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Effect of Pulmonary Artery Venting in Patients Having Elevated Pulmonary Artery Pressure Undergoing Mitral Valve Surgery, Comparative Study

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ABSTRACT

Background: Despite being controversial, left ventricular venting is still used to facilitate valvular heart surgeries and prevent distention. The classic way to vent the left ventricle is via the right superior pulmonary vein, which has many reported complications.

Objective: We aimed to evaluate the effectiveness of pulmonary artery venting in patients undergoing mitral valve surgery who have elevated pulmonary artery pressure.

Patients and Methods: 100 patients undergoing isolated mitral valve replacement, and having elevated pulmonary artery pressure were recruited in Cairo University Hospitals. They were divided into 2 groups; group 1 had pulmonary artery venting, and group 2 had no plmonary artery venting. Both groups were compared for preoperative, operative and postoperative variables.

Results: Patients were divided into 2 groups; group 1 comprised 51 patients and had pulmonary artery venting, and group 2 comprised 49 patients and had no pulmonary artery venting. Both groups had similar preoperative characteristics, with group 1 having 14 minutes shorter cross clamping time (p value = 0.001), and 0.6 days shorter ICU stay (p value = 0.002), mean hospital stay was 6.4 ± 1.7 in group 1 and 8.7 ± 2.2 in group 2 (p value = 0.001).

Conclusion: Using pulmonary artery venting during open heart surgery for mitral valve replacement, in patients with elevated pulmonary artery pressure is beneficial, facilitates the surgical procedure, and is associated with shorter ICU and hospital stay.

Keywords: Mitral valve replacement, Left ventricular venting, ICU stay, Surgical outcome, Elevated pulmonary artery pressure.

INTRODUCTION

Routine use of left ventricular vent is controversial in patients undergoing open heart surgery. However, surgeons use it during valvular surgery to maintain a dry field to make the operation easier. In addition, it helps to prevent left ventricular distention during the critical period of rewarming and reperfusion if ventricular function does not return immediately following the release of aortic cross clamp [(1)].

Many mitral valve disease patients present for valvular surgery at a late stage and often have severe left atrial dilatation, pulmonary hypertension, and impaired right ventricular function. Improper drainage of the blood returning to left atrium during surgery may cause RV distension and increase the inotropic requirement to wean off bypass. The most commonly used technique to drain the LA is venting via RSPV, however technique of insertion of the vent catheter is not easy [(2)], and many complications are reported with the use of this technique. Most of the studies focused on the value of LV vent for the reduction of myocardial oxygen consumption [(3)].

We aimed to assess whether the use of pulmonary artery (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 inotropics, shorter ICU stay, and easier weaning off bypass, in patients undergoing mitral valve replacement.

PATIENTS AND METHODS

This is a randomized prospective study including 100 consecutive patients, who were operated in Kasr Alainy hospitals, in the period between January 2017 and December 2019. Only patients with isolated mitral valve disease were studied. The study aimed to assess the effectiveness of PA venting in patients with PH undergoing mitral valve surgery regarding impact on cross clamp time, bypass time, need for inotropic support, time to extubation, ICU stay and total hospital stay. 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"[(2)] while those requiring small doses of inotropes, which was weaned before transfer from OR are not counted.

Inclusion criteria: All adult patients with PH undergoing isolated MVR surgery.

Exclusion criteria: Severe LV dysfunction with EF< 35%, combined procedures as DVR, ischemic MR, mitral repair, as operative time is variable depending on the complexity of the repair, those with

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a previous infarction and those with aortic incompetence were excluded. As these factors might change the conduct of the surgery and affect the measurements.

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 nor LA venting, comprised 49 patients.

All patients in both groups underwent the same anaesthetic and surgical technique, left atriotomy was used in all cases, interrupted 2/0 polyester sutures with pledgets (ethibond - Ethicon, Somerville, New Jersey) were used in all cases. All patients underwent routine preoperative investigation including electrocardiogram, chest roentgenogram, hemoglobin, urea, electrolyte, serum creatine, phosphokinase measurement, echocardiography and coronary angiography for male patients above 40 years and females after menopause.

Ethical approval:

An approval of the study was obtained from Cairo University academic and ethical committee. Every patient signed an informed written consent for acceptance of the operation. 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.

Technique of PA catheter insertion:

We used the same technique described by **Little *et al.*** [3]. A plastic sump-type catheter (usually size 18) 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 veinous 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 mitral valve replacement:

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. Temperature is lowered to 30°C, aortic clamp is applied and cold blood cardioplegic solution was administered. During bypass pulmonary artery venting was maintained. Left atriotomy was done. The mitral valve was excised and replaced with St. Jude Medical valve, with preservation of posterior mitral leaflet in all patients.

After closure of the left atrium, the heart was rewarmed, deaired using cannula in the aortic root for all patients, and bypass was weaned. Difficult weaning off bypass and the need for inotropic support more than 45 minutes is recorded. Routine monitoring in the ICU was done and echo was performed on day 1, day 5 and at six weeks.

