

National In-Hospital Outcomes of Pregnancy in Women With Single Ventricle Congenital Heart Disease



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Most patients with single ventricle (SV) congenital heart disease are expected to survive to adulthood. Women with SV are often counseled against pregnancy; however, data on pregnancies in these women are lacking. We sought to evaluate in-hospital outcomes of pregnancy in women with SV. We used nationally representative data from the 1998 to 2012 National Inpatient Sample to identify women ≥ 18 years of age admitted to the hospital with International Classification of Diseases-9th Revision codes for an intrauterine pregnancy and a diagnosis of hypoplastic left heart syndrome, tricuspid atresia, or common ventricle. A matched comparison group without a diagnosis of congenital heart disease or pulmonary hypertension was identified from the database. National estimates of hospitalizations were calculated. Length of stay, hospital charges, and complications were analyzed and compared between groups. Charge data were adjusted to 2012 dollars. There were 282 admissions of pregnant women with SV (69% with deliveries) and 1,405 admissions in the control group (88% with deliveries). Vaginal delivery was more common in SV (74% vs 71%, $p < 0.001$). Length of stay (4.1 ± 0.91 vs 2.8 ± 0.18 days, $p < 0.001$) and charges ($\$30,787 \pm 8,109$ vs $\$15,536 \pm 1,006$, $p < 0.0001$) were higher in the SV group. Complications occurred in most SV admissions and were more common in the SV group than in the control group. No deaths occurred. Cardiovascular complications occurred in 25% of pregnancy-related hospitalizations, although in-hospital pregnancy-related death is rare. Vaginal delivery is common in these patients. These data suggest that pregnancy and vaginal delivery can be tolerated in women with SV, although the risk for a cardiovascular event is significantly higher than in the general population. © 2017 Elsevier Inc. All rights reserved. (Am J Cardiol 2017;119:1106–1110)

Moderate or severe forms of congenital heart disease (CHD) occur in 6 in 1,000 live births,¹ and survival to adulthood is now expected in 90%.^{2,3} Approximately 8% of all CHD is composed of defects palliated with a single ventricle (SV) strategy,¹ and among those, hypoplastic left heart syndrome (HLHS) is the most common. Advances in therapies have increased survival in HLHS from essentially zero to the current expectation that 70% of patients will survive to adulthood.⁴ As women with SV reach reproductive age, considerations of pregnancy and motherhood become increasingly important. Pregnancy risk for women with SV and a history of Fontan palliation is World Health Organization class III, indicating a significantly increased risk of maternal morbidity and mortality compared with the

general population.⁵ As a result, these women have historically been advised against pregnancy.⁶ However, small studies have shown women with SV can tolerate pregnancy relatively well if their prepregnancy cardiovascular status is good,⁷ and the risk of maternal mortality in women with SV is low.⁸ These data are limited, and no studies have compared in-hospital, pregnancy-related events and mortality in women with SV with control women. The present study sought to characterize national trends of pregnancy-related hospital admissions for women with SV CHD, determine in-hospital pregnancy-related complications, and compare the hospitalizations of women with SV with contemporaneous controls.

Methods

Data were sourced from the 1998 to 2012 Healthcare Cost and Utilization Project National Inpatient Sample 2012 (NIS) (Agency for Healthcare Research and Quality, Rockville, Maryland, www.hcup-us.ahrq.gov/nisoverview.jsp). The NIS is the largest all-payor inpatient health care database in the United States, containing data from approximately 8 million hospital discharges per year, yielding a 20% stratified sample of all community hospitals. Earlier investigators have used the NIS to study trends in hospital resource utilization, including those trends involving adults with CHD.^{9–11} We have used the NIS to examine risk factors for increased hospital resource utilization and mortality in adults with SV.¹² The institutional

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See page 1109 for disclosure information.

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review board of the University of Arkansas for Medical Sciences waived the need for investigational approval because the secondary administrative data in the NIS are deidentified.

The data contained in the NIS database include detailed, deidentified information on each inpatient's demographics, diagnoses, procedures, disposition on hospital discharge, and hospital charges. Data were limited to include only patients ≥ 18 years of age admitted to the hospital with a pregnancy-related diagnosis ([Appendix](#)) and with International Classification of Diseases-9th Revision (ICD-9) codes for a diagnosis of HLHS (ICD-9 746.7), tricuspid atresia (746.1), or common ventricle (745.3). Hospitalizations with molar or ectopic pregnancies were excluded. In addition, a 5:1 matched control group of women with a pregnancy-related diagnosis without the diagnosis of SV or pulmonary hypertension was created and used for comparisons. Matched variables included age, race, insurance type, and year of admission.

