codes for each ED visit. Because the data available from NEDS are deidentified, the analysis was approved by the University of Kansas Medical Center institutional review board under exempt status.

2.2 | Selection of participants and covariates

We identified all ED visits of patients 18 years or older in the NEDS database from January 1, 2016, through December 31, 2018, with a diagnosis code for HT status ICD-10 CM codes Z94.1, Z48.21. We excluded cases of patients with combined heart and lung transplant status, ICD-10 CM code Z94.3 in our study population. For each ED visit identified, we recorded the following variables: patient demographics including age, sex, and insurance payer status. We also included patient comorbidities including dialysis dependence, cirrho-

The Bottom Line

Emergency department visits for heart transplant patients are not well characterized. Using the National Emergency Department Sample, the authors identified over 55,000 heart transplant-related visits, of which 54% of patients were hospitalized and 1% died. The most common ED diagnoses were sepsis, acute kidney injury, and chest pain.

sis, hypertension, diabetes mellitus, obesity, chronic obstructive pulmonary disease, and depression. Hospital characteristics included geographical region, hospital location, and teaching status.

2.3 | Outcomes

We analyzed data across 3 years to describe (1) total number of ED encounters among patients with history of HT including their demographics and comorbidities, (2) most common primary diagnosis of ED encounters, (3) hospital admission rates, (4) length of stay (LOS) among admitted patients, (5) ED and inpatient mortality, and (6) total ED and hospital charges.

2.4 | Statistical analysis

Our statistical analysis was conducted using the SAS 9.4 (SAS Institute Inc, Cary, NC) software. All variables were reported after appropriate survey weights. Continuous variables were expressed as median with interquartile range (IQR) values, and categorical variables were expressed as weighted frequencies with percent of total population. Two-sample *t* test or Wilcoxon rank-sum test was used to compare continuous variables; univariate logistic regression with odds ratios and corresponding 95% confidence intervals was used to compare categorical variables. All *P* values were 2 sided, and a value of less than 0.05 was considered significant.

3 | RESULTS

Out of a total 308,182,495 national ED visits, 55,583 (0.018%) were represented by adults with a history of HT (Table 1). The majority of ED visits in the HT group were male patients (69.4%), with the 65 years and older age group being the most frequently represented (42.1%). The most common comorbid conditions in the HT group were hypertension (66.1%), diabetes mellitus (41.63%), and depression (11.06%). Dialysis dependence was seen in 9.59% of HT patient visits compared with 1.1% of non-HT ED encounters. HT patient ED encounters were more likely to have government insurance (74.7%) as primary payer and more often presented to metropolitan teaching hospitals (73.1%).

