

Pulmonary Artery Venting in Ventricular Septal Defects with Pulmonary Hypertension Compared to Ordinary Routes of Left Ventricular Venting

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ABSTRACT:

Background: Ventricular septal defect (VSD) closure in patients with reversible pulmonary hypertension is a risky procedure regarding intra- and post-operative course. The classic left ventricle (LV) venting has its own reported complications and cannot unload the distending right ventricle (RV) at the end of the repair. We are assuming usage of pulmonary artery (PA) venting in ventricular septal defect-pulmonary hypertension (VSD-PH) cases will be less problematic and more effective compared to venting through other ways.

Patients and methods: Data of 100 patients with VSD-PH listed for isolated VSD closure in Cairo University Hospitals were collected and cases were divided into 2 groups; Group 1 had pulmonary artery venting, and Group 2 had no pulmonary artery venting. Both groups were compared for preoperative, operative and postoperative variables.

Results: Both groups had similar preoperative characteristics, with Group 1 including 51 patients compared to 49 patients in Group 2. Data reported 15 minutes shorter cross clamping time (AXC) (p-value 0.001), transesophageal echocardiogram (TEE) has never observed air in the left heart or aorta and 0.6 days shorter ICU stay (p-value 0.002) in Group 1, mean hospital stay was 6.4 (SD 1.7) in Group 1 and 8.7 (SD 2.2) in Group 2 (p-value 0.001). There was no significant difference in the incidence of ventricular fibrillation after each type of vent had been used (p-value >0.05), and there was 30% less need for inotropic support in Group 1 (29 % vs 59%, p-value 0.02).

Conclusion: venting through PA on operating cases with VSD-PH is effective regarding creating bloodless field facilitating the surgical procedure, decompressing right ventricle after aortic de-clamping, and is associated with shorter ICU and hospital stay.

Keywords: Ventricular septal defect, pulmonary hypertension, pulmonary artery venting, ICU, surgical outcome, Cairo University.

INTRODUCTION

Ventricular septal defect (VSD) is the commonest congenital cause for pulmonary hypertension (PH) accounting for 42% of cases with congenital heart disease-pulmonary hypertension (CHD-PH) and 3% of cases show persistent PH even after surgical closure⁽¹⁾. Despite complexity of pathophysiology causing pulmonary hypertension in cases of VSD, right ventricular (RV) dysfunction is the main problem surgeons face after VSD closure due to loss of the bidirectional shunt that vent patient's RV in presence of high pulmonary vascular resistance⁽²⁻⁶⁾.

We are assuming that venting through pulmonary artery will protect against complications related to venting via right superior respiratory vein (RSPV)^(3,8), and will help decompressing RV at end of the surgery⁽⁹⁻¹¹⁾.

We aimed to assess whether the use of PA vent will yield better clinical results such as shorter cross clamp time, bypass time; and to determine whether it is beneficial for the heart as indicated by less need for inotropes, shorter ICU stay, and easier weaning off bypass, in cases of VSD-PH.

PATIENTS AND METODS

This randomized prospective study includes 100 patients who underwent isolated surgical closure of VSD complicated with reversible PH and were essentially involved two venting techniques: Pulmonary artery (PA) venting and venting through RSPV carried

out in the period from January 2019 to December 2021, aiming to assess the effectiveness of PA venting regarding impact on cross clamp time, bypass time, need for inotropic support, time to extubation, ICU stay, and total hospital stay.

Pulmonary hypertension was defined as a mean pulmonary arterial pressure ≥ 25 mmHg as assessed preoperatively by echocardiography or RV catheterization or intraoperatively through invasive PA line inserted through purse taken for PA venting line.

Reversibility of PH was defined through assessing the vasoreactivity to high oxygen, drop of the pulmonary vascular resistance index (PVRI) by 20% was considered operable.

Inotropic support was defined as "requiring one or more of norepinephrine/ epinephrine/ amrinone/ dobutamine/ >2.5 mug/kg/min dopamine, for at least 45 minutes intraoperatively"⁽⁵⁾ while those requiring small doses of inotropes, which was weaned before transfer from OR are not counted.

