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Evaluation of Bidirectional Glenn Shunt

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Abstract: *A study was conducted to evaluate the outcomes of the bidirectional Glenn shunt technique performed between 2016 feb and 2017 feb, 14 patients underwent bidirectional Glenn shunt. The patients consisted of 7 males and 7 females with age range of (2 to 10) years. In the 14 patients who underwent a bidirectional shunt operation, 7 patients were done without Cardio Pulmonary Bypass(off pump), 7 with Cardio Pulmonary Bypass. The results have been satisfactory in terms of lower Pulmonary Artery pressure, shorter duration of Ventilatory support, and less thoracic fluid drainage. Off-pump shunt offers more benefits than with Cardio Pulmonary Bypass. However, oxygen saturation had increased to the same degree in both groups at discharge .There was no operative mortality. All the patients were discharged without complications. This shunt technique is easy to perform and is helpful in the early management of patients with a functionally univentricular heart.*

Keywords: *Bidirectional Glenn shunt, Superior vena cava,Tetrology of fallot,Cardio pulmonary bypass, Pulmonary Artery Pressure.*

I. Introduction

The bidirectional Glenn shunt (BDG) is an operation to divert systemic venous return from the superior vena cava (SVC) directly to both lungs through the right pulmonary artery (RPA), bypassing a hypoplastic or absent right ventricle. This cavopulmonary connection provides excellent palliation in complicated malformations associated with low pulmonary blood flow, low pulmonary arterial (PA) pressure, and low pulmonary vascular resistance. It raises systemic arterial oxygen saturation (SaO_2) by increasing the effective pulmonary blood flow. At the same time, it can relieve the volume load of the single functional ventricle and improve the geometric structure of the ventricle.[1–2] If intracardiac repair is not necessary, the connection could be performed without cardiopulmonary bypass (CPB).[3–4]

Moreover, myocardial ischemia need not be applied during construction of the anastomosis outside the heart. Since CPB is known to activate inflammatory mediators, increase lung hydrostatic pressure, and decrease right ventricular compliance, off-pump surgery offers the advantage of reducing postoperative complications in these patients. In this study, we assessed the results of BDG performed between 1 year period.

II. Patients And Methods

A total of 14 patients, 7 male and 7 female, underwent BDG with or without CPB between 2016 feb and 2017 feb was evaluated. The procedure was the primary operation in all the cases. All the patients were examined preoperatively by electrocardiography, chest radiography, and echocardiography. Diagnosis in 14 of them was confirmed by echocardiogram and CT pulmonary angiogram for selected cases. Preoperative percutaneous oxygen saturation, PA pressure and SaO_2 were monitored during and after the operation.

Table1. Patient Diagnosis

Diagnosis	No. Of Cases (n =14)
Dextrocardia+Singleventricle+situsinversus	1
Ebstein anamoly	1
Double outlet right ventricle + pulmonary stenosis	3
Transposition of the great arteries + Pulmonary stenosis	4

TOF+Pulmonary atresia	4
Tetralogy of Fallot + endocardial cushion defect	1

The operation was performed at normal temperature with or without CPB through a median sternotomy. Pulsatile antegrade pulmonary blood flow through the pulmonary valve was maintained. At the beginning of the operation, Pulmonary Artery pressure as well as developments of the main, left, and right pulmonary arteries were examined, and systemic heparinization (150U/kg) was administered.

In the 14 patients who underwent a bidirectional shunt operation, 7 patients with off pump, 7 patients on CPB. For those 7 patients who were done without CPB, a temporarily intra operative superior vena cava(SVC) - Right Atrial shunt was established. The SVC was cannulated near the innominate vein with a right-angled venous Cannula, which was connected through a short segment of pump tubing to another right-angled venous cannula placed in the right atrium. For the remaining 7 patients, AORTA, SVC, Inferior Vena Cava cannulated, CPB was established. Care was taken to avoid kinking. With this venous shunt opening, the SVC was occluded to check if blood pressure, SVC pressure, and oxygen saturation would change. Then the SVC was clamped and transected above the cavoatrial junction. The cardiac end of the SVC was closed with 6/0 polypropylene. Care must be taken not to damage the sino atrial node area. A large side-biting clamp was applied to the Right Pulmonary Artery, and a longitudinal incision of 1.5 to 2.0 cm was made on the superior aspect of the RPA. The distal end of the SVC was anastomosed end to side to the RPA with a running suture of 6/0 polypropylene. The clamp was then released, the temporary shunt removed, and heparin effect reversed.

III. Results

All patients had immediate improvement in SaO_2 and showed an excellent postoperative response to the shunt. The mean duration of postoperative ventilatory support in off pump was 13. ± 7. Hours, chest fluid drainage was 14 ± 6 mL/kg. Mean PA pressure rise from 14 ± 3 mmHg at the beginning of the operation to 16.6 ± 2.6 mmHg in the early postoperative period. The mean duration of postoperative ventilatory support in on pump was 22 ± 13hours, chest fluid drainage was 20 ± 13mL/kg. Mean PA pressure rise from 12 ± 2mmHg at the beginning of the operation to 17 ± 2mmHg in the early postoperative period. Cyanosis was clearly relieved at discharge from hospital, and SaO_2 had increased to 92 % ±4.0%. There was no operative mortality. All the patients received antiplatelet treatment in the form of a small dose of aspirin (25 to 50 mg/day) for 3 months or longer after the operation. There were no neurologic complications; no further arrhythmia occurred and so no antiarrhythmic medication was required.

For comparison, we analyzed the data of the 14 patients in the present study who underwent the shunt operation with and without CPB.