Collected data included patient demographics (age at admission, gender, race, ethnicity, and payor status), principal and secondary diagnosis codes, mechanical ventilation, procedures performed, duration of hospital length of stay (LOS) in days, in-hospital mortality, and hospital charges. All charge data were adjusted for inflation to 2012 dollars using Consumer Pricing Indices data. Co-morbid conditions most relevant to pregnant patients with SV were derived from principal and secondary ICD-9 diagnoses codes ([Appendix](#)).

Primary outcomes of interest were the total number of pregnancy-related inpatient admissions for women with SV; hospital resource utilization, measured by length of stay and charges per day; and the distribution of select co-morbid conditions.

The data use agreement of the NIS does not allow the presentation of any unweighted count <10 . In situations when this is not the case, percentages for each group and the statistical test result are presented. In situations wherein the count is <10 for only one of the groups (SV vs control), the percentage of cases for the group >10 will be reported along with the statistical test result and a notation of the direction of the result.

All statistical analyses were carried out using SAS version 9.4 software (SAS Institute Inc., Cary, North Carolina). Because the NIS is complex survey data, we used SAS survey analysis procedures. Continuous and categorical outcomes were presented as means (standard error) and frequency (percentage), respectively. Comparisons of continuous outcomes between SV and controls, as well as SV anatomic subtypes and controls, were done using the analysis of variance test. Likewise, categorical outcomes were compared by use of the Rao-Scott chi-square test. Sampling weights were used in all analyses to produce nationally representative estimates while adjusting for clustering by hospital and the complex sampling design of the data. Statistical significance was determined at p values <0.05 .

Results

There were a total of 282 intrauterine pregnancy-related hospital discharges of women with SV to US community

Table 1

Baseline hospitalization data for pregnancy-related admissions of women with single ventricle congenital heart disease compared to matched controls

Variable	Single ventricle patients (N=282)	Controls (N=1405)	p-value
Age (years)	25.8 $\pm$ 0.9	26.6 $\pm$ 0.4	0.3637
Length of stay (days)	4.1 $\pm$ 0.9	2.8 $\pm$ 0.2	0.0303
Total hospital charges	\$30,787 $\pm$ 8,109	\$15,536 $\pm$ 1,006	0.0004
Teaching hospital	218 (77%)	662 (47%)	<i><0.0001</i>
Admission type			0.0008
Antepartum	73 (26%)	144 (10%)	
Delivery	194 (69%)	1241 (88%)	
Postpartum	*	*	
Delivery route			0.0006
Vaginal	144 (74%)	879 (71%)	
Cesarean section	50 (26%)	362 (29%)	
Delivery outcome			<i><0.0001</i>
Liveborn	169 (87%)	1214 (98%)	
Stillborn	*	*	
Missing	*	*	

Italicized values indicate a statistically significant results.

* Indicates unweighted values > 0 but <10 , which cannot be reported in accordance with data use agreement from the National Inpatient Sample.

hospitals during the 15-year study period. Demographic and admission-related distributions of SV and control hospitalizations are listed in [Table 1](#). These data are reported by SV anatomic subtype in [Table 2](#). The median number of annual hospital admissions was 15 (range 4 to 54) with no change in admission rate across the study period. No differences in SV pregnancy-related outcomes were found between teaching and nonteaching hospitals.

As listed in [Table 3](#), cardiovascular complications occurred more commonly in hospitalizations of patients with SV (70 of 282 admissions, 24.8%) than in controls ($<1\%$; $p < 0.0001$). Arrhythmias were the most common cardiovascular complication in SV hospitalizations, occurring much more commonly (17.7% of admissions) than in controls ($p < 0.0001$). The most common arrhythmia was atrial flutter, followed by atrial fibrillation, ventricular fibrillation, and paroxysmal atrial tachycardia. Heart failure occurred in $<5\%$ of SV admissions and was not reported in the control group. Similarly, cerebrovascular accidents occurred in $<2\%$ of SV hospitalizations, whereas none were reported in the control group. No deaths occurred in either the SV group or the control group. No cardiovascular complications occurred in isolation from obstetric complications in either group.

Obstetric complications without a concomitant cardiovascular complication occurred more frequently in controls than in patients with SV (51.8% vs 24.7%; $p < 0.0001$). Patients with SV had higher rates of gestational diabetes, preterm labor and/or delivery, and fetal growth restriction. The odds ratio of preterm labor and delivery was 2.3 (95% confidence interval 1.04 to 5.15) in patients with SV compared with controls.

Discussion

Patients with SV CHD are now surviving to adulthood.⁴ Before the advent of the Fontan procedure for tricuspid atresia¹³ and the subsequent Norwood procedure for HLHS,¹⁴

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