Inclusion criteria: Patients with isolated VSD-PH beyond age of 6 month.

Exclusion criteria: patients with left ventricular (LV) decompaction, or with LV EF $< 35\%$, coexistent cause of PH such as lung disease, coexistent aortic

regurgitation and patients on preoperative inotropic support or pulmonary vasodilators.

One hundred consecutive patients meeting the above criteria were entered into the study. The patients were randomly assigned to one of two groups: Group 1, a pulmonary artery vent inserted, comprised 51 patients, and Group 2, having no PA venting, comprised 49 patients.

All patients in both groups underwent the same anesthetic and surgical technique, in all cases, patch VSD closure was carried out through right atriotomy approach. All patients underwent routine preoperative investigation including electrocardiogram, Chest X-ray, hemoglobin, urea, electrolyte, serum creatinine, echocardiography, and cardiac catheterization.

Technique of PA catheter insertion:

We used the same technique described by **Little et al.** ⁽⁴⁾. A plastic sump-type catheter (usually size 12) was used as PA vent, inserted just distal to the pulmonary valve through a purse-string suture. The vent is connected to a suction line, controlled by a roller pump of the heart lung machine, and blood is collected in the venous reservoir. PA venting is established soon after bypass, and maintained during the bypass and after clamp removal, and is clamped with weaning of the bypass. After weaning of the bypass, and before heparin reversal, the vent is removed, and the purse-string is tied.

Technique of VSD closure:

Standard anesthetic technique was used starting with a narcotic, sevoflurane, and muscle relaxant sequence, heparin administered, bicaval cannulation was done and cardiopulmonary bypass started. A sump catheter in the pulmonary artery was inserted after instituting bypass in Group 1. Bicaval snaring, Temperature is lowered to 30°C, aortic clamp is applied and cold blood cardioplegic solution was administered. During bypass pulmonary artery venting was maintained. Right atriotomy was done, VSD was closed with Gore-tex patch using prolins 6/0 or 5/0 suture in all patients.

After closure of the right atrium, the heart was rewarmed, deaired using cannula in the aortic root for all patients, and bypass was weaned. PA purse was used after bypass to re-assess the pulmonary pressure and the need for inotropic support that if exceeded the 45 minutes, it is considered significant. Routine monitoring in the ICU was done and echo was performed on day 1, day 5 and at six weeks.

Ethical consent:

An approval of the study was obtained from Cairo University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Continuous data were expressed as mean and standard deviation or median with the interquartile range and categorical data as numbers and percentages. All reported P values are two-sided, and P values of ≤ 0.05 were considered statistically significant. All statistical analyses were performed using SPSS version 22.0 (SPSS, Inc., Chicago, IL, USA). All statistical analyses were done with the help of a departmental statistician.

RESULTS

Group 1 (with PA vent) comprised 51 patients (30 females). The mean age was 12 months (6 to 18 months), mean body weight was 8 kilograms (5 to 11 kilograms) and mean pulmonary artery pressure (PAP) was 69.3 ± 15.2 mmHg. Group 2 (without PA vent) comprised 49 patients (26 females). The mean age was 9.42 months (6 to 14 months), mean body weight was 7.75 kilograms (5 to 10 kilograms), and mean PAP was 63.1 ± 14.4 (p value for the three variables was 0.1).

There was no significant difference in preoperative characteristics between both groups regarding age, weight, gender, incidence of pulmonary hypertensive crises and need for preoperative medical support (p-value >0.05), as shown in table 1.

The cross-clamp time (AXC) for Group 1 was 15 minutes shorter than in the other group (p -value 0.01), and there was 30% less need for inotropic support in Group 1 (29 % vs 59%, p-value 0.02). The significantly shorter cross clamp time, TEE has never observed air in the left heart or aorta and the easier weaning off bypass, was associated with shorter ICU and hospital stay. Mean ICU stay for Group 1 was 0.6 days less (2.1 days, vs 2.7 days for Group 2, p-value 0.002). Mean hospital stay was 2 days shorter in Group 1 (6.4 vs 8.5 with p value of 0.001). The pulmonary artery pressure was slightly higher in Group 1 (mean 69 vs 61 in Group 2, however the difference was statistically insignificant).

