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Effects of Race, Ethnicity, and Gender on Surgical Mortality in Hypoplastic Left Heart Syndrome

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Abstract

Information is limited regarding the effect of race, ethnicity, and gender on the outcomes of the three palliative procedures for hypoplastic left heart syndrome (HLHS). This study examined the effects of race, ethnicity, gender, type of admission, and surgical volume on in-hospital mortality associated with palliative procedures for HLHS between 1998 and 2007 using data from the University HealthSystem Consortium. According to the data, 1,949 patients underwent stage 1 palliation (S1P) with a mortality rate of 29 %, 1,279 patients underwent stage 2 palliations (S2P) with a mortality rate of 5.4 %, and 1,084 patients underwent stage 3 palliation (S3P) with a mortality rate of 4.1 %. The risk factors for increased mortality with S1P were black and "other" race, smaller surgical volume, and early surgical era. The only risk factors for increased mortality with S2P were black race (11 % mortality; odds ratio [OR], 3.19; 95 % confidence interval [CI] 1.69–6.02) and Hispanic ethnicity (11 % mortality; OR 3.30; 95 % CI 1.64–6.64). For S2P, no racial differences were seen in the top five surgical volume institutions, but racial differences were seen in the non-top-five surgical volume institutions. Mortality with S1P was significantly higher

for patients discharged after birth (37 vs 24 %; $p = 0.004$), and blacks were more likely to be discharged after birth (12 vs 5 % for all other races; $p < 0.001$). No racial differences with S3P were observed. The risk factors for increased mortality at S1P were black and “other” race, smaller surgical volume, and early surgical era. The risk factors for increased in-hospital mortality with S2P were black race and His-panic ethnicity.

Keywords

Congenital heart disease; Congenital heart surgery; Hypoplastic left heart syndrome; Racial disparities

Background

Although the overall mortality rate for patients with congenital heart disease (CHD) has decreased significantly over the last several decades [6, 22], mortality among black and Hispanic patients with CHD has not decreased as dramatically as among white patients [6, 22]. Several national database studies have shown that black and Hispanic patients with CHD have a higher surgical mortality rate than white patients [4, 8, 15, 23, 36, 38], but these studies have not analyzed specific diagnoses or individual procedures.

Outcomes specifically for children with hypoplastic left heart syndrome (HLHS) also have improved but remain unacceptably high [14, 16–18, 31, 32]. Black patients with single-ventricle lesions and Hispanic patients with HLHS have a higher early childhood mortality than white patients [18, 19, 35]. The reasons for the increased mortality rate for black and Hispanic patients are unclear because the studies did not distinguish between surgical, in-hospital, and interstage mortality.

In the current study, we used data from a large, multi-institutional database to investigate the effect of race, ethnicity, and gender on the in-hospital mortality for the three palliative procedures commonly used in the management of HLHS.

Materials and Methods

Data were obtained from the Clinical Database/Resource Manager maintained by the University HealthSystem Consortium (UHC). The UHC is an alliance of 116 academic medical centers and 276 affiliated hospitals that share demographic, diagnostic, procedural, and financial data on all discharges.

Encoded hospital identifiers were provided for individual institutions. The study was approved by the University of Virginia Institutional Review Board.

The database was queried for data on all patients discharged between 1998 and 2007 with the diagnosis of HLHS based on *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9) code 746.7. Procedures during each hospitalization were determined by using the listed procedure codes as previously described [32].

We collected information regarding race, ethnicity, gender, age at surgery, admission source, and discharge status for the three procedures used in palliation of HLHS between 1998 and 2007. The early surgical era was defined as 1998–2002 and the late surgical era as 2003–2007. For each of the three surgical procedures, the five institutions that performed the most procedures performed approximately half of the total and are subsequently referred to as “large-volume” institutions. The remaining institutions are referred to as “small-volume” institutions. The large-volume institutions each performed more than 124 stage 1 palliative (S1P) procedures (Norwood procedure with either Blalock-Taussig shunt or Sano modification), more than 76 stage 2 palliative (S2P) procedures (Glenn procedure), and more than 54 stage 3 palliative (S3P) procedures (Fontan procedure) during the ten year study period.

