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ORIGINAL ARTICLE

The Impact of Ventricular Dominance on the Early Outcome of Bidirectional Glenn Shunt in Children

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Abstract

Background: **Patients with UVH currently are accounting for about 20% of patients with complex heart defects, and have the highest mortality. Mortality is high during initial treatment and during long-term follow-up.**

Aim: **To compare the outcome after bidirectional glenn (BDG) procedure in patients with dominant right ventricle (RV) and patients with dominant left ventricle (LV) as a palliative procedure.**

Patients and methods: **A prospective comparative nonrandomized controlled trial included 60 patients who had undergone BDG (30 patients having pathology of dominant RV, and 30 patients having pathology of dominant LV). Patients were collected from Al-Azhar University Hospitals and of Misr Children Hospital during the period from January 2021 to March 2022.**

Results: **During this prospective study, we have found a significant difference in hospital stay, which was about 6 days in LV-dominant group and 9 days in RV group, and ICU stay was 2 days in LV group and 4 days in RV group. Also, early post-op. complications were in three (10%) patients of LV group and 16 (53%) patients in RV group. Complications after 6 months were in nine (30%) patients and were all in the RV group.**

Conclusion: **Despite improved surgical and medical management, there is a continuous risk of failure after BDG. However, in our study, there is a significant difference in early outcomes between the RV-dominant and the LV-dominant morphology, considering the complications, hospital stay, and the ICU stay, which carries a high incidence of comorbidities and more burdens on healthcare institutions.**

Keywords: Bidirectional glenn shunt, Children, Outcome, Ventricular dominance

1. Introduction

Bidirectional Glenn shunt (BDG) is a well-known operational technique that describes the procedure of connecting the SVC to pulmonary arteries in order to direct the blood from the former to the latter; this procedure has been employed as a palliative management in those who suffer from structural or functional univentricular heart defect.[1] Technically, this operation is carried out as a preparatory step for Fontan operation. Additionally, patients with Ebstein's anomaly can benefit from this procedure as it can help with decreasing the volume overload as a part of ventricular repair. Also, another application of this operation is bypassing the obstructed connection site between SVC and the right ventricle, or if the cava is directly connected to the left ventricle.[2]

Usually, cardiopulmonary bypass (CPB) is deployed during the performance of BDG. However, some reports declared performing BDG without using CBP: the majority of these reports have recommended SVC decompression simultaneously with clamping. Nevertheless, caval nondecompression with off-pump BDG could be considered simple, safe, and resource-saving technique.[3]

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Inspite of improvements in both surgical and medical management, along with establishing restrict selection criteria, the left ventricle (LV)-dominant patients had shown better survival results than right ventricle (RV)-dominant patients.[4]

The aim of this work was to compare the outcome after BDG procedure in patients with dominant RV and patients with dominant LV as a palliative procedure. Analysis of the difficulties preoperative and intraoperative with the postoperative course and the results after the BDG procedure will be studied.

2. Patients and methods

This prospective comparative nonrandomized controlled trial was conducted on 60 patients during the period from January 2021 to March 2022.

2.1. Study population

Sixty patients were nonrandomized into two groups:

Group A: 30 patients having pathology of dominant left ventricular heart.

Group B: 30 patients having pathology of dominant right ventricular heart.

The study included patients with any age above 6 months and below 18 years, cyanosis limiting the usual day effort where biventricular repair is not feasible (arterial oxygen saturation below 80%), suitable pulmonary artery pressure, Mc Goon ratio more than 1.5, with no or mild atrioventricular (AV) valve regurge, good dominant ventricular function, normal sinus rhythm, and with single unilateral or bilateral SVC.

The assessment was established by history-taking, clinical examination, and investigations, including chest radiography, echo-Doppler, cardiac catheterization, and computerized tomography when needed.

2.2. Methodology

Following general anesthesia, we were continuously monitoring the intraoperative ECG, oxygen saturation, Etco2, and SVC pressure. These were achieved by insertion of both invasive arterial pressure line and central venous line. Before the SVC was clamped, the patient was put on a starting elective dose of 5 mcg/kg/min of dobutamine with considering the elevation of mean ABP using volume loading.

In order to successfully access the heart and assess the cardiac anatomy, we conducted a midline incision followed by complete sternotomy with opening the pericardium. Skeletonization of the SVC from the innominate vein junction up to the cardiac end was achieved. Then, full dissection of the Rt PA from its origin to its division point was carried out.