TABLE 1 Baseline characteristics and comorbidities of study population

| Characteristic | ED Encounters of Adults with HT (N= 55,583) | ED Encounters of Adults without HT (N= 308,182,495) | OR (95% CI) | P value |
|------------------------------------|---|---|-------------------|---------|
| Sex | | | | |
| Male | 38,601 (69.44%) | 131,444,028 (42.65%) | 3.06 (2.86, 3.27) | <.0001 |
| Female | 16,982 (30.55%) | 176 738 466 (57.35%) | 0.33 (0.31, 0.35) | <.0001 |
| Patient age | | | | |
| 18–44 y | 12,035 (21.65%) | 141,581,550 (45.94%) | 0.33 (0.30, 0.36) | <.0001 |
| 45–64 y | 20,107 (36.17%) | 89,792,724 (29.14%) | 1.38 (1.29, 1.48) | <.0001 |
| ≥65 y | 23,442 (42.17%) | 76 808 221 (24.92%) | 2.20 (2.04, 2.37) | <.0001 |
| Median age (IQR) | 61.07 (46.91, 69.38) | 46.69 (30.81, 63.93) | | <.0001 |
| Comorbidities | | | | |
| Dialysis dependent | 5330 (9.59%) | 3,662,328 (1.19%) | 8.82 (7.79, 9.98) | <.0001 |
| Cirrhosis | 561 (1.01%) | 2,406,408 (0.78%) | 1.30 (1.03, 1.63) | <.0001 |
| Hypertension | 36,746 (66.11%) | 97,193,626 (31.54%) | 4.24 (3.94, 4.55) | <.0001 |
| Diabetes mellitus | 23,138 (41.63%) | 45,118,940 (14.64%) | 4.16 (3.90, 4.44) | <.0001 |
| Obesity | 4145 (7.46%) | 14,193,665 (4.61%) | 1.67 (1.50, 1.86) | <.0001 |
| COPD | 5065 (9.11%) | 20,568,345 (6.67%) | 1.40 (1.24, 1.59) | <.0001 |
| Depression | 6145 (11.06%) | 18,058,772 (5.86%) | 2.00 (1.81, 2.21) | <.0001 |
| Chronic medical conditions | | | | |
| No chronic conditions | 12,360 (22.23%) | 183,367,198 (59.50%) | 0.20 (0.18, 0.21) | <.0001 |
| 1 chronic condition | 16,973 (30.54%) | 69,480,465 (22.55%) | 1.51 (1.43, 1.59) | <.0001 |
| ≥2 chronic conditions | 26,251 (47.23%) | 55,334,832 (17.96%) | 4.09 (3.81, 4.39) | <.0001 |
| Location of patient | | | | |
| Urban | 47,289 (85.08%) | 250,313,840 (81.22%) | 1.32 (1.15, 1.51) | <.0001 |
| Rural | 8294 (14.92%) | 57,868,654 (18.78%) | 0.76 (0.66, 0.87) | <.0001 |
| Region | | | | |
| Northeast | 11,993 (21.58%) | 63,604,373 (20.64%) | 1.06 (0.83, 1.36) | 0.6565 |
| Midwest | 14,232 (25.60%) | 77,687,573 (25.21%) | 1.02 (0.80, 1.30) | 0.8659 |
| South | 22,749 (40.73%) | 136,596,095 (44.32%) | 0.87 (0.72, 1.06) | 0.1602 |
| West | 6610 (11.89%) | 30,294,454 (9.83%) | 1.24 (1.00, 1.54) | 0.0553 |
| Teaching status of hospital | | | | |
| Metropolitan non-teaching | 9304 (16.74%) | 79,551,040 (25.81%) | 0.58 (0.50, 0.67) | <.0001 |
| Metropolitan teaching | 40,636 (73.11%) | 177,270,249 (57.52%) | 2.01 (1.73, 2.33) | <.0001 |
| Non-metropolitan | 5643 (10.15%) | 51,361,206 (16.67%) | 0.57 (0.48, 0.66) | <.0001 |
| Primary payer | | | | |
| Government | 41,539 (74.73%) | 164,773,587 (54.47%) | 2.57 (2.39, 2.77) | <.0001 |
| Private | 12,159 (21.88%) | 87,370,083 (28.35%) | 0.71 (0.66, 0.76) | <.0001 |
| Other | 1881 (3.38%) | 56,022,785 (18.18%) | 0.16 (0.14, 0.19) | <.0001 |
| Missing/unknown | 5 (0.01%) | 16,040 (0.01%) | 1.68 (0.36, 7.79) | 0.5099 |

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; ED, emergency department; HT, heart transplantation; IQR, interquartile range; OR, odds ratio.

TABLE 2 Outcomes of ED visits in patients with and without HT

| Outcome | ED Encounters of Adults with HT (N= 55 583) | ED Encounters of Adults without HT (N= 308 182 495) | P value |
|---|--|--|---------|
| Admissions | | | |
| Hospital admission to same hospital | 26,701 (48.04) | 54,977,893 (17.84) | <0.0001 |
| Transfer to short-term hospital | 3527 (6.35) | 5,169,030 (1.68) | <.0001 |
| Admit/transfer | 30,228 (54.38) | 60,146,923 (19.52) | <.0001 |
| Mortality | | | |
| ED mortality | 182 (0.33) | 496,162 (0.16) | <.0001 |
| Inpatient mortality (%) | 643 (1.16) | 1,479,123 (0.48) | <.0001 |
| Total mortality | 826 (1.49) | 1,975,285 (0.64) | <.0001 |
| Length of hospital stay | | | |
| Inpatient LOS (day) (median, Q1, Q3) | 3.19 (1.63, 5.92) | 2.89 (1.53, 5.34) | <.0001 |
| Charges | | | |
| Inpatient and ED charges (\$, median, Q1, Q3) | 12,953 (4076.90, 37,357) | 3420.26 (1464.20, 9926.21) | <.0001 |
| Inpatient and ED charges among admitted patients (\$, median, Q1, Q3) | 37,911 (21,487, 71 262) | 31,499 (17,886, 58,505) | <.0001 |

Abbreviations: ED, emergency department; HT, heart transplantation; LOS, length of stay.

