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Medicine**

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# E Journal of Cardiovascular Medicine

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# Hybrid Coronary Revascularization in Beating Heart Coronary Artery Bypass; The Results and Review of The Literature

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## Abstract

**Background:** The aim of this study is to evaluate demographic, clinical and laboratory features and outcomes of the hybrid cases undergoing beating heart coronary artery bypass grafting.

**Methods:** January 2011 - 2015 in the isolated beating heart coronary bypass performed (n = 54). The cases were retrospectively analyzed with demographic characteristics and used hybrid approaches. After off-pump coronary artery bypass surgery (OPCAB), the cases were followed for following hybrid coronary revascularization (HCR) with multi-vessel coronary artery disease (MVCAD).

**Results:** Fifty-four consecutive patients underwent elective HCR (n = 7) or OPCAB (n = 47). The cases consisting of 12 female (22.2%), 42 male (77.7%) were found. 54 cases with an average age of 62.51 years (min: 41, max: 86) (13.279 SD) have been observed. There was no any complication in HCR group. Stroke in 2 case (3.7%), hypoxic ischemic encephalopathy (right internal lacunar infarct) and transient ischemic attack (TIA) in two cases (3.7%) were detected. Inpatients mortality ratio was 7.4% with multiple organ failure.

**Conclusion:** HCR is associated with successful results. We believe that OPCAB should be preferred in selected cases with potential high risk morbidity.

**Keywords:** Artery, cardiopulmonary bypass, hybrid coronary artery revascularization.

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## Introduction

Coronary artery bypass graft (CABG) is a superior management approach for severe coronary artery disease.<sup>(1-3)</sup> The left internal thoracic artery is considered to be the best conduit for CABG.<sup>(2-4)</sup> However, preferred standard coronary artery bypass grafting technique remains controversial between off pump and on pump or hybrid coronary revascularization.

In this sense, beating heart surgery for cardiac surgeons is a growing number of treatment options. Assigning anastomosis during cardiac surgery quality is improved even more with the technological developments in this area. Shortened length of hospital stay, decreased respiratory period and decreased pulmonary complications, less bleeding and blood transfusion, decreased inflammatory response, decreased arrhythmias, decreased neurological complications and decreased mortality with cost-effective management are very important. Recent studies show us that the off pump approach is less associated with the postoperative stroke. Also, the off pump patients had less perioperative death and lower incidences of all morbidities as present reports.<sup>(1-4)</sup>

Panoulas et al.<sup>(6)</sup> have demonstrated that the excellent patency rates of drug-eluting stents associated with HCR survival benefits. In the study of Harskamp et al.<sup>(7)</sup> they detected that among diabetic patients with percutaneous coronary intervention (PCI) of non-left anterior descending vessels are safety and efficacy.

However, limited literature was available about following hybrid coronary revascularization after OPCAB. The present study aimed at evaluating the results of HCR at mid-term follow up.

## 1. Patients

We have retrospectively collected the outcome data on all patients undergoing a beating heart CABG (n: 54). In the time period, from January 2011 through January 2015, 54 cases (42 males and 12 females) had been included in the study criterias. Perioperative follow-up period was determined as 7 days. We received data for all patients undergone a primary isolated OPCAB. Mean age of the cases is 62.51 years (min: 41, max: 86) (13.279 SD).

## 2. Exclusion Criteria

Patients with reoperative CABG, under 18 years old, operated peripheral vascular disease or muscle disease, trauma, shock, malnutrition, pregnancy, liver diseases, dialysis dependent renal failure and neoplasias were excluded.

## Materials and Methods

This study was prepared through the application of the guidelines of “The Declaration of Helsinki”. This retrospective study was conducted with the approval of the Ethics Committee for Clinic Research on 07 April 2015 with the protocol number 2079-GOA/2015. The cases were followed for 1 month in the study. 54 patients observed undergoing OPCAB between January 2011 and 2015. The primary outcomes were the risk factors including advanced age, sex, smoking status, hypertension, hyperlipidemia, carotid disease, diabetes mellitus, prior cardiac events, chronic obstructive pulmonary disease, peripheral vascular disease, body mass index, neurological events, HbA1c levels, and serum creatinine levels. The secondary outcomes were of preoperative New York Heart Association (NYHA) heart failure functional class, Euroscore II functional status, and left ventricular ejection fraction. Other outcome measures were perioperative death (in hospital) and intensive care unit vital follow up. In all calculations and statistical analyses, “Statistical Package for Social Sciences” (SPSS-Chicago, IL, USA) 16 and Software Excel (Microsoft-USA) programs were used.