CBP was permeated whenever needed, for example, in patients with septectomy, or after showing any hemodynamic instability following the PA clamping. As usual, patients were heparinized, then cannulation of the aorta, and SVC using a metal tip venous cannula. Then, the IVC cannulation was routinely conducted. Following the clamping of the Rt SVC, transection was done to divide it near the cavoatrial junction. A 5/0 continuous polypropylene suture was used to ensure the atrial integrity. The upper surface of the RT PA was opened, after that, the SVC end was anastomosed to the side of Rt PA using 6/O polypropylene. After making sure of anastomosis appropriateness, the clamps were damped to check the hemostasis achievement. In some cases when double SVC was confronted, the same anastomosis is carried out on the Lt PA as we formerly did on the Rt side. On the other hand, when an Modified Blalock Taussig (MBT) shunt was confronted, a dissection was applied to the MBT and then a PA clamping test took place. After making sure that there was no circulatory instability or desaturation, the shunt was ligated and divided, and its two ends were secured.

Postoperative assessment.

After stabilization, the SVC pressure was carefully checked for hours; then, we removed the IJV cannula to avoid any potential thrombosis. For the same reason, patients were prescribed Aspirin at a dose of 5mk/Kg/day. The follow-up postoperative reports included mortality records, re-intubation, Glenn's shunt failures, MV time, and patients' length of stay in both the ICU and hospital.

Outpatient clinic follow-up.

The patients were followed-up at 2 and 6 months to detect any complication as early as possible. Examination of the patients for signs of superior vena caval obstruction, congestive heart failure, pleural effusion, and estimation of O2sat by using pulse oximetry on room air.

3. Results

Demographic data for age and sex were in Figs. 1 and 2.

3.1. Preoperative assessment

ECHO, MSCT, and catheterization were done and the results came as the following in the table. Table 1 Fig. 3.

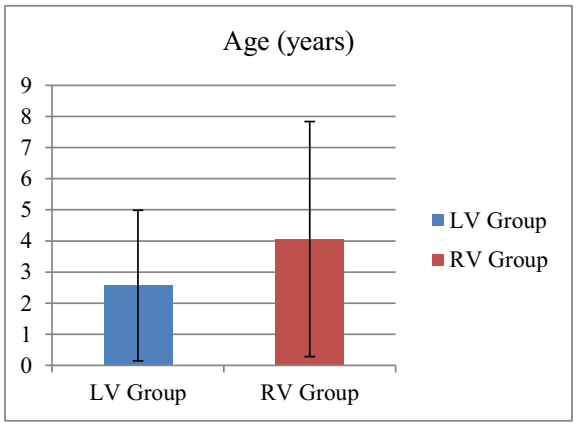

Fig. 1. Comparison between the LV group (first group) and RV group (second group) according to age. LV, left ventricle; RV, right ventricle.

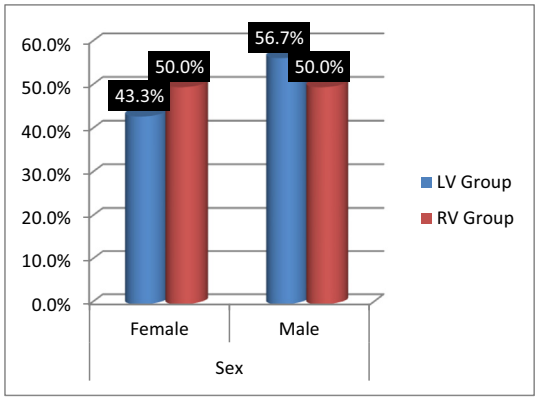

Fig. 2. Comparison between the LV group (first group) and RV group (second group) according to sex. LV, left ventricle; RV, right ventricle.

3.1.1. Intraoperative assessment

Off-pump operation was done for 34 (56.7%) patients, 19 (63.3%) patients of them in the first group and 15 (50%) patients in the second group. Decompression method was done for eight (13.3%) patients, four (13.3%) patients in the first group, and four (13.3%) patients in the second group.

On-pump operation has been done for 26 (43.3%) patients, 11 (36.7%) patients of them in the first group and 15 (50%) patients in the second group. Patients who needed septectomy were eight (13.3%), four (13.3%) patients of them in the first group and four (13.3%) in the second group. In the second group, only one patient needed bilateral Glenn.

