ORIGINAL RESEARCH PAPER

Cardiovascular

KEY WORDS: Bidirectional Glenn (BDG), Superior vena cava (SVC), cardiopulmonary bypass (CPB), Blalock Taussig shunt (BTS)

RETROSPECTIVE STUDY OF GLENN SHUNT WITHOUT CARDIOPULMONARY BYPASS

Dr Sushrut Potwar

Dr Karan Shetty

Dr Abhishek Potnis

ABSTRACT

The bidirectional Glenn shunt improves systemic arterial oxygen saturation without increasing ventricular work or pulmonary vascular resistance (1). BDG is a commonly performed procedure for a variety of cyanotic congenital heart diseases that lead eventually to a single ventricle repair (2). It is an important intermediate palliation in patients with a structurally or functionally univentricular heart who are ultimately destined to have a Fontan-type operation (3). Avoidance of cardiopulmonary bypass (CPB) has the advantage of early extubation, less blood products, reduced requirement and duration of inotropic support (4). The end-to-side anastomosis of the superior vena cava (SVC) to the right or left pulmonary artery, which may be converted to a total cavopulmonary connection later, can effectively both increase arterial blood oxygen saturation of the patients and decrease volume overload of the ventricle (5).

Introduction:

The bidirectional Glenn (BDG) diverts systemic venous return from the superior vena cava (SVC) to the bilateral pulmonary arteries bypassing the right heart. It is an accepted intermediate stage procedure for patients with single ventricle physiology prior to the Fontan.

Materials & Methods:

Between January 2021 to June 2022 ,30 patients underwent the BDG shunt at GSMC & KEM hospital, Mumbai without using CPB. There were 17 male & 13 female patients. The mean age at surgery was 2.3 + 1.4 years (range from 5 months to 13 years). The mean pre-operative O2 saturation was 73.3% + 4.4% and haematocrit was 54% + 9.6%. 17 patients had previously undergone Blalock-Taussig shunt (BTS) and 15 of those had patent shunts at the time of surgery. All patients underwent 2D echocardiography and cardiac catheterisation prior to surgery. Inclusion criteria were functional single ventricles with arterial O2 saturation < 80%, Mc Goon ratio > 1.5% and mean pulmonary artery pressure < 20 mm hg, adequate atrial septal defects and no atrioventricular valve regurgitation. Patients who required intra-cardiac repair or with low baseline O2 saturation < 60% were excluded from the study.

The procedure was performed under general anaesthesia. All patients had intra-operative monitoring including 5 lead ECG, pulse oximetry, capnography, internal jugular vein catheter and invasive arterial line in either radial or femoral artery.

Routine median sternotomy was done, pericardium was opened. BTS was dissected, looped but not ligated at this stage.

Table 1:

Diagnosis	Number
Double outlet right ventricle with VSD, PS	8 (26.6%)
Tricuspid atresia	10 (33.3%)
Double inlet left ventricle with VSD, PS	1 (3.3%)
d-TGA, VSD, PS, with RV hypoplasia	4 (13.3%)
Pulmonary atresia with intact septum	2 (6.66%)
Pulmonary stenosis	2 (6.66%)
Tetralogy of Fallot	1 (3.3%)
Ebstein anomaly	1 (3.3%)
Complete AV canal with PS	1 (3.3%)

VSD – ventricular septal defect, d-TGA – dextro transposition of the great arteries, PS – Pulmonary stenosis, AV - atrioventricular SVC was dissected along the entire length from its junction with the right atrium till the innominate vein. The azygous vein was identified and looped. The branch pulmonary arteries were dissected from their origin to hilum of the lung. Heparin (1mg/kg) was given to achieve activated clotting time of 180 seconds or more. Shunt was established between SVC or innominate vein and right atrium using right angled or straight cannulas age and size matched to the patient.