The patients were classified as black, Hispanic, white, or “other” (including Asian and Native American patients) by the admitting hospital. Patients for whom race was listed as “unknown” were included in the overall mortality analysis but not in the racial comparisons. Some institutional protocols do not allow date of birth or race information to be sent to the UHC, so the numbers for analyses involving race and age are fewer than those for the total cohort.

The admission source was used to determine whether a patient had been discharged to home before diagnosis. Because neonates with a known diagnosis of HLHS are rarely, if ever, discharged home before an S1P procedure, it was assumed that all patients admitted under the category, “ED referral,” “clinic referral,” “HMO referral,” “extramural birth,” or “physician/MD referral” had been discharged home after birth without a diagnosis of HLHS. It was assumed that the diagnosis for inborn and transferred neonates was determined either prenatally or during the immediate newborn period.

Mortality rates were determined on the basis of survival to discharge. Data on mortality after discharge are not included in the data set.

For each disease stage, the effects of race, gender, admission status, institutional surgical volume, and surgical era on in-hospital mortality were compared by Chi square analysis (SAS, version 9.2; SAS Institute Inc., Cary, NC, USA). Logistic regression was used to assess the simultaneous effect of these factors and their two-way interactions on mortality risk. Additionally, for S1P, the effect of prematurity was assessed by Chi square analysis, and for S2P and S3P procedures, the age at the time of surgery for each of the racial/ethnic groups was compared using a Kruskal–Wallis test.

Results

Between 1998 and 2007, 48 UHC institutions performed 1,949 S1P procedures, 47 institutions performed 1,279 S2P procedures, and 46 institutions performed 1,084 S3P procedures (Table 1). Racial information was missing for 220 patients who underwent S1P, 55 who underwent S2P, and 52 who underwent S3P.

Unadjusted Outcomes (Table 1)

For S1P, the overall in-hospital mortality rate was 28.6 %. The mortality rate was higher among females (31.6 vs 26.7 %; $p = 0.045$). It was significantly lower at large-volume institutions than at small-volume institutions (23.6 vs 34.3 %; $p < 0.0001$). Racial differences were seen at both large- and small-volume institutions. The mortality rate was significantly higher for patients admitted from home to the institution that performed the S1P (36.9 %) than for those born at or transferred to the institution that performed the S1P (27.7 %; $p = 0.045$). Black patients were more likely to have been admitted from home than nonblack patients (12 vs 5 %; $p < 0.001$). The incidence of prematurity did not differ significantly between races ($p = 0.62$) and ranged between 8 and 10 % for each race.

The in-hospital mortality rate for patients undergoing S2P procedures was 5.4 %. The overall mortality rate at the large-volume institutions was similar to that at the small-volume institutions (5.5 and 5.3 %; $p = 0.84$), but blacks and Hispanics had increased mortality (13.5 and 13.2 %, respectively; $p < 0.001$) at the small-volume centers. Age at the S2P procedure was available for 812 patients and did not differ significantly across races ($p = 0.25$).

The in-hospital mortality rate for the patients undergoing S3P procedures was 4.1 %. Gender, race, ethnicity, institutional surgical volume, and surgical era did not influence mortality. Age at S3P was available for 818 patients and did not differ significantly across races ($p = 0.31$).

Adjusted Outcomes (Table 2)

The results for logistic regression analysis are shown in Table 2. For stage 1 palliation, black and “other” race, smaller surgical volume, and early surgical era were significant risk factors for in-hospital mortality. Female gender trended toward but did not reach statistical significance and admission category was not significant.