Statistical analysis

Continuous data were expressed as mean and standard deviation or median with the interquartile range and categorical data as percentages. All reported P values are two-sided, and P values of ≤ 0.05 were considered statistically significant. All statistical analyses were performed with 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 (24 females), mean age was 35.4 years (27 to 51 years) and mean PAP was 69.3 ± 15.2 mmHg. Group (2) (without PA vent) comprised 49 patients (26 females), mean age was 34.2 years (25 to 53 years) 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, gender, incidence of AF and predominant mitral valve lesion (p value > 0.05), as shown in table (1).

The cross clamp time for group (1) was 14 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 siginificantly shorter cross clamp time, 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 mitral valve replacement surgery, group 1 with pulmonary artery vent inserted, group 2 without pulmonary artery vent

	Group 1 (N=51) Mean ±SD, or number (%)	Group 2 (N=49)	P value
Age (years)	35.4 ± 8.7	34.2 ± 7.5	0.48
Female gender	24 (48%)	26 (52%)	0.54
Systolic pulmonary artery pressure (mmHg)[a]	69.3±15.2	61.9 ± 14.1	0.14
Ejection fraction (%)	57 ± 6.8	59 ± 6.1	0.2
Atrial fibrillation	19 (53%)	17 (47%)	0.7
Mitral valve lesion			
MS	22 (59.6%)	15 (40.5%)	0.2
MR	25 (50%)	25 (50%)	0.21
Double lesion	4 (30.4%)	9 (69.2%)	0.15
Cross Clamp Time (minutes)	40.4 ± 5.9	54.4 ± 7.5	0.01
Bypass Time (minutes)	60.7 ± 8.2	77.6 ± 8.9	0.02
Ventilation 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	2.7 ± 0.7	0.01
Hospital Stay (days)	6.4 ±1.7	8.7 ± 2.2	0.08
Associated surgery for TV [c]	18 (54%)	15 (45%)	0.6

[a] measured by preoperative echo [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. [c] all cases who need tricuspid surgery, had Tricuspid annular band repair

DISCUSSION

We found that the use of pulmonary artery venting in patients undergoing mitral valve surgery was associated with easier surgical technique as indicated by shorter cross-clamp and bypass times. It was also associated with less need for inotropic support, shorter ICU and hospital stay and easier weaning of bypass suggesting beneficial effects to the heart.

We could classify advantages of the PA vent into 3 categories, during aortic cross clamp, during weaning off bypass, and after leaving the operating room. During AXC, there was less blood backflow to LA, subsequently improving field visualization and minimizing the need to stop and suck blook from the field. This is reflected on shorter cross clamp time with all its beneficial effects. Mean cross clamp time was 8 minutes less in group A using PA vent, when compared to the other group.

Weaning off bypass was faster in PA vent group, with less need to use inotropic support. This may be because of the negative pressure created by the suction in the PA, which almost totally unloaded the RV, facilitating blood ejection to PA, and allowing RV to recover better from ischemia, and giving time to wash metabolites with being faced with low PA pressure. Minimizing the cross clamp time and faster weaning of bypass leads to shorter total operative time, which is strongly linked to better outcome[(4)].

We found the mean mechanical ventilation time was significantly shorter in the PA vent group being 7.1

hours compared to 9.6 hours in the non-vent group. This is probably due to shorter operative and anesthesia time, and because less inotropes are required for the PA vent group, which reflects better myocardial condition, all of which facilitate weaning of bypass.

We found that the visualization of the operative field is better with the PA vent, which resulted in 14 minutes less aortic cross clamp time in the pulmonary artery venting group (group 1), when compared to no PA. This difference is probably due to clearer left atrium with easy and fast surgical manipulations and the presence of the catheter in the pulmonary artery away from the surgical field facilitate the surgical technique.

Regarding the bypass time, it was also significantly shorter in the PA venting group, probably due to avoiding LV distension, and maintaining a low PA pressure, which unloads the RV, allowing faster recovery from cardioplegia after removal of the aortic clamp. Despite all patients already had severe pulmonary hypertension and RV straining preoperative, the need for inotropic support was minimal in the PA vent group.

Heimbecker and McKenzie[(5)] in 1976 named PA vent as “ a new approach to left heart decompression”. They also claimed that direct left heart venting is "obsolete". They used a stab in the RVOT to insert the vent; a technique, which was later modified [(3)]. They showed effective decompression of the LV in all 66 cases of the study. These findings are accordant with what **Little *et al.*** [(6)] demonstrated that pulmonary arterial venting that was effective in maintaining left ventricle decompression via enabling aspiration of the blood coming from the right heart through the coronary sinuses, blood from the thebesian veins draining to the left atrium, part of systemic venous blood and blood from the bronchial veins draining to the pulmonary veins. However, manual compression of the left ventricle is sometimes needed to help emptying LV. Furthermore, mitral valve becomes incompetent during cardiac arrest or fibrillation, so left atrium and left ventricle act as a single chamber. Thus pulmonary arterial venting can aspirate the blood in both chambers. This is not astonishing because there are no valves in the pulmonary circulation.