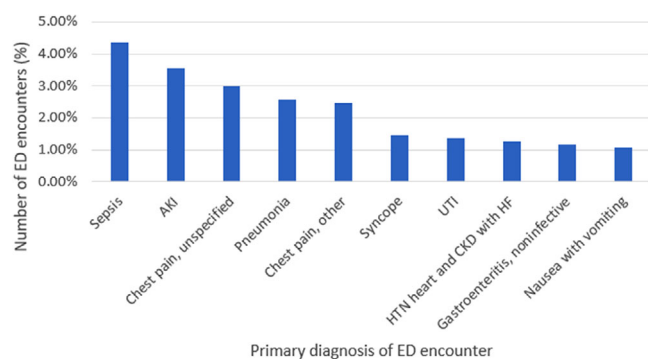


FIGURE 1 The top 10 primary diagnoses of ED encounters among patients with heart transplantation. Abbreviations: AKI, acute kidney injury; CKD, chronic kidney disease; ED, emergency department; heart failure; HTN, hypertension; HF, UTI, urinary tract infection

The top ten primary diagnosis for ED visits among HT patients were sepsis (4.3%), acute kidney injury (AKI) (3.57%), unspecified chest pain (3%), pneumonia (2.56%), other chest pain (2.48%), syncope (1.45%), urinary tract infection (UTI) (1.37%), hypertensive heart, and CKD (1.27%), non-infective gastroenteritis and colitis (1.18%), nausea and vomiting (1.07%) (Figure 1).

Of the 55583 ED visits for patients with HT, 54.3% were admitted to the hospital compared to an admission rate of 19.4% of all non-HT ED visits ($P < 0.0001$) (Table 2). The median hospital LOS among admitted patients was longer in the HT cohort compared to non-HT cohort (3.19 vs 2.89; $P < 0.0001$). The overall mortality in the HT group was 1.46% compared to 0.68% in non-HT encounters ($P < 0.0001$). Subgroup analysis of ED encounters of patients with HT who received dialysis had higher mortality and LOS compared to patients with HT who did not

receive dialysis (5.42% vs 1.38%; $P < 0.001$), [5.02 (IQR:2.60-9.29) vs 3.11 (IQR:1.59-5.78); $P < 0.0001$] respectively.

Regarding cost of care, the median charge for each visit was USD 12953 (IQR:4076.9-37 357) in the HT cohort compared to USD 3420.26 (IQR:1464.20-9926.21) in the non-HT cohort. For ED visits that resulted in admission, the median charges were USD 37911 (IQR:21 487-71 262) in HT visits compared to USD 31499 (IQR:17 886-58 505) in non-HT cohort.

4 | LIMITATIONS

This study is a retrospective analysis of large administrative claims data and is subject to several limitations inherent to these databases. ED visits of specific patient populations were identified using ICD-10 codes, thus possibility of errors in disease coding might impact the results. There is a possibility that the total ED visits in the HT patients might have underestimated due to patients not reporting the history of HT to the ED physician or errors in coding. The unit of analysis is unique ED visit rather than unique patient and it is possible that a single patient might have represented multiple times. Patient comorbidities were recorded during ED encounters, and this might lead to an underestimation of chronic medical conditions. The large size of the database, however, might have partially compensated for these limitations.

5 | DISCUSSION

To our knowledge, this is the largest study to assess ED visits specifically focused on adult HT recipients. We performed a contemporary analysis of a nationwide administrative database consisting of 55583

unique ED encounters among patients with history of HT. The study findings show that there is a significant healthcare system burden due to higher rates of ED visits and subsequent hospital admissions among HT recipients. The most frequent reason for ED visits in patients with HT was for sepsis. Patients with HT presenting to the ED are more than twice as likely to be admitted to the hospital compared to general ED visit population. HT patients who required dialysis in the hospital were at significantly higher risk of inpatient mortality compared to patients who were not on dialysis.