For stage 2 palliation, black race and Hispanic ethnicity were significant risk factors for in-hospital mortality. Gender, institutional surgical volume, and surgical era were not significant.

Discussion

Using a large, national hospital database, we identified several risk factors for increased mortality for the three palliative procedures commonly used to treat patients with HLHS. For S1P, the risk factors were black and “other” race, smaller surgical volume, and early surgical era. For S2P, the risk factors were black race and Hispanic ethnicity. For S1P, female gender and discharge before diagnosis were significant in the unadjusted analysis but not significant when adjustment was performed for other factors. No risk factors were identified for S3P palliation. The most novel finding in our study was the increased risk of in-hospital mortality for black and “other” race patients at S1P and for black and Hispanic patients at the time of S2P.

Using large national inpatient databases, other studies [4, 8, 15, 23, 36] have demonstrated increased mortality for black and Hispanic patients undergoing surgery for CHD, but these

studies did not describe mortality for specific diagnoses or procedures. Three studies using the Texas Birth Defect Registry focused on single-ventricle-physiology patients and demonstrated racial differences in early childhood survival [18, 19, 35]. Our study indicates that these discrepancies in early childhood mortality are partially due to increased in-hospital mortality at S1P for black and “other” race patients and increased in-hospital mortality at S2P for black and Hispanic patients. The increased mortality does not appear to be due to racial groups undergoing procedures at smaller-volume institutions because approximately half of the black and “other” race patients had their procedures performed at a large-volume institution, and approximately half of the black and Hispanic patients had their S2P procedures at a large-volume institution.

The reason for the increased mortality rate for black and Hispanic patients at S2P is unclear. Previous studies have shown that lower weight-for-age z -scores increase the risk of complications after S2P [1, 33]. More recently, Anderson et al. [2] demonstrated that non-Caucasian races have lower weight-for-age z -scores.

Our database did not contain data on weight or nutritional status, so we were unable to determine whether these factors contributed to the increased mortality among blacks and Hispanics. The racial differences seen at both large-and small-volume institutions at S1P and the lack of racial differences at the five institutions performing the largest number of S2P procedures argues against biologic factors as a cause for the racial differences in mortality. We speculate that more resources and more robust interstage monitoring programs at large-volume institutions may help to eliminate the racial differences at S2P.

In our study, age at S2P and S3P did not differ significantly between the races. Several studies have found that blacks undergo S2P at an older age than whites [11, 34], but our findings coincide with those of Ingaramo et al. [26], who also found no significant racial difference in age at S2P and S3P in a large national database.

In our cohort, the patients admitted from home at the time of their S1P operation had a significantly higher unadjusted mortality rate than those born at or transferred to the institution that performed the S1P (36.9 vs 27.7 %). Although logistic regression did not find this to be significant, we believe it may be due to the high percentage of black patients discharged home before diagnosis (12 vs 5 % for all other races). This finding adds to the growing evidence that screening for CHD in the prenatal period [42] or in the newborn nursery is important [7, 20, 29, 30, 40], especially for infants whose skin pigmentation may prevent adequate visual assessment of cyanosis [29].

Similar to previous studies, we found increased risk of death for smaller surgical volume and earlier surgical era [5, 10, 24, 25]. Although black patients have an overall higher incidence of prematurity [12] and although other studies have shown that prematurity is an independent risk factor for mortality [3, 21, 37, 39, 41], in our patients, the incidence of prematurity was similar across races and did not contribute to racial disparities.

Although some studies have shown increased mortality for female infants undergoing cardiac procedures [4, 9, 27, 38], we did not find a gender discrepancy in adjusted analysis

for any of the three palliative procedures. Other studies looking specifically at risk factors associated with S1P for HLHS also have not found a gender difference [25, 28, 37, 39].

