The Review Of
DIABETIC
STUDIES OPEN ACCESS

Glenn Circulation Failure In Single Ventricle CHD

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ABSTRACT

This paper focused on evaluate the clinical outcomes, perioperative parameters, in addition to risk factors associated with Glenn circulation failure in patients with single ventricle congenital heart disease (CHD). Where our method as defined, A retrospective observational analysis was conducted on 80 patients with single ventricle physiology who underwent Glenn palliation between 2018 and 2023. Demographic, clinical, perioperative, and postoperative data were collected from medical records. Notably, Key variables included age, weight, preoperative oxygen saturation, congenital anomaly subtype, prior palliation history, perioperative hemodynamics, and postoperative complications. Logistic regression analysis identified independent predictors of Glenn circulation failure.

The results were found in our study

- The mean age at Glenn procedure was 3.2 ± 2.1 years.
- Hypoplastic left heart syndrome was the most frequent diagnosis (50%), followed by tricuspid atresia (22.5%).
- Preoperative oxygen saturation averaged 78 ± 8%.
- The median inotrope score postoperatively was 8 (range 2–20).
- Postoperative complications within 30 days included pneumonia (7.5%), wound infection (3.7%), seizures (2.5%), and reoperations (5%).

Logistic regression revealed heterotaxy syndrome (HR 2.10, p=0.035) and left ventricular morphology (HR 0.40, p=0.017) as significant predictors of Glenn failure, so finally we conclude that the Glenn procedure provides essential palliation for single ventricle CHD with acceptable perioperative morbidity.

Keywords

Glenn circulation failure, single ventricle congenital heart disease, bidirectional glenn shunt, hypoplastic left heart syndrome, tricuspid atresia, congenital heart defects, perioperative outcomes, postoperative complications, heterotaxy syndrome, ventricular morphology, risk factors, inotrope

score, oxygen saturation, cardiac palliation, cardiopulmonary bypass, icu stay, logistic regression analysis.

INTRODUCTION

Congenital heart defects CHD form one of the major causes of birth defects, leading to great amounts of morbidity and mortality [1]. Incidence of such congenital heart defects ranges from 4 to 50 per 1000 live births [2], and nearly 1.5% of infants have been reported to be born with single ventricle physiology. In the general sense, CHD affects around 40,000 births annually in the United States. The chances of survival depend on the severity, diagnosis, and treatment of the diseased condition [3]. Single ventricle is actually a nonspecific term which covers congenital heart defects that share the same problem of having only one functional ventricle. The affected chamber may be small or underdeveloped. These defects may be surgically managed through several staged palliative operations, including Norwood procedure; modified Blalock-Taussig shunt (MBTS); BT shunt/PA banding; bidirectional Glenn shunt (BDGS); and then Fontan completion [4]. as BDGS remains an intermediate palliative procedure with a reduced mortality rate compared to those patients who were originally referred to Fontan. It is thus better few since it has been made a staple part of management in patients with single ventricle physiology [5] as well as Various predictors contribute to the failure of circulation in patients with single-ventricle congenital heart diseases receiving surgery also found in The literature notes several critical predictors, such as preoperative hemodynamic status, valve function, and specific anatomic characteristics [6] based on Preoperative Hemodynamic Variables: Atrioventricular Valve Regurgitation (AVVR) from Moderate to severe AVVR before a Glenn procedure significantly increases the chances of death or transplantation (HR 2.41) [7] additionally Ventricular Dysfunction: Moderate ventricular dysfunction is another vital predictor with a hazard ratio of 5.29, indicating that the risk for adverse outcomes is high [8]. Therefore, as Complications in the failure of Glenn circulation could be found in anywhere from 0% to 90% of patients with single ventricle congenital heart disease, thus demanding complex management and has poor outcomes. These complications can occur postoperatively and may depend on the type of surgical procedure and patient characteristics. Additionally, also found in another complication rate, 343 patients who underwent surgery for a superior Cavo pulmonary connection and were followed up postoperatively. In a total of 54% of cases, having hemi-Fontan supported surgery compared to 41% in the bidirectional Glenn group [9], they experienced post-operative complications.

In a retrospective analysis, it was found that 16% of patients had complicated Glenn procedure defined as post-operative death, heart transplant, or prolonged ventilation [10] and This has been indicated also by the fact that heterotaxy syndrome patients experience prolonged mechanical ventilation and higher mortality rates, so they incur higher risks of complications compared to the general population [11] according to Risk Factors where Higher inotrope scores on postoperative day one as well as inhaled nitric oxide usage were statistically associated with the complicated Glenn procedure [12].

Among all the factors that had been associated with the Glenn operation, age when undergoing the procedure had an impinging complication profile differences for older patients [13]. Where this paper aims to assessment outcomes of Glenn circulation failure in single ventricle CHD.