3.1.2. Early postoperative

It was demonstrated in the following table. Table 2 Figs. 4 and 5.

3.1.3. Complications

Pleural effusion was in 10 (16.75%) patients divided between the two groups as two (6.7%) patients in the first group and eight (26.75%) in the second group. Reopening for bleeding was in five (8.35%) patients and were all in the second group. Pericardial effusion was also noted in one patient in the second group. Chest infection was observed in the two groups in four (6.7%) patients, one (1.7%) patient in the first group and three (10%) patients in the second group with *P* value 0.301. Total complications noted were 19 (31.7%) patients divided between the two groups as three (10%) patients in the first group and 16 (53.3%) patients in the second group.

3.1.4. Follow-up after 2 months

It was demonstrated in the next table after ECHO and examination was done. Table 3.

3.1.5. Follow-up after 6 months

It was demonstrated in the next table after ECHO and examination was done. Table 4.

4. Discussion

The results of SV patients who underwent BDG were significantly affected by the accompanying cardiac pathology. The dominant LV patients had shown better early outcomes when compared with dominant RV patients. A large study from Emory had endorsed these results; it depicted that the dominant Rt ventricular morphology increased the risk of mortality in those patients.[5]

In this study, we could observe patients in early time and we had some significant data that support this hypothesis as the RV-dominant ventricle patients needed higher support such as Dobutrex and epinephrine and norepinephrine that are not needed in patients of LV-dominant ventricles. Also, patients with dominant RV morphology needed long ventilation support that was of mean 31 h. While in the LV-dominant morphology, patients needed much less ventilation support that was of mean 11 h.

In a study performed by Ashraf *et al.*, 2017, the weight was of mean 11.18 ± 3.15 kg.[6] In Talwar *et al.*, 2017, median weights in the on-CPB group and off-CPB group were 13.5 (5–50) kg and 15 (7–36) kg, respectively ($P = 0.927$).[7] In our study, the mean weight was 13.10 ± 6.27 kg.

As pulmonary artery pressure is one of the most reliable factors that affect the outcome of the BDG, we had found that PAPG as a reflection that supposes low pulmonary artery pressure was in the LV group about 67 mmHg, while in the RV-dominant group, it was 76 mmHg that was different but not suggesting high PA pressure and that is supported

Table 1. Comparison between the LV group and RV group according to preoperative assessment.

Preoperative assessment	Total ($N = 60$) [n (%)]	LV group ($N = 30$) [n (%)]	RV group ($N = 30$) [n (%)]	Test value	P value
PAB	2 (3.3)	0	2 (6.7)	x^2: 2.069	0.15
MBT	5 (8.3)	3 (10.0)	2 (6.7)	x^2: 0.218	0.64
EF%					
Mean ± SD	65.23 ± 2.28	65.30 ± 2.07	65.17 ± 2.51	t: 0.225	0.823
Range	60–70	62–70	60–70		
MSCT and catheterization					
PAPG					
Mean ± SD	72.02 ± 11.09	67.29 ± 14.48	76.07 ± 4.10	t: 3.072	0.003*
Range	40–89	40–85	70–89		
MPA					
Mean ± SD	7.87 ± 1.66	7.28 ± 1.33	8.47 ± 1.76	t: 2.944	0.005*
Range	5.5–12.5	5.5–11	6–12.5		
LPA					
Mean ± SD	7.12 ± 0.73	6.84 ± 0.52	7.40 ± 0.81	t: 3.168	0.002*
Range	6–9.8	6–8.1	6.5–9.8		
RPA					
Mean ± SD	7.26 ± 0.76	7.01 ± 0.59	7.51 ± 0.84	t: 2.666	0.010*
Range	6.2–10.5	6.2–8.8	6.7–10.5		
MG					
Mean ± SD	1.78 ± 0.08	1.76 ± 0.06	1.80 ± 0.09	t: 1.915	0.06
Range	1.67–2	1.7–2	1.67–2		
PAP					
Mean ± SD	20.67 ± 1.65	20.81 ± 1.78	20.57 ± 1.57	t: 0.496	0.622
Range	18–25	18–25	18–24		

Using: t-Independent Sample t-test; χ^2: Chi-square test; P value greater than 0.05 NS; *P value less than 0.05 S; **P value less than 0.001 HS. LV, left ventricle; MBT, Modified Blalock Taussig; RV, right ventricle.