In 1984, **Burton *et al.*** [(7)] reported using PA venting in more than 1000 patients (including mitral valve surgery patients) with satisfactory results and negligible complications, early and late. They also praised the use of PA vent being technically easy, and effective in left ventricular decompression, even in cases associated with mild AR (which is yet controversial). In the same year, **Little *et al.*** [(3)] also showed the effectiveness of the PA vent in decompressing the LV, and achieving bloodless field during cardiac operations, via using scintigraphy of serial blood samples from PA, and systemic veins, and aortic root after injection of 10 cc ^{99m}technetium fluid into LA during aortic cross clamp;

complete return via PA vent with only trace systemic or aortic activity confirmed backward flow across pulmonary circulation, and showing 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.

They confirm that PA vent is the standard way of LV decompression used in University of Chicago for 6 years applied to more than 6000 patients "without any significant complication related to its placement or use" as they stated. They also showed changes in LA and LV pressure a few seconds after PA vent switched on or off. They depended on showing lower LV pressure to demonstrate the protective effect of PA vent on LV, while we used shorter bypass time and less need for inotropes as indicators of good LV recovery after ischemia. They stated that survival may be equal with and without PA vent, but more convenient bloodless field and better LV protection and decompression with easier recovery from ischemia is a plus for PA venting.

Michell *et al.*[(8)] used radionuclide measurement of ejection fraction to assess the immediate and late LV function after using PA vs LA vent in 20 patients undergoing CABG surgery, and found no significant difference in function or in aortic cross clamp time and bypass time. This demonstrates again the effectiveness of PA vent in decompressing the LV, which is in agreement with our results. In a reply to a comment on their results [(9)], the authors stated that PA vent helped achieve a perfect, bloodless field for aortic valve replacement, in addition to effective myocardial protection. In accordance with our results, **Haberal *et el.*** [(6)] stressed the value of PA vent in achieving good pulmonary outcome after CABG surgery, when compared to aortic root venting. They showed significantly higher postoperative PO_2 and less need for bronchodilator treatment with the use of PA vent. They failed to show significant difference regarding postoperative intubation times, however all patient who needed reintubation were in the aortic root venting group.

In our study, postoperative intubation times were better for PA venting compared to no venting. The mean postoperative intubation time was 7.1 hours for the PA venting group while 9.6 hours for the other group ($p = 0.001$). These findings favor pulmonary arterial venting in terms of postoperative pulmonary functions. With pulmonary arterial venting, the pulmonary vascular bed and the left heart are emptied as occurs in total bypass and as a result, hydrostatic pulmonary edema is prevented, resulting in better postoperative pulmonary functions.

Also, the ICU stay was shorter in the PA venting group, with a mean stay of 2.1 days, and a P value < 0.05. The same applies to the overall hospital stay, which was shorter significantly for the PA venting group. This was clearly explained from the shorter bypass and operative time, less need for inotropes and faster weaning of mechanical ventilation, which is reflected on a better patient outcome, with less use of resources.

There was only one case report [(10)] showing marked distension of LV, while trying to wean off bypass in a patient undergoing CABG, with no initial LV venting (direct or indirect) that failed to decompress by PA vent inserted after failed weaning. This patient had mild AR by intraoperative TEE. All other studies reported above, in addition to our experience, didn't find PA vent to fail to decompress the LV, even in cases of mild AR.

Intraoperative TEE was not readily available in all patients to allow proper quantification of the degree of RV and LV distension, throughout the process of aortic declamping and during weaning off bypass. This would demonstrate properly the exact mechanism of the beneficial effects of PA vent in mitral valve surgery. Swan Ganz catheter was not available to assess whether the vent really decreased the PAW pressure, and to assess the effect of the vent on the RV output. We must interpret the results cautiously, as the presence of more than mild degree of AR or other valvular disease might change the results.

CONCLUSION

Venting the left side during cardiac surgery is beneficial, with many proved advantages. We found that PA vent is an easy cheap technique, associated with better visualization of the surgical field, shorter aortic cross clamp and bypass times, easier weaning off bypass ,and shorter ICU and hospital stay. This study focuses on the technical implications of using PA venting, ease of surgery, clarity of the surgical field - achieved by both bloodless field and a vent in the PA away from the field, avoiding time loss for interrupting the procedure by repeated blood suction, and fast weaning off bypass in a patient with already severe pulmonary hypertension. These results should revive the use of PA venting as an easier alternative to other methods of LV venting, with negligible rate of complications.

In addition, it highlights that more research is needed to assess its value in patients undergoing cardiac surgery via mini-sternotomy incisions, in whom other methods of LV decompression are surgically challenging.

ABBREVIATIONS

RV	Right Ventricle
RSPV	Right Superior Pulmonary Vein
LA	Left Atrium
LV	Left Ventricle
PH	Pulmonary Hypertension
PA	Pulmonary Artery
ICU	Intensive Care Unit
OR	Operating Room
MV	Mitral Valve
MVR	Mitral Valve Replacement
EF	Ejection Fraction
DVR	Double valve replacement
MR	Mitral Regurge
SD	Standard deviation

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