## Surgery

We preferred with the table in trendelenburg position. Standard full sternotomy was performed. The patients were kept under control for blood pressure. Standard doses (1-1.5 mg/kg) of systemic heparin had been applied. The target ‘Activated Clotting Time’ (ACT) was greater than 300-350 seconds. Left internal mammary artery (LIMA) was prepared as long as possible. Surgical loops (Design for Vision \*3.5, US) were used during dissection and the operation. The grafts were harvested with scissors and hemoclips used for bleeding. The grafts were protected inside of ‘Perlingalit’ (1.0 mmol/L) mixed with heparinized blood. Also,

heparinized blood was injected intraluminally into the saphenous vein grafts (SVG) after harvesting. SVG was commonly used for the obtuse marginal branches and/or the posterior descending coronary artery. SVG in patients with advanced age group (over 80) was used as autograft and supported by literature.<sup>(5-6)</sup> For an excellent exposure, an additional deep pericardial retraction suture was used. Also, the table was raised and rotated towards the right. This position would allow us to displace the heart to the right and apex it anteriorly. Right pleural space was opened to help for the right incision. These maneuvers had allowed us to move the heart towards the right pleural space easily. We had used the stabilizers that devices work by attachment (suction). Silastic® tape or silk suture had passed around the target vessel for proximal occlusion. Intracoronary shunts were used as recommended. A CO2 blower (Novatech aspirateur microvac® 2 x 70 mm) had been used with saline irrigation to prevent damage to the coronary endothelium. The anastomosis was performed in a traditional CABG with routine approaches. Proximal anastomoses had been performed after the distal anastomoses to protect the stabilization. Heparin reversal had not been carried out except for mandatory cases (3 case had bleeding status). We had not used to placed temporary pacing wires except in 4 unstable case. Intra-aortic balloon counter-pulsation (IABP) was introduced in four case at the end of the operation. We avoided from renal dysfunction with blood pressure regulation. Routine perioperative operation room and intensive care unit (ICU) vital follow up was performed.

## Results

Demographic data and comorbidities are analyzed in **Table-1**. A total of 54 patients with MVCAD included the study.

7 patients were treated with HCR. PCI was possible without diffuse stenosis and severe calcification. PCI was performed before and after the operation with MVCAD. All cases were performed electively. Only one case had unsuccessful PCI on the right posterior descending coronary artery.

Most of the procedural characteristics were similar in the OPCAB and HCR groups. Comorbidities relat-

ed to the patient group were the diabetes mellitus in 6 cases (11.1%) (Insulin dependent-HbA1c median ratio 7.58) and the hypertension in 5 cases (9.25%). Smoking was observed in 26 patients (48.1%). Chronic Obstructive Pulmonary Disease was observed in 5 cases (9.25%). Alcohol use was not found. The average body mass index was found to be  $28.21 \pm 5.1$ . There were 5 cases (9.2%) with atrial fibrillation. One of them had neurological events like transient ischemic attack (TIA). History of myocard infarction was found in 14 cases (25.9%). Prolonged ventilatory use ( $\geq 24$  hours), reoperation for bleeding, sternal wound infection, or mediastinitis had not been put forth. No patients had required a mechanical circulatory support or dialysis. In both groups, no outcomes of perioperative myocardial infarction were observed. Also, there was no evident doubt requiring the distal anastomosis. There was no need for early repeat revascularization (following 7 days). In addition, cardiac arrest and multi-organ dysfunction were performed in four OPCAB cases during ICU following up. Inpatients mortality ratio was 7.4% with multiple organ failure in the OPCAB group. The early postoperative mortality rate was 0% (no mortality or complication during HCR). In the 1st postoperative month, functional capacity improved dramatically: the number of patients in New York Heart Association functional class (NYHA) IV moved from 22 (preoperatively) to II; in class II, from 24 to 10; in class II; and in class I, from 8 to 2.

Only two cases (3.7%) had postoperative major adverse cardiovascular and cerebral event (MACCE) (right internal lacunar infarct). Also, one TIA was detected. After 1 year, cerebrovascular diseases (CVA) were detected in a patient whose carotid arteries were normal.

Number of bypass grafts performed per patient was as follows: 1 graft (LIMA) in 24 cases (44.4%), 2 graft in 22 cases (40.7%), 3 grafts in 8 cases (14.8%). The LIMA conduit was used to the left anterior descending artery in all cases. We placed temporary pacing wires in the four left main coronary artery cases to avoid cardiac arrhythmias. Intra-aortic balloon counter-pulsation (IABP) was introduced in four cases at the end of the operation. In this study, there was no cardiac complication during the postoperative 7 days without four cases.

Outpatients' follow-up control was unproblematic.

