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An Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) analysis of hospitalization, functional status, and mortality after mechanical circulatory support in adults with congenital heart disease

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KEYWORDS:
adult congenital heart disease;
mechanical circulatory support;
left ventricular assist device;
heart failure;
adverse events;
outcomes

BACKGROUND: Adult congenital heart disease (ACHD) prevalence is increasing worldwide, with advanced heart failure (HF) as a leading cause of death. Limited data are available on durable mechanical circulatory support (MCS) in ACHD patients.

METHODS: ACHD patients from the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) database were identified and propensity matched with non-ACHD patients using risk factors from the INTERMACS Seventh Annual Report. We compared these groups for the primary outcome of post-MCS mortality. We also investigated adverse event rates, functional status, and health-related quality of life.

RESULTS: ACHD ($n = 128$) and non-ACHD ($n = 512$) patients were appropriately matched by baseline characteristics. ACHD patients had a longer length of stay at MCS implant (24 vs 19 days, $p = 0.006$) but similar rates of post-MCS adverse events and hospitalization. There were similar improvements in functional status and health related quality of life post-MCS in both groups. ACHD patients had significantly higher mortality post-MCS exclusively during the first 5 months after implant ($p = 0.003$) and a lower probability of receiving a transplant ($p = 0.003$). Risk factors for early mortality were biventricular or total artificial heart device implant and age > 50 years.

CONCLUSIONS: ACHD patients experience a higher early mortality after MCS but have similar adverse event rates and similar improvements in functional capacity and quality of life compared with non-ACHD patients. These data support expansion of MCS use in selected ACHD patients.

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End-stage congestive heart failure (HF) is a growing problem among patients with adult congenital heart disease (ACHD). The ACHD population is expanding,[1,2] and with

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growth in the size of the population, hospitalization rates have progressively increased.[3] HF is among the most common reasons for hospitalization in ACHD[3–5] and is the most common reason for readmission.[6] As the ACHD population continues to age, with the onset of age-related acquired heart disease and deterioration of earlier repairs, HF hospitalization rates will likely continue to increase.[7,8] Furthermore, HF is responsible for most of the mortality in ACHD.[9,10] Although cardiac transplant is an option for ACHD patients with end-stage HF, they are more likely to have prolonged waiting list times and to die or be delisted for clinical worsening while awaiting transplant compared with their non-ACHD counterparts.[11–13]

In this setting, durable mechanical circulatory support (MCS) devices have a major potential benefit. Among non-ACHD patients, MCS decreases mortality for non-transplant candidates and transplant candidates alike.[14–16] It is speculated that increased use of MCS in ACHD might be similarly beneficial[17,18]; nevertheless, MCS remains rarely used in ACHD.[17,19] One of the primary reasons MCS use lags in this group is the limited nature of available data demonstrating success and safety in an anatomic milieu for which the devices were not designed.[20] In the present study, we sought to address this limitation by investigating differences in outcomes after MCS between propensity-matched ACHD and non-ACHD patients using a large national MCS database. We hypothesized that ACHD patients and non-ACHD patients would have similar outcomes after MCS.

Methods

Data source

We conducted a retrospective analysis of data from the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) database, a national prospective database of patients supported on United States Food and Drug Administration–approved durable MCS devices in the United States.[21] The database is a collaboration between the National Heart, Lung, and Blood Institute (NHLBI), the Food and Drug Administration , the Centers for Medicare and Medicaid Services, industry, and implanting centers. A National Institutes of Health–appointed independent study-monitoring group monitors all registry data. In addition, the registry is monitored by an observational study monitoring board and all hospitals have local Institutional Review Board (IRB) approval or exemption.

ACHD study population

Between June 23, 2006, and April 30, 2016, 17,197 patients aged older than 19 years at the time of MCS implant were enrolled in the INTERMACS database. We identified patients with congenital heart disease (CHD) by searching the INTERMACS database for the following variables: "cardiac diagnosis, primary," "cardiac diagnosis, secondary," "previous cardiac operation-congenital cardiac surgery," "concomitant surgery," "intervention within 48 hours of implant," and "clinical events this hospitalization." All data of identified patients were reviewed by 2 cardiologists (A.M.C. and C.J.V.) with training in CHD to ensure that primary diagnoses and previous surgical procedures were consistent. In cases where diagnosis was unclear or data was missing, the inputting center was contacted for clarification. Of 164 patients identified in this manner, 27 were excluded for erroneous coding, 2 were excluded as having an isolated patent foramen ovale, 4 were excluded due to insufficient information to confirm the diagnosis, and 3 were excluded for having isolated pulmonary ventricular MCS, yielding a final ACHD cohort of 128 patients.

Propensity-matched non-ACHD population

A propensity-matched non-ACHD patient cohort in the INTERMACS database served as a comparator group. All risk factors for the primary outcome of mortality on a device as identified in the seventh INTERMACS annual report[22] were evaluated for inclusion in a propensity score model. These included age, sex, body mass index, blood type, history of stroke, ventilatory support at the time of implant, implanted cardiac defibrillator, INTERMACS patient profile, New York Heart Association (NYHA) functional class, device strategy, serum albumin, serum creatinine, dialysis dependence, blood urea nitrogen, right atrial pressure, device type, serum bilirubin, history of cardiac surgery, history of coronary artery bypass (CABG), and concomitant cardiac surgery. The flow type (continuous vs pulsatile) was also included because of known association with survival. The annual report only included continuous-flow devices.

Among these variables, history of cardiac surgery, history of CABG, and concomitant surgery were excluded from the matching model because these variables were highly correlated with the ACHD exposure group of interest given the nature of ACHD as a disease process frequently requiring surgical intervention before adulthood. Several other variables, including NYHA class, serum albumin, right atrial pressure, serum bilirubin, INTERMACS patient profile, and blood type were subsequently excluded because of extensive missing data. Variables were included in the initial model regardless of their level of statistical significance given their known association with outcomes of interest. Non-ACHD control patients were selected in this manner in a 4:1 ratio to ACHD patients, yielding a final non-ACHD cohort of 512 patients.

Definitions

We grouped ACHD patients by ventricular morphology with the assumption that complications associated with device implantation would be related predominantly to the type of ventricle into which the device was being implanted. The groups were systemic morphologic left ventricle (LV), systemic morphologic right ventricle (RV), and single ventricle. The particular lesions included in each group were:

- Morphologic RV: levo-transposition of the great arteries (TGA, or congenitally corrected TGA) unrepaired, dextro-TGA after atrial switch procedure (Senning or Mustard)
- Morphologic LV: dextro-TGA after arterial switch procedure, or levo-TGA after a double-switch procedure, complete atrioventricular canal, tetralogy of Fallot, congenital valvular disease (stenosis or regurgitation of the tricuspid, pulmonary, mitral or aortic valve), ventricular septal defect, atrial septal defect, patent ductus arteriosus
- Single ventricle: Single ventricle circulations, unbalanced atrioventricular canal with hypoplastic LV or RV after Fontan circulation