Our study demonstrates that patients with HT contribute significantly to the healthcare system burden. According to 2017 OPTN/SRTR annual report, total 32210 HT patients were alive on June 30, 2017.⁸ For context, our analysis showed that there were 55583 ED visits and 30281 hospital admissions among approximate mean 32210 living HT recipients during our study period from 2016-2018. This represents overall hospital admission rate among a reasonable mean number of live patients with HT was 94% during the study period.

The study shows that infections are a leading reason for HT patients seeking emergency care, with sepsis (4.37%) being the most common primary diagnosis. While there were no studies that reported the rate of sepsis among ED visits in HT patients, a retrospective cohort study of ED visits among kidney transplant recipients from California, New York and Florida using 3 years State Inpatient and Emergency Databases showed 5.2% of the visits were for sepsis.⁴ However, the most common primary diagnosis of ED visits in kidney transplant patients were graft related complications (17.2%). A single center study evaluated 505 ED visits among lung transplant recipients has showed that infection was the most common primary ED diagnosis.⁶ An another single center study analyzed 352 ED visits among 158 solid organ transplant recipients including 3% HT patients reported that the infections were most common cause for hospitalization and 11.7% were diagnosed with sepsis.⁵ Our study also shows that pneumonia and UTI were other infections that contributed to a major proportion of ED visits among HT patients. A single center retrospective evaluation of 620 HT patients for infectious complications has shown that lungs, oral cavity, and urinary tract were the most common sites of infection.⁹ Patients with transplantation are at increased risk of developing infections as a result of chronic immunosuppressive therapy,³ a likely explanation for the observed high burden of infections.

In terms of demographics, a larger proportion of ED visits in HT patients were males and were more likely to have chronic medical conditions. These demographics likely reflect the fact that most HT recipients in the US are men and also that men are more likely to have several of the comorbidities compared to females.¹⁰

A notable finding in our study is that more than half (54.4%) of the ED visits among patients with HT resulted in hospital admission, a frequency 2-fold higher than the admission rate of the larger ED visit population resulting in a median charge of \$37911 per hospital admission. The hospital admission rates are comparable to the admission rates in patients with other solid organ transplantation. A single center study on lung transplant recipients showed that 53% of total 505 ED visits resulted in hospital admission.⁶ Schold et al. reported that 48% of total 17575 ED visits resulted in hospital admission among kidney

transplant patients in 3-year study period.⁴ A possible explanation for high hospital admission rates is the higher prevalence of comorbidities in transplant patients, raising admitting clinician concern for complicating care. Since admissions can be associated with hazards such as falls, nosocomial infections, thromboembolism, etc., further studies to analyze factors affecting rates of hospital admission in these patients may be helpful to establish strategies to decrease hospital admissions, reduce risk of harm, and improve healthcare resource use.

In conclusion, patients with HT have higher rates of ED visits and subsequent hospital admission. Infectious concerns, including sepsis, pneumonia, and UTI, represent major proportions of top causes of ED visits. Other common primary diagnoses were AKI and non-specific chest pain. The HT patients are twice as likely to be admitted to the hospital. Dialysis-dependent HT patients have a higher rate of inpatient mortality and LOS. Further investigation into the implications of these observations is warranted.

CONFLICT OF INTEREST

The authors report no conflict of interest.

AUTHOR CONTRIBUTIONS

Suveenkrishna Pothuru: conceptualization, methodology, resources, writing-original draft preparation; Wan-Chi Chan: data curation, statistical analysis, writing-review & editing; Amandeep Goyal: conceptualization, validation, writing-review, and editing; Tarun Dalia: resources, visualization, writing-review, and editing; Ioannis Mastoris: writing-review and editing; Andrew Sauer: supervision, writing-review and editing; Kamal Gupta: supervision, writing-review, and editing; Charles B Porter: supervision, writing-review, and editing Zubair Shah: conceptualization, methodology, writing-review and editing, supervision.

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