Standard anticoagulant therapy (acetyl - salicylic acid 100 mg/day and clopidogrel 75 mg/day per oral) was given to all postoperative cases. Mean duration of intensive care unit (ICU) was 1/day, and the duration of hospital stay was 5 days. Both erythrocyte replacement and fresh frozen plasma were used for bleeding.

the world today.<sup>(4-5)</sup> The average of this number, 150 – 200 thousand, constitutes the beating heart surgery.

Percutaneous coronary intervention reported successful patency rates.<sup>(6-7)</sup> Drug-eluting stents associated with safety and efficacy.<sup>(7)</sup> Less blood and faster recovery are benefits of PCI. Recent studies have associated with less morbidity outcomes.<sup>(6-7)</sup>

Hybrid coronary revascularization determines both combine arterial coronary artery bypass surgery and percutaneous coronary intervention of multivessel coronary artery disease. It was first began in the mid-2000s. HCR associated with the excellent patency rates and survival benefits with multivessel coronary artery disease.<sup>(6)</sup>

Stroke is one of the most dramatic complications after cardiac surgery as present studies show that stroke mechanisms are predominantly embolic.<sup>(4)</sup> However, numerous reports describe the neurological results of OPCAB.<sup>(3-7)</sup> Off-pump CABG may reduce the rate of stroke, due to minimal aortic manipulation. OPCAB has been reported to present a lower risk of stroke.<sup>(4-10)</sup> Some reports have associated with less morbidity outcomes.<sup>(4-13)</sup>

CABG results in excellent long term survival.<sup>(8-10)</sup> The durable LIMA graft to the left anterior descending artery has the best patency rates.<sup>(6-10)</sup> Studies show that patients with hypertension, diabetes, peripheral vascular disease, aortic disease and stroke have higher risk for coronary artery disease especially in elderly patients.<sup>(7-8)</sup> For coronary artery in patients older than 75 years, OPCAB reported a higher incidence.<sup>(7)</sup> Advanced preoperative NYHA heart failure functional class and Canadian Cardiovascular Society angina class are associated with increased morbidity.<sup>(10)</sup> In this group, stroke, peripheral vascular disease, chronic obstructive pulmonary disease, congestive heart failure, and left main coronary artery diseases are often particularly high.<sup>(8-9)</sup> For cardiac surgery, an age of  $\geq 75$  years is an independent risk factor for postoperative mortality and morbidity.<sup>(11-13)</sup> OPCAB is indicated in severe aortic calcification, carotid artery stenosis, history of stroke, renal dysfunction, and pul-

Table 1: The demographic characteristics of the cases (n=54)

Mean Age (yr)	62.51±13.27 (min: 41, max: 86)	
Body Mass Index	28.21±5.1	
Mortality	7.4%	
	n	%
Current Smoker	26	48.1
Hypertension	5	9.25
Diabetes (HbA1c $\geq 7$ mg/dl)	6	11.1
History of Myocard Infarction	14	25.9
Chronic Obstructive Pulmonary Disease	5	9.2
Peripheral Vascular Disease	1	1.8
Cerebral Vascular Disease	2	3.7
Atrial Fibrillation	5	9.2
Number of affected coronary arteries		
1 vessel	24	44.4
2 vessel	22	40.7
3 vessel	8	14.8

## Discussion

Isolated coronary artery bypass grafting, and cardiopulmonary bypass (CPB)'s extensive usage have been made well before the beating heart (Kolessov 1967).<sup>(1-4)</sup> CPB's side effects (inflammation, stroke, hemorrhage, renal failure, pulmonary insufficiency, etc.) have been a drawback. Benetti began to perform the Buffalo beating heart in a case of large series in 1990 and 1997.<sup>(2-4)</sup>

Despite increasing technological innovation, the CPB's disadvantages have been increased by age in the following years. Convincing the CABG patients to become candidates is also important. The standard CABG is performed per year for 650 to 950 thousand times in