For S1P, the finding that “other” races had increased inhospital mortality is difficult to interpret. Whereas a small number of these patients were Asian or Native American/Eskimo, the majority simply had “other” listed as their race. We do not know whether the patient’s family identified itself as an unlisted race or had a multiracial lineage, or whether the person entering the information in the database was uncertain about the race of the patient. This limitation is true of virtually all the racial studies involving CHD [4, 8, 15, 23, 36] and is difficult to avoid in a multiracial county such as the United States. Our data were similar to those of Oster et al. [36] and Dibardino et al. [15], each of whom found increased mortality for “other” races after congenital heart procedures.

The limitations of our study were those related to the use of an administrative discharge database, especially one based on the ICD-9 procedure coding system, which has no specific code for S1P (Norwood procedure). We attempted to circumvent this by using both the ICD-9 diagnostic and procedural codes to identify patients, as previously described [13, 32]. We did not have clinical data such as weight, nutritional status, oxygen saturation, metabolic status, or the presence of a prenatal diagnosis, factors that may have explained some of the differences in mortality. We also did not have information regarding socioeconomic status, data that may have served as a surrogate for access to care.

We made several assumptions regarding admission category for the S1P hospitalization. Admission category (inborn vs outborn) is admittedly a crude way to determine clinical status, although it may have validity for the neonate with HLHS, whose clinical deterioration may occur very rapidly. We also assumed that patients transferred to the S1P institution were born at the referring institution and had the diagnosis of HLHS there. Because some of them may have been discharged before admittance to the referring institution, we may have underestimated the number of patients admitted from home.

Conclusions

In a large, nationwide database, we found that the independent risk factors for increased in-hospital mortality at S1P for HLHS were black and “other” race, lower surgical volume, and earlier surgical era. The risk factors for increased mortality at S2P were black race and Hispanic ethnicity. The fact that the five institutions performing the largest number of procedures did not differ in mortality at S2P suggests that the racial differences are not innate and can be minimized by the implementation of routine pulse oximetry screening programs in the newborn period, increased interstage monitoring, and better pre-S2P nutrition of patients with HLHS.

Abbreviations

CHD	Congenital heart disease
HLHS	Hypoplastic left heart syndrome

S1P	Stage 1 palliation (Norwood procedure)
S2P	Stage 2 palliation (Glenn or Hemi-Fontan procedure)
S3P	Stage 3 palliation (Fontan procedure)
UHC	University HealthSystem Consortium

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Table 1

Unadjusted in-hospital mortality

Stage	Variables	Subcategory	Operations	Deaths	Mortality rate (%)	Chi square <i>p</i> value
Stage 1	Cohort	–	1,949	557	28.5	–
	Gender ^a	Male	1,209	323	26.7	0.045
		Female	738	233	31.6	
	Race	White	1,163	291	25.0	
		Black	231	70	30.3	
		Hispanic	158	38	24.0	< 0.001
		Other	177	70	39.5	
		Unknown ^b	220	88	40.0	
	Institutional volume	Top 5	1,046	247	23.6	< 0.0001
		Non-top 5	903	310	34.3	
	Large-volume institutions	White	630	135	21.4	
		Black	113	20	17.7	
		Hispanic	72	18	25.0	0.04
		Other	94	31	33.0	
		Unknown ^b	137	43	31.4	
	Small-volume institutions	White	533	156	29.3	
		Black	118	50	42.4	
		Hispanic	86	20	23.3	< 0.001
		Other	83	39	47.0	
		Unknown ^b	83	45	54.2	
	Surgical era	Early	970	323	33.3	< 0.0001
		Late	979	234	23.9	
	Admission category ^c	Inborn ^d	1,771	491	27.7	0.045
		Admitted from home	103	38	36.9	
Stage 2	Cohort	–	1,279	69	5.4	–
	Gender	Male	844	41	4.9	0.24
		Female	435	28	6.4	
	Race	White	883	32	3.6	