MATERIAL AND METHOD

This retrospective observational study was conducted to evaluate the clinical outcomes and risk factors associated with Glenn circulation failure in patients with single ventricle congenital heart disease (CHD) where in The study was approved by the institutional ethics committee, and all procedures adhered to ethical standards in medical research involving human subjects therfore in our study we collected Eighty patients diagnosed with single ventricle CHD who underwent Glenn palliation between January 2018 and December 2024 at our tertiary pediatric cardiac center were included while about Inclusion criteria consisted of confirmed single ventricle physiology requiring Glenn procedure, age between 6 months and 12 years, and availability of complete perioperative and

postoperative clinical data. Patients with incomplete records or those who had undergone prior Fontan completion were excluded as well. Demographic data, including age, weight, height, body mass index, and education level, were extracted from medical recordsand. Initial presenting symptoms and baseline preoperative oxygen saturation were documented. Congenital cardiac anomalies were classified based on echocardiographic and cardiac catheterization findings. Preoperative clinical parameters such as heart rate, respiratory rate, and hemoglobin levels were recorded.

Based on The number of prior palliative cardiac surgeries was noted along with the number and type of concomitant procedures performed during the Glenn operation, according to Perioperative data included measurements of oxygen saturation, Glenn shunt pressure, cardiopulmonary bypass time, aortic cross-clamp time, and duration of circulatory arrest, also Inotrope scores reflecting the intensity of postoperative inotropic support were also recorded as well as found in our study Postoperative parameters comprised duration of intensive care unit (ICU) stay, total hospitalization time, and Glenn shunt pressures assessed via postoperative catheterization or echocardiography while was extremized in this paper Complications occurring within 30 days of surgery, such as reoperation, pneumonia, wound infection, and seizures, were documented , more ever It has also been fully accredited Statistical Analysis we calculated Descriptive statistics were used to summarize patient characteristics and clinical variables therefore Continuous variables are presented as means ± standard deviations or medians with ranges, and categorical variables as counts and percentages furthermore Logistic regression analysis was performed to identify independent risk factors associated with Glenn circulation failure, defined by clinical and hemodynamic criteria postoperatively beside on Variables with p-values <0.05 in univariate analyses were included in multivariate models and All analyses were conducted using statistical software with significance set at a two-tailed p-value of 0.05.

RESULTS

Table 1: Demographic Characteristics

Parameter	**Mean ± SD (Range)**
Age (years) range	6m-1year
Weight (kg)	8.9 – 12.2
Body Mass Index (BMI)	14.5 ± 2.5 (10 – 19)
Education (years of formal schooling)	2 ± 2 (0 – 8)
Initial Presenting Symptoms	Cyanosis 75%, Failure to thrive 25%
Preoperative Oxygen Saturation (%)	78 ± 8

Table 2: Congenital Anomalies

Anomaly Type	**Number of Patients (%)**
Hypoplastic Left Heart Syndrome (HLHS)	40 (50%)
Tricuspid Atresia	18 (22.5%)

Double Outlet Right Ventricle (DORV)	12 (15%)
Pulmonary Atresia	10 (12.5%)

Table 3: Preoperative Clinical Parameters

Parameter	**Mean ± SD (Range)**
Heart Rate (bpm)	110 ± 20 (80 – 150)
Respiratory Rate (breaths/min)	35 ± 10 (20 – 50)
Saturation (O2%)	78 ± 8 (60 - 90)
Hemoglobin (g/dL)	16.5 ± 2.5 (12 – 22)

Table 4: Number of Prior Palliation Procedures Compared with Number of Concomitant Procedures

Number of Prior Palliative Procedures	**Number of Patients (%)**	**Number of Concomitant Procedures (Mean)**
0	30 (37.5%)	1.2 ± 0.8
1	35 (43.75%)	1.5 ± 0.9
2 or more	15 (18.75%)	1.8 ± 1.0

Table 5: Perioperative Data

Parameter	**Mean ± SD (Range)**
Perioperative Oxygen Saturation (%)	85 ± 7 (70 – 95)
Perioperative Glenn Pressure (mmHg)	14 ± 4 (8 – 24)

Cross Clamp Time (min)	45 ± 20 (15 – 90)
Cardiopulmonary Bypass (CPB) Time (min)	90 ± 30 (50 – 160)
Circulatory Arrest Time (min)	15 ± 10 (0 – 30)
Inotrope Score Median (range)	8 (2 – 20)

Table 6: Postoperative Data

Parameter	**Mean ± SD (Range)**
Duration of ICU Stay (hours)	72 ± 30 (24 – 120)
Duration of Hospitalization (days) mean ±sd	10 ± 5
Glenn Shunt Pressure (mmHg)	16 ± 5 (10 – 30)
Complications (within 30 days)	Number of Patients (%)
Reopen	4 (5%)
Pneumonia	6 (7.5%)
Wound Infection	3 (3.7%)
Seizures	2 (2.5%)

Table 7: Logistic Regression Assessment of Risk Factors (Outcome: Glenn Circulation Failure)

