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Glenn procedure should be done as soon as possible and definitely before the mean Pulmonary artery pressure elevated

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Abstract

Introduction: There are still conflicting results regarding the effect of basal pulmonary arterial pressure on the consequences of Glenn surgery and require further studies in this regard.

Aim of the study: Our main goal was to assess this hypothesis that the use of Glenn surgical technique (Glenn shunt implantation) can lead to better prognosis in patients with a single ventricular heart who are candidate of Fontan surgery by preserving pulmonary artery pressure, while that high baseline pulmonary artery pressure is considered a risk factor for poor prognosis.

Methods: This retrospective study was conducted on 81 consecutive patients with single ventricle heart defect who underwent isolated Glenn surgery and their files were complete in Shahid Rajaei Heart Center in Tehran from 1 January 2019 till 3 March 2020 Based on the pulmonary artery pressure assessed by angiography, patients were classified into two groups, group A patients whose pulmonary artery pressure equal to or less than 15 mmHg (n=41) and group B patients whose pulmonary artery pressure above 15 mmHg (n = 40) and information on the outcome after surgery was compared between the two groups.

Results: The prevalence rate of ascites (3 pts. 7.4% versus 19 pts. 48.1%, p = 0.001) and pleural effusion (33.3% versus 85.2%, p = 0.001), the mean length of hospital stay (6.00 ± 2.37 days versus 9.48 ± 6.86 days, p = 0.16) and length of ICU stay (3.93 ± 1.07 days versus 5.30 ± 2.30 days, p = 0.008) all were longer in those patients with PAP >15 mmHg (group B). But there was no difference in the rate of cardiac arrhythmia between the groups (p = 0.192) in our study.

Conclusion: High pulmonary artery pressure is associated with more postoperative complications and can be considered as a prognostic factor in patients undergoing Glenn surgery as in fact, high pulmonary pressure associated with postoperative ascites, pleural effusion, and long-term hospitalization.

Introduction

The goal of a systemic venous-to-PA shunt is to improve oxygenation by channelling the systemic venous return in part or in whole to the pulmonary vasculature. This procedure is commonly used in patients with a cyanotic defect who are staged to a Fontan circulation or total cavopulmonary connection. Although first performed experimentally and reported in 1950 by Carlon, [1,2] William Glenn is credited with the clinical application of a systemic venous to-PA connection, effectively bypassing the right ventricle [3-5]. Bidirectional Glenn shunt surgery plays a key role in improving the outcome of surgery in patients undergoing Fontan surgery, to the extent that it significantly reduces the risk of mortality in high-risk patients [6-10]. However, several factors affect the mortality resulting from the aforementioned surgery, including abnormal lung artery structure, high pulmonary hypertension, heterotaxy syndrome, systemic right ventricle, and abnormal pulmonary venous drainage [6-8]. In this regard, if the pulmonary artery pressure below 15 mmHg as well as if PAP below 20 mm Hg and the ventricular end-diastolic pressure less than 15 mm Hg has been considered as good candidate for Fontan surgery. It seems that reducing the resistance of pulmonary arteries and in fact maintaining pulmonary artery pressure can be considered as a prognostic factor in patients undergoing this surgery. The major limitation to early palliation with a Glenn-type anastomosis is the need for low pressures in the pulmonary bed, which are usually not present until 3 or 4 months of age [9-11]. Although initially successful, the Glenn shunt felt out of favour as the final procedure when the Fontan or total caval pulmonary connection was popularized for patients with single-ventricle physiology. Conversion of the Glenn anastomosis to a total cavopulmonary connection allowed complete separation of the systemic and pulmonary circulations, completely obviated the volume load on the single ventricle, and also reduced the development of pulmonary arteriovenous malformations by providing inferior vena cava blood to the lungs. Although a trend toward early completion of a total cavopulmonary connection (at less than 2 years of age) has been established, not all children are ideal candidates for immediate bicaval connection to the PA. In these patients, a bidirectional Glenn became an intermediate step in management of the single ventricle. The usual palliative sequence for univentricular heart disease is therefore

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the creation of a systemic-to-pulmonary shunt (or placement of a PA Banding in cases with pulmonary over circulation) for palliation in the neonatal period, followed by a Glenn or hemi-Fontan connection at around 6 months of age and, eventually, by completion of the Fontan operation when the child reaches about 15 kg in size [11-14].