SVC was transected after clamping just above the right atrial end and atrial end was closed. A vascular clamp was placed on the right pulmonary artery. End to side anastomosis was made between the SVC to right pulmonary artery in a continuous fashion using 6-0 prolene. BTS was clipped or divided at this stage. The azygous vein was clipped to avoid steal from SVC to inferior vena cava except in 1 case with interrupted inferior vena cava with azygous continuation. In bilateral BDG right side was performed first. Cannulas were removed, purse string sutures tied, and protamine given.

Results:

Mean SVC clamp time was 9 + 4.3 minutes, mean SVC pressure during clamping was 24.53 + 3.92 mm hg, hemodynamic stability was maintained with O2 saturation at 65-70% during surgery. The SVC pressure during clamping ranged from 15 - 32 mm hg. Average period of post operative ventilation was 6.3 + 4.5 hours. Mean ICU stay ranged from 1.3 + 0.5 days. 2 patients developed right sided pleural effusion managed by intercostal tube drainage and adequate dosage of vasodilators. 1 patient developed post operative bleeding and needed re-exploration. 1 patient developed convulsions 48 hours after the procedure, managed with anti-convulsant. CT scan revealed mild cerebral oedema with no obvious neurological injury.

Post-operative 2d echocardiography done prior to discharge revealed a well-functioning BDG in all patients.

There was 1 post-operative death in a patient who developed right side chylothorax with prolonged intercostal drainage.

Table 2:

Time	SVC pressure (mm hg)	Oxygen saturation (%)

Before SVC clamping	8.63 + 1.41	69 + 1.5
During clamping	24.53 + 3.92	67.2 + 0.83
After clamping	16.9 + 2.3	85.42 + 3.26

Discussion:

The classic Glenn shunt used to be performed through a thoracotomy without CPB (2). In 1990, Lamberti et al. described the technique of BDG without CPB in 7 patients. In 6 patients, an SVC-right atrial temporary shunt was used to prevent elevation of intracranial pressure during the period of SVC clamping while in 1 patient with bilateral SVC no shunt was used (1). Murthy et al. described a novel technique in 5 patients, in which a temporary shunt, using two standard right-angle cannulas, between SVC and the contralateral pulmonary artery for SVC decompression was established till the anastomosis was completed. They reported a temporary increase in oxygenation during this technique because this shunt acted as a temporary Glenn shunt (6). Jahangiri et al. described BDG shunt in 7 patients, through a right thoracotomy without using any shunts during the clamping of the SVC. The median SVC pressure during clamping was 26 mmHg. They attempted to maintain the cerebral perfusion (transcranial pressure) at a minimum of 30 mmHg (7).

Liu et al. reported their series of 20 patients who underwent BDG without CPB. They used venoatrial or venopulmonary shunt in their series. The mean SVC clamp time was 24.3 + 4.7 min. They reported the mean SVC pressure of 26.9 + 5.5 mmHg during clamping. There was no postoperative neurological complication (8). Luo et al performed offpump Glenn operation in 36 patients. They used temporary SVC-right atrial shunt in 28 patients who had single SVC, while not using any shunt in the remaining eight patients with bilateral SVC. They reported no neurological complications in their patients. On comparing the results with 35 patients who had earlier undergone Glenn procedure on CPB, they demonstrated that the off-pump group showed better postoperative results in terms of lower PA pressure, shorter duration of ventilatory support, and less thoracic fluid drainage (9).

Clamping the SVC without a temporary shunt can lead to decreased cerebral blood flow and put the brain at risk (10). Rodriguez and co-workers found the blood flow velocity in the middle cerebral artery decreased 50% when clamping the SVC (11). In a second study, Rodriguez and associates also found significant electroencephalogram changes during SVC clamping (12). Liu et al. observed by using nearinfrared spectroscopy that the oxyhaemoglobin in brain tissue decreased significantly as SVC pressure increased during clamping of the SVC (8).

The current accepted optimal age for the BDG is in 3–9 months (13). The mean pulmonary artery pressure should be < 18 mmhg or ideally < 15 mmhg, with a calculated pulmonary vascular resistance of <2 units/m2 (13,14). The estimated safest pulmonary artery index in terms of postoperative haemodynamic should exceed 250 mm2 /m2 as described by Senzaki et al (15). A mild atrioventricular regurgitation and a mean ventricular end-diastolic pressure <12 mmhg were added criteria for better outcomes (13,14).