Stage	Variables	Subcategory	Operations	Deaths	Mortality rate (%)	Chi square <i>p</i> value
Stage 3	Cohort	Black	146	16	11	< 0.001
		Hispanic	109	12	11	
		Other	86	6	7	
		Unknown ^b	55	3	5.5	
		Top 5	708	39	5.5	
	Gender	Non-top 5	571	30	5.3	0.84
		White	490	24	4.7	
		Black	82	6	6.8	
		Hispanic	50	3	5.7	
		Other	50	5	9.1	
	Race	Unknown ^b	36	1	2.7	0.4
		White	393	8	2.0	
		Black	64	10	13.5	
		Hispanic	59	9	13.2	
		Other	36	1	2.7	
Stage 3	Surgical era	Unknown ^b	19	2	10.5	< 0.0001
		Early	548	28	5.1	
		Late	731	41	5.6	
		–	1,084	44	4.1	
		Male	369	17	4.6	
	Gender	Female	715	27	3.8	–
		White	769	31	4.0	
		Black	115	4	3.5	
		Hispanic	91	6	6.6	
		Other	57	1	1.7	
	Race	Unknown ^b	52	2	3.8	0.5
		Top 5	614	20	3.3	
		Non-top 5	470	24	5.1	
		White	315	16	5.1	
		Black	51	3	5.9	
Stage 3	Institutional volume	Hispanic	52	4	7.7	0.7
		White	52	4	7.7	
		Black	52	4	7.7	
		Hispanic	52	4	7.7	
		Other	52	4	7.7	
	Large-volume institutions	Unknown ^b	52	4	7.7	0.2
		Top 5	614	20	3.3	
		Non-top 5	470	24	5.1	
		White	315	16	5.1	
		Black	51	3	5.9	
	Small-volume institutions	Hispanic	52	4	7.7	0.2
		White	52	4	7.7	
		Black	52	4	7.7	
		Hispanic	52	4	7.7	
		Other	52	4	7.7	

Stage	Variables	Subcategory	Operations	Deaths	Mortality rate (%)	Chi square <i>p</i> value
Small-volume institutions		Other	27	0	0 %	
		Unknown ^b	25	1	4.0	
		White	454	15	3.3	
		Black	64	1	1.6	
		Hispanic	39	2	5.1	0.9
		Other	30	1	3.3	
		Unknown ^b	27	1	3.7	
Surgical era		Early	478	16	3.3	0.4
		Late	606	28	4.6	

^a Gender data were missing for two patients

^b Unknown race was not used in Chi squared analysis

^c Admission category was missing for 75 patients

^d "Inborn" is defined as patients born at or transferred to the stage 1 palliation (S1P) (Norwood procedure) institution

Table 2

Adjusted outcomes: logistic regression for stages 1 and 2 palliation

Stage	Variables	Effect	OR	95 % CI	p value
Stage 1	Gender	Female vs male	1.21	0.96	1.52
		Black vs white	1.41	1.02	1.95
	Race	Hispanic vs white	0.97	0.65	1.45
		Black vs Hispanic	1.45	0.90	2.33
		White vs other	0.46	0.33	0.65
		Black vs other	0.65	0.43	1.00
	Institutional volume	Hispanic vs other	0.45	0.28	0.74
		Large vs small	0.57	0.45	0.71
		Early vs late	1.83	1.46	2.29
	Admission category	Inborn vs outborn	1.07	0.67	1.72
Stage 2	Gender	Female vs male	1.16	0.69	1.95
		Black vs white	3.19	1.69	6.02
	Race	Hispanic vs white	3.30	1.64	6.64
		Black vs Hispanic	0.97	0.44	2.15
		Large vs small	1.17	0.70	1.95
	Institutional volume	Large vs small	1.17	0.70	1.95
		Early vs late	0.96	0.57	1.63
	Surgical era	Early vs late	0.96	0.57	1.63
		Early vs late	0.96	0.57	1.63
		Early vs late	0.96	0.57	1.63

OR odds ratio, *CI* confidence interval