Materials and methods

Between January 2019 and March 2020 all files of 184 patients that underwent Glenn surgery in Shahid Rajaei Heart Center in Tehran were reviewed retrospectively, from them 81 patients who underwent isolated Glenn operation for single ventricle heart defect were included in our study, patients with incomplete file data, who operated for other indication, or who underwent concurrent cardiac procedures were excluded. As this study was conducted on patients' files, we had took the ethical agreement of our centre.

First, with a comprehensive review of the recorded files of the patients with single ventricular heart underwent bidirectional Glenn shunt surgery were collected, background information such as demographic characteristics, medical or surgical history, as well as the information related to angiography and echocardiography of patients were collected and included in the study checklist. Also, information on the consequences of Glenn reconstructive surgery, including postoperative complications, hospital mortality, the need for mechanical ventilation, the use of inotropes, the need for re-intubation, the level of cardiac biomarkers before and after surgery, the length of hospital stays in the ICU and also, the total length of hospital stay was extracted from patients' files. Based on the pulmonary artery pressure assessed by angiography, patients were classified into two groups with pulmonary artery pressure equal to or less than 15 mmHg (n = 41) and pulmonary artery pressure above 15 mmHg (n = 40) and information on the outcome after surgery was compared between the two groups.

For statistical analysis, results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by frequency (percentage) for categorical variables. Continuous variables were compared using t test or Mann-Whitney test whenever the data did not appear to have normal distribution or when the assumption of equal variances was violated across the study groups. Categorical variables were, on the other hand, compared using chi-square test. The difference in study outcomes between the two groups adjusted for baseline variables, multivariable regression modelling was employed. For the statistical analysis, the statistical software SPSS version 23.0 for windows (IBM, Armonk, New York) was used.

Results

Baseline characteristics in the two groups are summarized in (Table 1). The two groups were matched for gender and mean age, but we found significantly lower body weight, lower height, and lower serum levels of haemoglobin and haematocrit in the group with PAP >15mmHg as compared to those with lower PAP. The mean heart rate was also higher in former groups. There was no difference in mean pump time and aortic cross-clamp time between the two groups. We also found no difference between the groups in terms of the average injection dose of milrinone and epinephrine. We also showed no association between mean PAP and body mass index (r = 0.144, p = 0.410) and inotrope score (r = 0.003, p = 0.984).

With respect to postoperative outcome (Table 2) in the two groups with PAP ≤15 mmHg and PAP >15 mmHg, we revealed no difference in the rate of cardiac arrhythmia between the groups (p = 0.192), but the prevalence rate of ascites (7.4% versus 48.1%, p = 0.001) and pleural effusion (33.3% versus 85.2%, p = 0.001) were both higher in those with PAP >15 mmHg. The mean length of hospital stays (6.00±2.37 days versus 9.48±6.86 days, p = 0.16) and length of ICU stay (3.93±1.07 days versus 5.30±2.30 days, p = 0.008) were longer in those patients with PAP >15 mmHg. In the multivariate linear regression model and in the presence of baseline characteristics, there was still a difference in the length of hospital stay of patients in the ward between the two groups (beta coefficient equal = 3.898, p = 0.022). Also, in the same linear regression model, there was a difference in the length of ICU stay between the two groups (beta coefficient equal = 1.341, p = 0.021). In the multivariate logistic regression model and in the presence of baseline characteristics, the difference in the prevalence of ascites in the two groups with PAP≥15 mmHg and the group with PAP <15 mmHg was significant (OR = 116.900, p = 0.003). Also, in another multivariate logistic regression model, the difference in the prevalence of pleural effusion was completely different between the two groups with PAP≥15 mmHg and the group with PAP <15 mmHg (OR = 27.891, p = 0.001).