‘

The main unexpected complications during off-pump BDG include sudden arrhythmias and persistent hypoxia spells. If So2 becomes too low, continual intravenous dopamine should be used to keep the blood pressure at a satisfactory level so it will increase the So2 effectively. The ventricular muscle of these patients was usually irritable owing to hypoxemia. If supraventricular tachycardia occurs, synchronized defibrillation or drugs such as procaine amide or adenosine might be used to convert it. If the arrhythmia does not convert or the blood pressure decreases sharply, CPB must be established at once and the operation finished with the support of parallel extracorporeal circulation (5).

REFERENCES:

1) Lamberti JJ, Spicer RL, Waldman JD, et al. The bidirectional Cavo pulmonary shunt. J Thorac Cardiovasc Surg. 1990, 100:22-9; discussion 29-30.
2) Glenn WWL. Circulatory bypass of the right side of the heart. IV. Shunt between superior vena cava and distal right pulmonary artery – report of clinical application. N Engl J Med 1958; 259: 117–120
3) Ezzeldin AM, Ashraf AH, El Midany, Mahmoud MZ, Ahmed Helmy. Cavo pulmonary anastomosis without cardiopulmonary bypass. Interactive Cardiovascular and Thoracic Surgery 16 (2013) 649–654.
4) Talwar S, Sharma P, Kumar TKS, Chaudhary SK, Gharade P, Airan B. Bidirectional superior cavopulmonary anastomosis without CPB, Ind Journal Thorac Cardiovasc Surg, 2008, vol 24(pg 269-76).
5) Jinfen Liu, Yanan Lu, Huiwen Chen, Zhenying Shi, Zhaokang Su, Wenxiang Ding. Bidirectional Glenn procedure without cardiopulmonary bypass. Ann Thorac Surg 2004; 77:1349-52.
6) Murthy KS, Coelho R, Naik SK, Punnoose A, Thomas W, Cherian KM. Novel technique of bidirectional Glenn shunt without cardiopulmonary bypass. Ann Thorac Surg 1999; 67:1771–4.
7) Jahangiri M, Keogh B, Shinebourne EA, Lincoln C. Should the bidirectional Glenn procedure be performed through a thoracotomy without cardiopulmonary bypass? J Thorac Cardiovasc Surg 1999; 118:367–8.
8) Liu J, Lu Y, Chen H, Shi Z, Su Z, Ding W. Bidirectional Glenn procedure without cardiopulmonary bypass. Ann Thorac Surg 2004; 77:1349–1352.
9) Luo X, Yan J, Wu Q, Yang K, Xu J, Liu Y. Clinical application of bidirectional Glenn shunt with off-pump technique. Asian Cardiovasc Thorac Ann 2004; 12:103–106.
10) Jonas RA. Commentary to Jahangiri. J Thorac Cardiovasc Surg 1999; 118:368.
11) Rodriguez RA, Weerasena NA, Cornel G. Should the bidirectional Glenn procedure be better performed through the support of cardiopulmonary bypass? J Thorac Cardiovasc Surg 2000; 119:634–5.
12) Rodriguez RA, Cornel G, Semelhago L, et al. Cerebral effects in superior venal caval cannula obstruction: the role of brain monitoring. Ann Thorac Surg 1997; 64:1820–2.
13) Freedom RM, Nykanen D, Benson LN. The physiology of the bidirectional cavopulmonary connection. Ann Thorac Surg 1998; 66:664-7.
14) Azab S, El-Sayed MH. The role of bi-directional cavopulmonary anastomosis in the surgical treatment of patients with complex cardiac anomalies. Egypt Heart J 1998; 50:163–70.
15) Senzaki H, Isoda T, Ishizawa A, Hishi T. Reconsideration criteria for the Fontan operation. Influence of pulmonary artery size on postoperative hemodynamics of the Fontan operation. Circulation 1994; 89:1196–202.