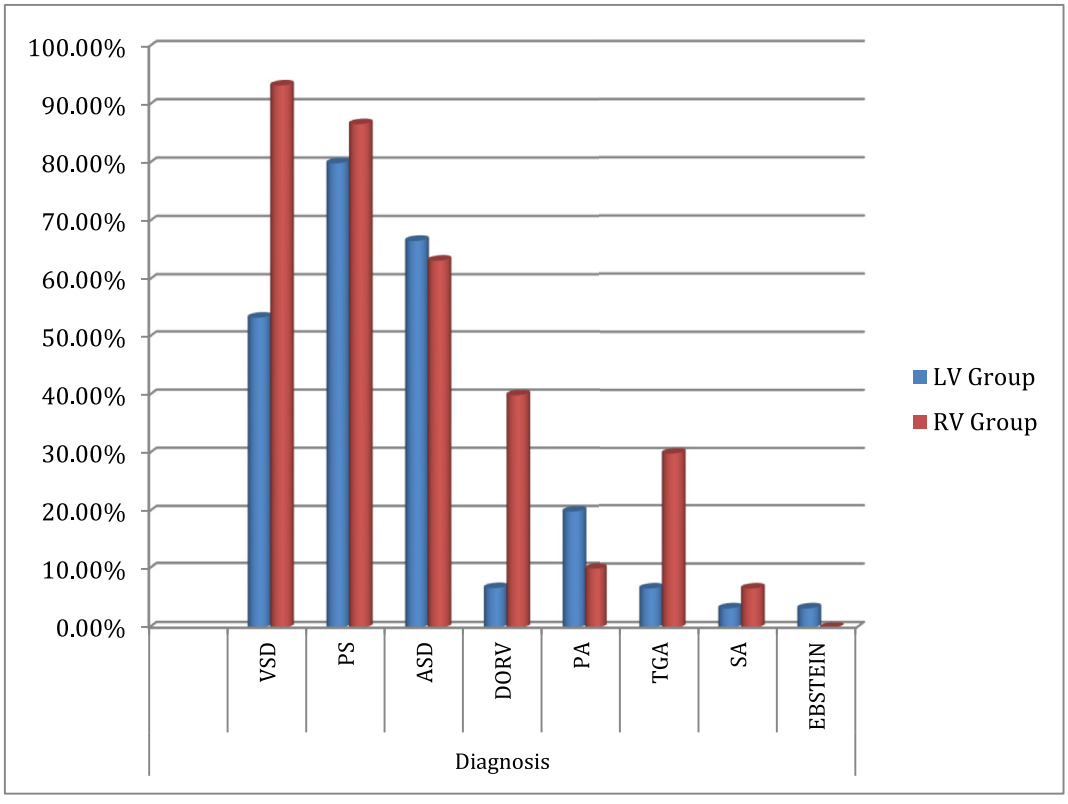

Fig. 3. Comparison between the LV group and RV group according to preoperative assessment (ECHO). LV, left ventricle; RV, right ventricle.

Table 2. Comparison between the LV group and RV group according to early postoperative stay.

Early postoperative	Total ($n = 60$)	LV group ($n = 30$)	RV group ($n = 30$)	Test value	P value
Echo					
EF%					
Mean ± SD	66.23 ± 2.28	6.30 ± 2.07	65.17 ± 2.51		0.823
Range	60–70	663–70	60–70	t: 0.225	
Support					
DOB					
Mean ± SD	8.08 ± 3.07	6.00 ± 2.03	10.17 ± 2.45	U: 5.419	<0.001**
Range	5–15	5–10	5–15		
ADR					
Mean ± SD	95.83 ± 36.60	63.64 ± 23.35	110.00 ± 32.27	U: 3.545	<0.001**
Range	50–150	50–100	50–150		
LEVO					
Mean ± SD	–	–	93.75 ± 17.68	–	–
Range	–	–	50–100		
Vent. (h)					
Mean ± SD	21.45 ± 17.25	11.50 ± 10.13	31.40 ± 17.25	U: 5.259	<0.001**
Range	5–72	5–50	5–72		
O2 Sat.%					
Mean ± SD	86.50 ± 3.80	87.77 ± 2.64	85.23 ± 4.38	t: 2.716	0.009*
Range	78–93	82–92	78–93		

Using t-Independent Sample *t*-test; χ^2: Chi-square test; *P* value greater than 0.05 NS; **P* value less than 0.05 S; ***P* value less than 0.001 HS. LV, left ventricle; RV, right ventricle.