Table 1. Baseline and intraoperative characteristics in study population

Characteristics	PAP ≤ 15 n (41)	PAP >15 n (40)	P value
Male gender	28 (70.4)	24 (59.3)	0.393
Mean age, year	5.43±0.84	3.97±0.92	0.247
Mean weight, kg	18.88±12.68	12.91±6.91	0.036
Mean height, cm	108.41±28.28	91.31±23.94	0.019
Mean hemoglobin level	16.72±2.53	15.32±2.58	0.049
Mean hematocrit level	51.99±8.57	47.41±8.37	0.050
Mean heart rate	127.70±20.64	143.63±20.79	0.007
Mean pump time, min	75.54±35.44	83.08±50.71	0.540
Mean cross-clamp time, min	35.14±25.76	35.75±30.12	0.967
Mean milrinone use	0.75±0.35	0.86±0.22	0.967
Mean epinephrine use	0.08±0.04	0.13±0.05	0.379

Table 2. Postoperative outcome in study population

Characteristics	PAP ≤ 15 n (41)	PAP > 15 n (40)	P value
Cardiac arrhythmia	2 (3.7)	8 (18.5)	0.192
Ascites	3 (7.4)	19 (48.1)	0.001
Pleural effusion	14(33.3)	34 (85.2)	0.001
Mean hospital stay, day	6.00±2.37	9.48±6.86	0.016
Mean ICU stay, day	3.93±1.07	5.30±2.30	0.008

Discussion

In the present study, we examined the early outcome after Glenn surgery in patients with a single ventricular heart with pulmonary arterial pressure above 15 mmHg and compare it with patients with pulmonary artery pressure below 15 mmHg to determine the influence of pulmonary artery hypertension on consequences of Glenn surgery.

The main clinical outcomes assessed were complications such as arrhythmias, pleural effusion, and ascites, as well as long-term hospitalization as well as in the ICU. In our cohort PAP group had significantly higher rates of post operation ascites, pleural effusion, long-term hospitalization and prolonged ICU stay. Therefore, before performing Glenn surgery and with the aim of preventing postoperative side effects, continuous and stable evaluation and control of pulmonary artery pressure in such patients seems absolutely necessary [15,16]. The use of small shunts with the aim of preventing single-ventricular volume overload is a very desirable measure in reducing peripheral vascular resistance [17,18]. In fact, it can be argued that the optimal outcome of Fontan reconstructive surgery in patients with a single ventricle will depend on the balance between the optimal development of the pulmonary vascular bed as well as the reduction of pulmonary

vascular resistance. One of the best ways to balance the above would be to optimize pulmonary vascular resistance by creating shunts such as the bidirectional Glenn shunt, which will obviously improve the postoperative consequences [19-21].

In Silvilairat et al. study [22] the predicting factors for long-term mortality in patients with single ventricular heart underwent Glenn procedure were, age at time of surgery, arterial oxygen saturation level, history of previous surgery, and pulmonary artery hypertension. While in Tanoue et al study, [23] the predictors of mortality following Glenn surgery were high pre-surgical pulmonary artery pressure and presence of heterotaxy syndrome. In study by Mendelsohn et al study, Glenn surgery showed a significant increase in total pulmonary blood flow and mean pulmonary hypertension, indicating that not only pulmonary artery hypertension is a predictive factor for adverse consequences of Glenn surgery, but also, following this surgery, a significant improvement in the vascular index is quite predictable [24]. In Pridjian et al study, [25] increased pulmonary vascular resistance and pulmonary artery distension were risk factors associated with mortality in patients undergoing Glenn surgery. In a study by Hussain et al, [26] the most important contraindication to Glenn surgery was the presence of PVRI above 3.5, which in fact led to adverse outcomes after surgery. In a recent study by Tran et al [27], mPAP > 16 mmHg was associated with hospital mortality. Finally, it must be acknowledged that maintaining pulmonary artery pressure and resistance is essential to prevent postoperative complications, especially pleural effusion and ascites, which lead to longer hospital stays and therefore greater hospital savings costs.

Conclusion

As a general conclusion, high pulmonary artery pressure is considered as a prognostic factor in patients undergoing Glenn surgery and in fact, high pulmonary artery pressure is independent risk factor for postoperative ascites and pleural effusion, long-term ICU stay and hospitalization.

Recommendation

Patients with single ventricle defect should underwent Glenn procedure as soon as possible and definitely before the mean PAP elevated, meticulous follow up with aggressive treatment for all causes which increase mean PAP is mandatory.

Limitations

Our study is limited by its retrospective study design, which is prone to bias and administration errors, the other limitations of this study that we excluded some files:

1. If the measure of mPAP done by other than angiography, that case was eliminate.
2. If the documented information of case wasn't enough was eliminate.

Conflict of interest

The authors have no conflict of interest.

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