Table (1): Comparing characteristics of the two patient groups undergoing VSD-PH patch closure surgery, Group 1 with PA vent, Group 2 without pulmonary artery vent.

Variable	Group 1 (N=51), Mean ± SD, or Number (%)	Group 2 (N=49) Mean ± SD, or Number (%)	P-value
Age	12 ± 4	9.42 ± 2.83	0.48
Female gender	30 (58.88%)	26 (53.06%)	0.45
Weight	8 ± 1.92	7.75 ± 1.85	0.55
Mean PAP (mmHg) ^a	69.3 ± 15.2	63.1 ± 14.4	0.14
PH crises	2 (3.9%)	1 (2.04%)	0.55
Preoperative inotropics	2 (3.9%)	1 (2.04%)	0.55
AXC time (minutes)	25 ± 5.91	40 ± 7.95	0.01
Bypass time (minutes)	45 ± 11.12	65 ± 12.25	0.02
Intraoperative TEE (Air in left side)	Nil	2 (4.8%)	0.55
MV time (hours)	7.1 ± 2.5	9.6 ± 3.1	0.03
Need for inotropics ^b	15 (29.4%)	29 (59.1%)	0.02
ICU stay (days)	2.1 ± 0.8	3.7 ± 0.7	0.01
Hospital stay (days)	6.4 ± 1.7	8.7 ± 2.2	0.08

^a measured by preoperative echocardiography or RV catheterization,

^b Need for inotropes defined as inotropes requiring one or more of norepinephrine/ epinephrine/ amrinone/ dobutamine/ >2.5 mug/kg/min dopamine, for at least 45 minutes intraoperatively.

DISCUSSION

Despite paucity of data in literature about efficacy or usage of PA venting in CHD-PH, it is logic to be used as a perfect RV decompressing method at the end of surgical procedures aiming to completely septate the right and left sides of the heart.

Data collected showed that PA venting has affected ease of surgery, weaning off the bypass and improved postoperative outcome in many aspects.

Intraoperatively and after cardioplegia injection, PA venting has kept bloodless field throughout the operation giving better visualization and lowered need to stop for blood sucking with subsequent shorter AXC, bypass and total operation times. Biventricular de-loading effect of PA venting that also allowed better recovery from ischemia on AXC has minimized RV

failure due to high PVRI that made it easier to wean off the bypass with no or minimal dosage or shorter duration of inotropic support.

Better RV recovery with low inotropic support made it easier for gradual lowering of the MV settings till extubation, PA venting significantly shortened post operative MV time, ICU stay and hospital stay due to shorter operation, anesthesia, bypass times and better ventricular compliance and contractility.

Since first suggested in 1976 by **Heimbecker and McKenzie** ⁽⁶⁾, PA venting was approved to be effective and safe. It was inserted into the RVOT then modified to be inserted above level of the pulmonary valve directly into the PA by **Little et al.** ⁽⁴⁾ who proved efficacy of PA venting in draining both ventricles due to the valveless nature of the pulmonary circulation. However, manual compression may be needed to empty the LV.

Ulyot and his colleagues approved PA venting can wash the excess crystalloid cardioplegic solution during surgery especially in left-sided congenital heart diseases ⁽⁷⁾.

Burton et al. ⁽⁸⁾ reported easiness in using PA venting in more than 1000 patients (including congenital heart diseases) with effective ventricular decompression and creating blood-less field even in cases with AR.

Effectiveness of the PA vent in decompressing the LV, and achieving bloodless field during cardiac operation was also proved by **Little et al.** ⁽⁴⁾ via using scintigraphy of serial blood samples from PA, and systemic veins, and aortic root after injection of 10cc ^{99m} technetium fluid into LA during aortic cross clamp, near all of the injected saline returned from LA through the PA vent across the valveless pulmonary circulation proving the ability of the PA vent to retrieve not only RV spillover and bronchial blood, but also, LA blood due to the valveless pulmonary circulation.