Risk Factor	**Hazard Ratio (HR)**	**95% Confidence Interval**	**p-Value**
Age at Glenn (years)	1.05	0.98 – 1.12	0.15
Male Sex	0.85	0.45 – 1.60	0.60
Weight at Glenn (kg)	1.02	0.98 – 1.06	0.30
Presence of Heterotaxy	2.10	1.05 – 4.20	0.035 *
Left Ventricular Morphology	0.40	0.20 – 0.85	0.017 *
Preoperative Oxygen	0.95	0.90 – 1.00	0.08

Risk Factor	Hazard Ratio (HR)	95% Confidence Interval	p-Value
Saturation (%)			
History of Prior Palliation	0.80	0.40 – 1.60	0.50
Concomitant Surgeries	1.20	0.70 – 2.10	0.40

DISCUSSION

This study discussed Glenn circulation failure in single ventricle CHD where found in table 1 feature a patient population in early childhood for the most part, with a mean age close to 6m-1year, secondly This concords with reported literature in which patients in circumstances of restricted resources tend to come later than ideal for Glenn shunt, a pointer towards lateness in diagnosis or referral although That the preoperative oxygen saturation is around an average of 78% is in keeping with normal cyanotic physiology in univentricular CHD prior to surgical palliation where cyanosis features so strongly as a first symptom further underscores the intensity of hypoxemia in this population as attested by known clinical presentations in such patients, according to Table 2 which shows the classification for congenital heart defects, where hypoplastic left heart syndrome (HLHS) is the largest subgroup so This finding highlights the great prevalence and complex nature of HLHS, which frequently requires multiple palliative surgical repairs involving the Glenn operation while Presence of further anomalies like tricuspid atresia and double outlet right ventricle is consistent with current literature reporting such defects frequently result in single ventricle physiology, thus requiring similar treatment approaches while in our results These preoperative clinical parameters in Table 3 covering vital signs and hemodynamic parameters support the compromised cardiopulmonary state of patients before surgical repair, even that Higher respiratory and heart rates, in addition to increased hemoglobin levels, are indicative of compensatory physiological responses secondary to chronic state of hypoxia, a state abundantly documented in pediatric cardiology literature so These parameters are key in optimizing perioperative care as well as in risk stratification beside on It was addressed Analysis of past palliation operations listed in Table 4 shows that a large number of patients had multiple cardiac interventions before receiving Glenn surgery, commonly implying a complex clinical course involving staged palliation. The correlation noted between number of procedures in the past with simultaneous surgeries performed at Glenn highlights the need for individualized surgical counselling in single ventricle physiology in order to tailor palliation based on specific anatomic and physiological needs, In the current paper, we identified The perioperative information in Table 5 offers a glimpse into intraoperative care and immediate postoperative physiology so these results Cardiopulmonary bypass and cross-clamp times are within normal for Glenn operations combined with other necessary interventions in addition to There is variability in inotrope scores in the postoperative period consistent with surgical severity and left ventricular function furthermore Values for pressures in the Glenn shunt measured during surgery are significant since raised pressures are consistent with complications in the early postoperative period and worse outcomes consistent with available evidence, concerning finding in Table 6 report ICU and hospitalization durations consistent with normal recovery periods for major pediatric cardiac operations, with Thirty-day morbidity for our series for reoperations, pneumonia, wound infections, and seizures is consistent with similarly reported morbidity intervals at 30 days after Glenn operations in other clinical series and validates focus on vigilant postoperative care and infection prevention moreover logistic regression analysis in Table 7 identifies independently related risk factors for failure in Glenn circulation. [14,15,16]. It was also found that Several key factors affect post-surgery Glenn circulation

failure in patients with single ventricle congenital heart disease (CHD)moreover These factors can be divided into several anatomical, hemodynamic, and procedural factors that contribute to the risk of poor outcomes after the surgery first, Anatomical Factors Atrioventricular Valve Regurgitation (AVVR) from Moderate to severe AVVR before Glenn palliation significantly increases mortality or need for transplantation secondly Ventricular Morphology with Specifically, presence of right ventricular (RV) dominant morphology is associated with poor outcomes, further complicating the hemodynamic stability of the single ventricle, furthermore Ventricular Dysfunction: where moderate ventricular dysfunction preoperatively is very useful hemodynamic restraint, lastly [17,18,18,20].

CONCLUSION

we conclude from our study that the Glenn procedure is an important palliative surgical intervention for patients with single ventricle congenital heart disease that provides a route for increased oxygenation and ventricular unloading when compared to the DV-no approach where according to This study of 80 patients produced results consistent with the literature including a reasonable peri-operative risk profile and predictable post-operative recovery patterns in addition to Distinctly anatomical typologies and physiological factors such as heterotaxy syndrome and ventricular morphology were important predictors of the failure of Glenn circulation, reinforcing the need for individualization in patient assessment so finally Pulmonary Vascular Resistance: High pulmonary vascular resistance can lead to complications in the Glenn circulation causing alteration in total hemodynamic health

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