Table2. Comparison of Outcomes after Bidirectional Glenn Shunt With and Without Using Cardiopulmonary Bypass with mean values

Variable	**Without CPB (*n* = 7)**	**With CPB (*n* = 7)**
Age (years)	5.7	4.8
Body surface area (m^2)	0.72	0.65
Preoperative SpO_2 (%)	76 ± 7	70 ± 12
Preoperative PA pressure (mmHg)	14 ± 3	12 ± 2
Postoperative PA pressure (mmHg)	16 ± 2	17 ± 2
Duration of ventilatory support (h)	13± 7	22 ± 13
Thoracic fluid drainage (mL/kg)	14± 6	20 ± 13
Death	0	

CPB = Cardiopulmonary bypass; PA = Pulmonary artery; SaO_2 = Arterial oxygen saturation; SpO_2 = Percutaneous oxygen saturation.

IV. Discussion

After a series of experiments on the direct delivery of venous blood into the PA circulation, Glenn[5] demonstrated the clinical use of an SVC-RPA shunt in 1958. Since then, a number of variations of the cavopulmonary shunt have been performed to provide palliation in cyanotic congenital heart disease. These included bidirectional cavopulmonary shunt between the SVC and the undivided RPA[6] and total

cavopulmonary connection (TCPC).[7] All of these variations provided excellent palliation in patients with a single-ventricle heart, tricuspid atresia, or hypoplastic right ventricle syndrome. TCPC, whenever feasible, has been shown to be effective in treating these patients. However, in order to improve the outcome of TCPC, many centers advocate staging it with a bidirectional cavopulmonary shunt, a strategy that we have also adopted.

There is no consensus on the criteria for performing BDG. Most authors would suggest that the mean PA pressure should be less than 18 mmHg, or ideally below 15 mmHg.[1]In contrast to a systemic pulmonary shunt, the cavopulmonary shunt does not increase ventricular work, thereby avoiding further ventricular hypertrophy and compliance reduction. In comparison with the classic Glenn shunt, BDG provides bilateral pulmonary blood flow, thereby avoiding the mismatch that may occur between the SVC flow volume and the cross-sectional area of the entire right lung.

The role of accessory pulmonary blood flow in the setting of a BDG remains contentious. An additional source of pulmonary blood flow may mitigate some of the benefits of a bidirectional cavopulmonary shunt physiology by offsetting the reduction in ventricular volume load and increasing the likelihood of pulmonary vascular complications. On the other hand, it may offer some advantages over a pure cavopulmonary shunt physiology: the increased SaO_2 may be sufficient to reduce baseline cyanosis, and the additional source of pulmonary blood flow may allow for modestly improved exercise tolerance. In addition, by providing hepatic blood directly to the lungs, introducing an element of pulsatility to the pulmonary flow and increasing flow rates, an additional source of pulmonary flow may in fact reduce the likelihood of pulmonary vascular complications (such as arteriovenous fistulas and aortopulmonary collaterals) and improve pulmonary artery growth.[2]

CPB plays a vital role in cardiac surgery. However, it may activate inflammatory mediators as well as lead to lung injury and blood cell destruction. These adverse effects can increase pulmonary vascular resistance and decrease pulmonary blood flow after cavopulmonary connection. For this reason, we try, whenever possible, to create the shunt off-pump at normal temperature. The results have so far been satisfactory. Comparing the results BDG with or without CPB, the off-pump group showed better postoperative results in terms of lower PA pressure, shorter duration of ventilatory support, and less thoracic fluid drainage. However, oxygen saturation had increased to the same degree in both groups at discharge. Off-pump offers more benefits than with CPB.

There is certainly no unanimity on the criteria for performing a bidirectional cavopulmonary connection.[10, 11, 12] Most authors would suggest that mean PA pressure should be less than 18 mm Hg, ideally less than 15 mm Hg, with a calculated pulmonary vascular resistance of less than 2.0 u/m^2. Although there are some general guidelines as to the caliber of PA acceptable for cavopulmonary anastomosis, it is acknowledged that these measurements do not take into consideration the compliance of the vascular bed, the so-called maturity of the pulmonary bed, or the most peripheral and intra parenchymal pulmonary arteries. PA distortion defined as peripheral PA Stenosis, hypoplasia, or discontinuity, remains a risk factor for suboptimal operative outcome. The timing of cavopulmonary anastomosis is poorly defined. We believe it can be performed at approximately 6 months of age; others have indicated that it can be carried out at any age after the pulmonary vascular resistance has reached its nadir.[13] Some have applied the technique in very young patients.[14] It was found to facilitate ventricular volume unloading and regression of ventricular mass in younger children (< 1 year old), and the beneficial effect on ventricular end-diastolic volume and mass is clearly age-dependent, with older patients benefiting less in terms of enhanced systemic oxygen saturation.[15] Older age might be a risk factor for postoperative cyanosis because of the lower proportion of caval return from the SVC relative to the inferior vena cava in the older child.[16].However, the risk of these late complications are thought by most authors to be lower in BDG, especially when Pulsatile antegrade pulmonary blood flow is maintained.[2,9]

V. Conclusion

In conclusion, Bidirectional glenn shunt provides excellent palliation for selected patients with cyanotic congenital heart disease. The results have been satisfactory, off-pump shunt offers more benefits than with CPB interms of lower PA pressure, shorter duration of ventilatory support, and less thoracic fluid drainage. However, oxygen saturation had increased to the same degree in both groups at discharge . Long term follow-up is needed for these patients.

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