# Background

Heart failure (HF) affects an estimated 5.8 million people in the United States and contributes to over 300,000 deaths every year1,2. It is the most common cause of hospital admission and readmission in people aged >65 years, annually accounting for over 2.4 million hospitalizations2,3 and $39 billion in healthcare costs1,4. Although most patients respond favorably to standard medical treatment, a considerable number progress to end-stage heart failure, an advanced stage of HF that is refractory to existing medical therapy5. Currently, orthostatic heart transplant (OHT) is the gold standard therapy for these patients6. However, the number of donor hearts available for transplantation are far fewer than the number of patients with end-stage heart failure, leaving many patients waiting too long for an OHT7,8. Therefore, these patients are placed on mechanical circulatory supports like the Left Ventricular Assist Device (LVAD) as either a temporary bridge to transplantation (BTT) or permanent destination therapy (DT).

With the growing elderly population and improved medical treatment of HF, the proportion of end-stage heart failure patients in the United States is steadily rising and LVADs are becoming increasingly important in their care and management5. The famous REMATCH trial in 2001 showed significant mortality reductions in patients placed on a pulsatile-flow LVAD compared to standard medical treatment9. Several subsequent studies since confirmed the survival benefit of both the older pulsatile and newer continuous-flow LVADs10-13. Patients bridged to OHT with a LVAD achieve equal survival rates as patients who undergo direct heart transplant14. Although a comparatively less effective option to BTT, patients placed on LVADs as destination therapy experience lower mortalities compared to patients on standard medical treatment9,15. LVADs, like the TandemHeart percutaneous LVAD, can also be used for short-term in-hospital support of patients during cardiogenic shock, left ventricular heart failure, and high-risk coronary interventions until cardiac recovery or bridge to OHT16,18.

Although BTT, DT, and in-hospital LVADs have substantially reduced mortality in end-stage heart failure patients, the absolute mortality rates still remain at an unacceptable high. A large portion of this mortality is attributable to complications and other occurrences during the patient’s stay in the hospital15. In-hospital mortality rates as high as 27% have been reported in patients after LVAD surgery15. As the rate of LVAD implantation in the United States increases and readmission and in-hospital mortality rates, although decreasing, remain at a high level19-22, effective recommendations on the in-hospital management of LVAD implantation are immediately warranted.

Past studies on the appropriate use and outcomes of LVADs have been limited to institutional experience and case series of select populations. While such descriptive investigations are useful, they are often limited by small sample size and significant baseline variation between comparison groups. Therefore, here we use the National Inpatient Sample, a large consolidation of data from over 36 million hospitalizations, to assess the optimal management of patients before, during, and after LVAD implantation in the hospital. In particular, we report trends in mortality by duration of hemodynamic monitoring, timing of LVAD implantation, and wait time for same-admission OHT. We also report trends in LVAD mortality by age, gender, and year and present demographic characteristics of documented LVAD recipients from 1998 to 2011.

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# Results

**Patient characteristics and LVAD implantations**

Utilization Trends:

2200 total LVAD implants

LVAD use increased over the years

Heart transplants stayed the same over the years

Age remained the same

Males were preferred more than females

Whites and Black and Other Races LVAD implantation trends

Include average for all

**Mortality Trends:**

In-hospital mortality has reduced overtime (especially after 2006 heartmate II)

In-hospital mortality increased with age

In-hospital mortality did not differ between male and female

-Along the way, describe how this is consistent with existing data

**Duration of Hemodynamic Monitoring Prior to LVAD Implantation**

403 (%) patients received Swan Ganz before LVAD implantation

Demographically most all differences are comparable

Higher percent of LVAD patients were on Swan Ganz in 2011 than not on it; higher percentage of northeast hospitals had swan ganz- than swan ganz +; higher percentage of west hospitals had swan ganz + than swan ganz –

Patients on Swan Ganz had lower mortality than patients not on Swan Ganz

Swan Ganz was not predictive of OHT so heart transplant did not influence mortality difference

Patients on Swan Ganz had longer wait time for LVAD than patients not on Swan Ganz

Divided into quartiles of duration of Swan Ganzcatheritization before LVAD implantation, median = 5 days (first quartile = 2, third quartile = 12); mortality decreased with longer duration of Swan Ganz catheterization

**Timing of LVAD implantation**

Initial drop in mortality when LVAD was implanted 2 days after admission. Plateaus after that with no obvious trend in mortality observed by day of LVAD implantation after admission

**Wait time for OHT after LVAD Implantation**

LVAD patients receiving OHT in the hospital were younger than LVAD patients who did not receive OHT during their hospital stay. There were a lot more in-hospital heart transplants done from 2001-2005 but fewer in-hospital heart transplants done from 2009 to 2011. Means there are fewer people doing in-hospital bridge to OHT with LVAD.

Higher percentage of OHT+ cases were done in the West than OHT- cases, (look at south too if you want)

Demographics of Early to Late is also important, so discuss this also

Patients who received OHT after in-hospital LVAD support did better than patients who were not transplanted

Divided into quartiles of wait time for OHT after LVAD implantation, median = 32 (first quartile = 8, third quartile = 66); mortality decreased with longer wait time for OHT

Calcualting risk ratio of in-hospital mortality in these patients for each day after LVAD implantation shows a similar decline with wait time. In particular we find that after 8 days of wait, the risk of mortality drastically drop and continues to drop with wait time. 25% of LVAD to OHT operations are done earlier than 8 days and may be an area for improvement.