Readmissions for Heart Failure in Children

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Objective To assess the frequency of inpatient 30-day readmission for heart failure in children with cardiomyopathy discharged after an admission for heart failure and the impact of discharge pharmacotherapy on readmissions.

Study design The Pediatric Health Information System Database was queried for patients ≤18 years of age with an *International Classification of Diseases, Ninth Revision* code for heart failure (428.xx) or cardiomyopathy (425.xx) discharged from 2004 to 2013. Patients were excluded if they had congenital heart disease, expired on the initial admission, or underwent cardiac surgery. Patient admission characteristics were documented and discharge medications were captured. Frequency of 30-day readmission for heart failure was identified, and mixed effects multivariable logistic regression analysis was performed to determine factors significant for readmission.

Results A total of 2386 patients met study criteria (52.1% male, median age 8.1 years [IQR 1.2-14.6 years]). Vasoactive medications were used in 70.3% of patients on initial admission, the most common of which was milrinone (62.8%). Angiotensin converting enzyme inhibitors and beta-blockers were given at discharge to 67.4% and 35.9%, respectively. Frequency of 30-day readmission for heart failure was 12.9%. Duration of milrinone or beta-blocker use at discharge and institutional heart failure patient volume were associated with a greater odds of 30-day readmission, whereas mechanical ventilation on initial admission was associated with decreased odds of readmission.

Conclusions Pediatric patients with cardiomyopathy and heart failure have a high frequency of heart failure-related 30-day readmission. Outpatient pharmacotherapy at discharge does not appear to influence readmission. *(J Pediatr 2016;177:153-8)*.

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Hospital readmission after an episode of acute heart failure has been studied extensively in adults.[1,2] Prevention of readmission after an acute heart failure exacerbation is an important topic, not only from an individual patient care perspective, but also from a public health and payer perspective.[3,4] However, data for pediatric heart failure are sparse. Available data suggest that readmissions for pediatric heart failure are resource-intensive and have high mortality (~7%) rates.[5,6] The frequency of readmission for pediatric heart failure after an admission for exacerbation of an acute heart failure has been demonstrated to be high in a single center experience.[7]

Many institutions that care for adult patients with heart failure have comprehensive programs to prevent hospital readmissions after heart-failure exacerbations. One of the currently recommended pharmacologic interventions is that adult patients admitted for an acute heart failure exacerbation should be discharged on a beta-blocker and an angiotensin converting enzyme (ACE) inhibitor.[8] Use of these medications at discharge has been shown to reduce morbidity and mortality rates in adult patients with heart failure.[3,4] In addition, this process measure is part of the 6 requirements for discharge instructions endorsed by the Join Commission on Accreditation of Health Care Organizations for adults with Heart Failure, but recent evidence suggests that the application of this recommendations is inconsistent and that the outcomes have provided mixed results.[9,10] The data supporting the use of beta-blockers and ACE inhibitors at discharge in pediatric patients is lacking, although they have potential to be of benefit.[11-13]

We sought to investigate the incidence and risk factors for 30-day heart-failure related readmission in children (<18 years of age) and the association between the use of ACE-inhibitors/angiotensin receptor blockers (ARBs) and beta blockers and the frequency of 30-day readmission.

ACE	Angiotensin converting enzyme
ARB	Angiotensin receptor blocker
ICD-9	*International Classification of Diseases, Ninth Revision*
PHIS	Pediatric Health Information System

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Methods

A retrospective cohort study was designed, and patients were included in the study population if they had an *International Classification of Diseases, Ninth Revision* (ICD-9) code for heart failure (428.xx) and ICD-9 code for cardiomyopathy (425.xx) and were discharged between January 1, 2004 and December 31, 2013. Patients were excluded if they were older than 18 years of age, had structural congenital heart disease (ICD-9 code 745-747), had undergone a cardiac surgical procedure as evidenced by Risk Adjustment in Congenital Heart Surgery-1 score, had an orthotopic heart transplantation, or expired during the initial admission. If a patient had multiple admissions during the study period, only the first admission or readmission was used.