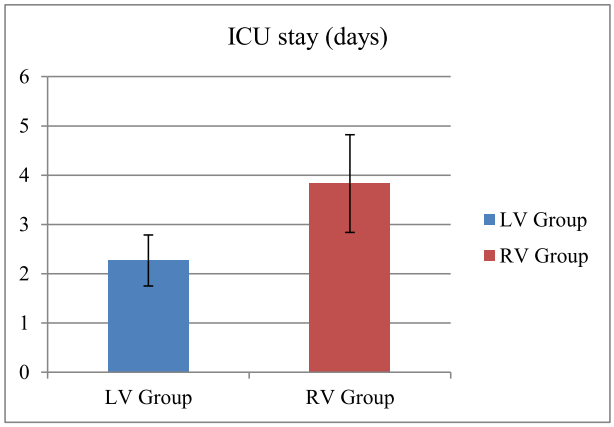

Fig. 4. Comparison between the LV group and RV group according to early postoperative ICU stay. LV, left ventricle; RV, right ventricle.

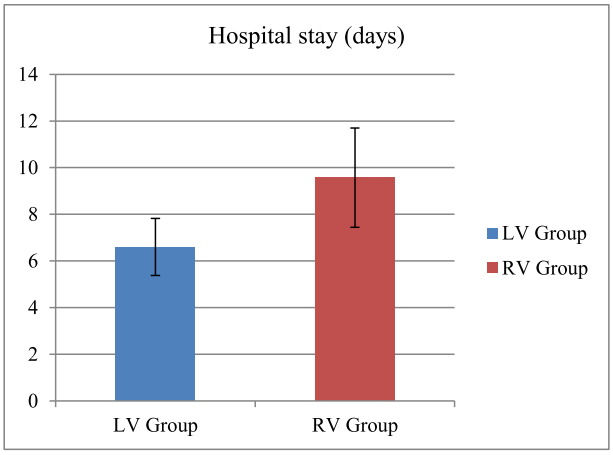

Fig. 5. Comparison between the LV group and RV group according to early postoperative hospital stay. LV, left ventricle; RV, right ventricle.

by no significant difference between the two groups as the PA pressure was about 20 mmHg in the two groups, which causes no affection on BDG function.

During this study, we found that o2 sat was on average of 88% in the LV-dominant group, while it was of 85% in the RV-dominant group, with no other factors affecting the o2 sat such as chest condition and cardiac function or Glenn function, it was of significant difference that may need more studying to correlate the lung condition with the pathology and cardiac morphology to identify the difference.

We also have found that there is a significant difference in ICU stay and hospital stay between the LV-dominant group and the RV-dominant group, which could be due to prolonged ventilation support, medical support, or the possibility of early complications such as reopening for bleeding and pleural effusion.

In our study, we have found that in early postoperative during hospital stay, there was a significant difference between the two groups in total complications as 16 patients in the RV-dominant ventricle patients compared with only three patients in the LV-dominant ventricle patients.

Usually, the presence of cyanotic heart disease is associated with increased postoperative blood loss in children, and using fresh-frozen plasma had decreased the blood loss and causes a higher maximal clot firmness on FIBTEM (fibrinogen–thromboelastometry).[8] Despite there were no

Table 3. Comparison between the LV group and RV group according to outcome after 2 months.

Outcome after 2 months	Total ($n = 60$)	LV group ($n = 30$)	RV group ($n = 30$)	Test value	P value
Echo					
EF%					
Mean ± SD	65.14 ± 6.20	67.21 ± 1.18	63.13 ± 8.19	t: 2.651	0.010*
Range	36–69	65–69	36–68		
AV regurge	5 (8.5%)	1 (3.4%)	4 (13.3%)	x^2: 1.858	0.173
O2 Sat.%					
Mean ± SD	88.34 ± 3.13	90.03 ± 2.08	86.70 ± 3.13	t: 4.802	<0.001**
Range	80–94	85–94	80–92		

T-Independent Sample t-test; χ^2: Chi-square test; P value greater than 0.05 NS; *P value less than 0.05 S; **P value less than 0.001 HS. AV, atrioventricular; LV, left ventricle; RV, right ventricle.