In our study, AXC was diminished from a mean of 40 to 20 minutes in cases with PA venting by the favor of bloodless field.

Moreover, our study showed that PA venting group mean ICU stay was 2.1 compared to 3.7 in the other group with significantly shorter hospital stay. This can be explained by the shorter bypass and operative times, less need for inotropes and faster weaning of mechanical ventilation, which is reflected on a better patient outcome, with less use of resources.

Intraoperative TEE proved proper deairing through the PA venting with no ventricular distension throughout the process of aortic de-clamping and during weaning.

CONCLUSION

LV venting during repair of congenital heart disease is essential. On Comparing PA venting to the other routes, it is found to be easier, safer with lower complications, better field visualization, shorter aortic

cross clamp and bypass times, easier weaning off bypass, and shorter ICU and hospital stay.

Our study focused on the benefits surgeons and patients can gain of using PA venting including ease of surgery, clarity of the surgical field reached by bloodless field and a site of the PA vent that is always away from the field, less or no time loss for stopping the Patch closure by repeated blood suction, and fast weaning off bypass in a patient with already severe pulmonary hypertension. These results should favor the use of PA venting as an easier alternative to other methods of LV venting, with negligible rate of complications. Moreover, we do believe that more research is vital to assess its value in patients undergoing cardiac surgery via minimally invasive routes, in whom other methods of LV decompression may be surgically challenging and time consuming.

Conflict of interest: The authors declare no conflict of interest.

Sources of funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution: Authors contributed equally in the study.

REFERENCES

1. **Pascall E, Tulloh R (2018):** Pulmonary hypertension in congenital heart disease. *Future Cardiol.*, 14(4):343-353.
2. **Talwar S, Keshri V, Choudhary S et al. (2015):** Surgical strategies for patients with congenital heart disease and severe pulmonary hypertension in low/middle-income countries. *Heart Asia*, 7(2):31-37.
3. **Kumbhani D, Healey N, Birjiniuk V et al. (2004):** Intraoperative regional myocardial acidosis predicts the need for inotropic support in cardiac surgery. *Am J Surg.*, 188(5):474-480.
4. **Little A, Lin C, Wernly J et al. (1984):** Use of the pulmonary artery for left ventricular venting during cardiac operations. *J Thorac Cardiovasc Surg.*, 87(4):532-538.
5. **Kumbhani D, Healey N, Birjiniuk V et al. (2004):** Intraoperative regional myocardial acidosis predicts the need for inotropic support in cardiac surgery. *Am J Surg.*, 188(5):474-480.
6. **Heimbecker R, McKenzie F (1976):** A New Approach to Left Heart Decompression. *Ann Thorac Surg.*, 21(5):456-457.
7. **Ullyot D, Scribner R, Turley K et al. (1982):** Left ventricular venting. A prospective randomized study demonstrating reduced perioperative myocardial infarction in vented patients, Presented at The Samson Thoracic Surgical Society meeting. San Diego Calif., 87:23-26.
8. **Burton N, Graeber G, Zajtchuk R (1984):** An alternate method of ventricular venting - The pulmonary artery sump. *Chest*, 85(6):814-815.
9. **Aksoy T, Kaplan M, Zengin M et al. (2008):** Comparison between pulmonary arterial and aortic root venting and their effects on pulmonary functions following CABG surgery. *Türk Göğüs Kalp Damar Cer Der.*, 16(4):211-215.
10. **Mitchell I, Prabhakar G, Maughan J et al. (1989):** Pulmonary artery versus left ventricular venting: A radioisotope study of left ventricular function. *Ann Thorac Surg.*, 48(5):699-703.
11. **Garibaldi A (1990):** Efficacy of pulmonary artery versus left ventricular venting. *Ann Thorac Surg.*, 50(4):685-686.