Data fields collected on initial admission included patient demographics, hospital length of stay, ventilator days, intensive care unit admission, vasoactive medications, use of ACE inhibitor or ARB, use of beta-blocker, use of diuretic, presence of arrhythmia, and use of mechanical circulatory support. Patients were considered to be discharged on a medication if they were receiving the medication on the last day of admission. Readmission information collected included time to readmission, use of vasopressors or inotropes, intensive care unit admission, mechanical ventilation, length of hospital stay, cost of readmission, and mortality. The cost of readmission is entered into the database as a ratio of cost-to-charges and was adjusted to 2013 dollars. Health insurance status (public or private) was collected. Hospitals were divided into regions (North, South, East, West, Midwest) and were classified according to number of heart failure admissions during the study period.

Data for this study were obtained from the Pediatric Health Information System (PHIS), an administrative database that contains inpatient, emergency department, ambulatory surgery, and observation data from 43 not-for-profit, tertiary care pediatric hospitals in the US. These hospitals are affiliated with the Child Health Corporation of America (Shawnee Mission, Kansas), a business alliance of children's hospitals. Data quality and reliability are assured through a joint effort between the Child Health Corporation of America and participating hospitals. The data warehouse function for the PHIS database is managed by Thomson Reuters (Ann Arbor, Michigan). For the purposes of external benchmarking, participating hospitals provide discharge/encounter data including demographics, diagnoses, and procedures. Forty-two of these hospitals also submit resource utilization data (eg, pharmaceuticals, imaging, and laboratory) to PHIS. Data are deidentified at the time of submission and are subjected to a number of reliability and validity checks before being included in the database.

The endpoint for the study was readmission for heart failure (ICD-9 code 428.xx) within 30 days of discharge. Descriptive statistical methods (mean, SD, median, IQR, percent) were used to characterize patient demographics, hospital information, and pharmacotherapy. Three-year moving averages were used to graphically evaluate length of stay, use of ACE or beta-blocker, heart failure readmissions, and adjusted cost. ANOVA was used to determine differences in cost over the time period studied. Univariable analysis was performed using Student *t* test, Fisher exact test, and Wilcoxon rank sum test to determine significant differences in variables in patients who were readmitted within 30 days of discharge for all causes or readmitted exclusively for heart failure. Patient characteristics and pharmacotherapeutic variables with a P value of <.2 on univariable analysis were placed into a multivariable, mixed-effect logistic regression model clustered on institution and discharge year to adjust for institutional differences and time, to determine significant variables for heart failure readmission. All analyses were performed with Stata IC v 12 (StataCorp, College Station, Texas), and a P value of <.05 was considered significant a priori.

Results

A total of 2386 patients met study criteria (52.1% male) (**Figure 1**; available at www.jpeds.com). Median age at initial admission was 8.1 years (IQR 1.2-14.6 years of age) with 23.1% less than 1 year of age. The majority of the population was Caucasian (54.1%), followed by African American (24.1%), other (14.1%), and Asian (2.9%). Hispanic patients composed 18.7% of the cohort. Patients were nearly evenly divided with respect to public insurance (55.4%). Patients were admitted for a median length of stay of 11 days (IQR 6-21 days) during the initial admission. Cardiomyopathy subtypes, per ICD-9 code, were as follows: other primary cardiomyopathies (81.1%), cardiomyopathy in other diseases classifications (6.8%), secondary cardiomyopathy, unspecified (6.8%), endocardial fibroelastosis (2.4%), hypertrophic obstructive cardiomyopathy (1.1%), nutritional and metabolic cardiomyopathy (1.1%), and other hypertrophic cardiomyopathy (0.9%). Admission to an intensive care unit occurred in 74.9%, and mechanical ventilation was used in 35.1% of patients. Intensive care unit admission was not highly correlated with use of mechanical ventilation (r = 0.24). Extracorporeal membrane oxygenation was used in 3.7% and a ventricular assist device was used in 1.8%. A tachyarrhythmia was present in 32.1%. Initial admission length of stay increased over the study time period (P = .01) (**Figure 2**; available at www.jpeds.com).

A vasoactive or inotropic medication was used at initial admission in 70.7% of patients, with a median total of 8 days (IQR 4-16 days) of therapy. The most common vasoactive or inotropic medication used was milrinone (62.8%), followed by epinephrine (29.9%), dopamine (29.2%), dobutamine (16.6%), vasopressin (4.4%), norepinephrine (4.2%), and nesiritide (2.5%). Vasoactive medication use did not differ by year across the study period (P = .22) Use of an ACE inhibitor at discharge occurred in 67.4% (enalapril 43.8%, captopril 13.0%, lisinopril 11.4%). An ARB was prescribed at discharge in 1.6% (losartan 1.3%, valsartan