Table 4. Comparison between the LV group and RV group according to outcome after 6 months.

Outcome after 6 months	Total ($N = 60$) [n (%)]	LV group ($N = 30$) [n (%)]	RV group ($N = 30$) [n (%)]	Test value	P value
Echo					
EF%					
Mean ± SD	64.66 ± 6.34	66.72 ± 1.00	62.67 ± 8.43	t: 2.574	0.013*
Range	40–68	65–68	40–68		
AV regurge	8 (13.6)	2 (6.9)	6 (20.0)	χ^2: 2.160	0.142
O2 sat. %					
Mean ± SD	85.95 ± 4.32	88.21 ± 1.08	83.77 ± 5.11	t: 4.58	<0.001**
Range	67–90	85–90	67–89		
Complications					
Pleural effusion	8 (13.6)	0	8 (26.7)	χ^2: 8.946	0.003*
Pericardial effusion	1 (1.7)	0	1 (3.3)	χ^2: 0.983	0.321
Venus collaterals	2 (3.4)	0	2 (6.7)	χ^2: 2.001	0.157
Total complications	9 (15.3)	0	9 (30.0)	χ^2: 10.266	<0.001**

T-Independent Sample t-test; χ^2: Chi-square test; P value greater than 0.05 NS; *P value less than 0.05 S; **P value less than 0.001 HS. AV, atrioventricular; LV, left ventricle; RV, right ventricle.

differences between the two groups in pre-and postoperative bleeding profile and platelet count, there was a significant difference in reopening for bleeding, which was found in five patients in the RV-dominant group.

Prolongation of hospital stay, and continued drainage may eventually lead to nutritional and immunological depletion. It was proposed that this procedure creates an elevated central venous pressure that may facilitate the transudation of fluid into the interstitial space.[9] Some studies found no correlation between the degree of central venous pressure and the incidence of effusion. They suggested that patients demonstrated transient increase in antidiuretic hormone, cortisol, and aldosterone levels that were proposed to account for the increased fluid retention.[10]

In this study, we have found that there was a significant difference between the LV-dominant group with only two patients who came with plural effusion and the RV-dominant group that came with six patients. And this is not supporting any of the two theories of the causes of the pleural effusion and did not support any difference in the way of management.

The overall complications are of significant difference between the two groups that support the hypothesis of the relation between the ventricular dominance and the outcome of BDG.

In our study, we had concluded that the existence of heterotaxy and PAPVC did not result in undesirable outcomes. This is contrary to the most published reports where these two conditions have been shown to affect the outcome after the BDG operation.[11]

Ante grade pulmonary blood flow (APBF) has been debatable among most studies in the era of BDG. Most of them had reported that pulsatile blood flow was linked to APBF from the RV, patent ductus arteriosus (PDA), or MBT shunt, hence, they claimed that this was associated with PA endothelial preservation that permitted their growth. Moreover, this secured hepatic factor to the lungs, which can lead to prevention of AV malformations.[12]

Nevertheless, according to Berman and Kimball, there were concerns about remarkable ventricular size decrease after BDG if all different pulmonary blood flow sources were ligated.[13]

In our research, we carefully tried to prevent volume overload in any functionally single ventricle using ligation or division, like in cases of PDA and previous MBT shunts. O2sat. In the present study rose from a mean of 67% preoperatively to 87% at

the latest follow-up. These findings are similar to those in other studies.[14] Despite using the rise of o2 saturation in assessment of BDG, exercise-induced desaturation is also crucial in determinization of exercise tolerance after BDG.

Although there were many debates around prescribing captopril following the BDG, especially if there were no AV valvular regurgitations, some researchers advocated its ability to improve both COP and contractility. On the other hand, some researchers questioned its benefits following the BDG.[15] However, we continued prescribing our patients captopril although we do not have sufficient evidences to support this practice.

4.1. Conclusion

The BDG operation is an essential surgical palliation, especially those at high risk, should have repetitive follow-ups for any potential failure, and referral for heart transplantation. Especially that it could be performed at a low-risk mortality level.

In our study, there is a significant difference in early outcome between the RV-dominant morphology and the LV-dominant one, considering the complications and the hospital stay and the ICU stay, with a high incidence of comorbidities and more burdens on healthcare institutions.

Conflicts of interest

There are no conflicts of interest.

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