monary artery diseases.<sup>(10-15)</sup>

Anesthesiologists and surgeons compliance is essential for a successful beating heart surgery. Surgical plan-shape incision, place of the arteriotomy, internal mammary artery (IMA) preparation, and proximal anastomoses to be made before or after operation are important. Also, 'Shunt' or 'Occluder' decision to use for bloodless field and distal perfusion is important for the quality experienced surgical approach. Therefore, beating heart surgeon must do  $\geq 50$  beating heart cases.<sup>(2-4)</sup> Invasive monitoring, ischemia time, electrolyte imbalance (magnesium and potassium balance) and pH balance are important during the perioperative period. Reperfusion must begin within 15 min. Full-reperfusion should begin after the proximal anastomosis. In order to maintain hemodynamic stability; 'Trendelenburg position', careful manipulation of the heart, the right pleural and pericardial incision, intra-aortic balloon pump and pacing wires preparation, pharmacological interventions, and anesthesia monitoring are very important. Global left ventricular regional wall motion should be observed carefully during occlusion and 'shunt' placement should be quick and attentive. For the stabilization of the surgical field 'vacuum or compression stabilizers' are required. Stabilizers should protect the hemodynamic function of the heart and avoid the myocardial damage. The stabilizers must create an immobile field. When using compression stabilizers, hemodynamic changes on the posterior aspect of the heart is so important. By contributing with pericardial incisions, the surgeon can take required positions at the heart without hemodynamic changes. In appropriate cases, cardiac position transmitters can be placed in the apex of the heart with using vacuum technology.

Normothermia preservation must be ensured by keeping the operating room warm, avoiding radiant heat loss. The anesthesiologist must be suitable for beating heart surgery as collaboration crucial for success. The follow-up is required with a great experience. Involvement of the anesthesia team is essential for successful beating heart surgery. Also, the availability of heart-lung machine and perfusionist is necessary. Inotropic and beta antagonist blocker agents are important to maintain cardiac output during the manipulations. If necessary, an IABP, cardiac assist devices, pacemaker support can be inserted immediately for temporary support. Fluid and electrolyte balance must be protected during the operation and intensive care unit.

In the current review, we discuss HCR's results, its limitations and procedural challenges with multi-vessel coronary artery disease at mid-term follow up. In addition, limited literature was available about following hybrid coronary revascularization after OPCAB. We preferred the off pump cardiac surgery for hemodynamically unstable patients, patients with other organ-system problems, urgent or emergent operation, re-operative CABG, patients with severe left ventricular dysfunction (LVEF  $< 30\%$ ), and patients with critical left main disease. Also, we have used this approach for patients underwent carotid disease including greater prevalence of cerebrovascular events. Recent studies show us that the CPB is positively associated with the postoperative stroke. The cross clamp ischemia occurs with conventional CABG. Only localized ischemia occurs when coronary artery occlusion is performed in the OPCAB. Patients with  $\geq 75$  years old should be operated with the beating heart approach to avoid the stroke.

Future studies should examine the results of the OPCAB on long-term outcomes of high-volume centers. Modern surgical techniques and experiences would decline the ratio of the complications.

## Conclusions

We believe that HCR should be preferred in selected patients with MVCAD to reduce high risk morbidity. OPCAB performed by an experienced surgical and heart team by using 'hybrid approach' techniques can be a useful strategy in reducing postoperative morbidity and mortality.

## Study Limitations

The primary limitation of our study is the risk factors including severe multivessel coronary artery disease. In addition, long-term follow-up and large-scale prospective studies are needed to determine the frequency of HCR.

## Disclosure

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# Effectiveness of Off Pump CABG in Impaired Left Ventricular Function

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## Introduction

In most of the cardiac centers, the off-pump coronary artery bypass (OPCAB) surgery is an accepted mode of revascularization. The surgery without cardiopulmonary bypass has obvious advantages in high-risk patients. Severe left ventricular (LV) dysfunction is a known independent factor of operative mortality in patients with coronary artery bypass grafting (CABG) surgery.<sup>(1-2)</sup> The technique of off-pump (OPCAB) has both theoretical and practical advantages. Critical patients with impaired left ventricular (LV) function who need coronary artery bypass grafting (CABG) have an augmented risk of Perioperative mortality and morbidity.<sup>(3, 4, 5)</sup> The aim of this single-center retrospective study was to compare early and short-term outcomes after conventional (CCAB) in patients and off-pump beating heart coronary artery bypass grafting (OPCAB) in patients have ejection fraction (EF) equal to or less than 35%, with regards to intensive care unit (ICU) stay, hospital course, the use of intra-aortic balloon pump support, the need of inotropic support, blood loss and renal function deterioration.

## Patients and Methods

Preoperative assessment and data collection, all data according to the legal Customs and traditions of Saudi Arabia with granted informed consent were collected retrospectively, patients demographics data, risk factors, operative information and postoperative outcome data from our database system at Prince Sultan Cardiac Center – Al Hofuf– KSA which is maintained in our center to document all cardiac surgical activity. 150 patients with impaired LV function based on a recorded ejection fraction (EF) equal to or less than 35% subjected to isolated CABG between September 2010 to July 2013 were collected and statistically analyzed. 60 (40%) patients underwent CABG with off-pump beating technique (group1) and 90 (60%) patients with the conventional technique (group2). For each group, the clinical, angiographic characteristics, the operative and early and short-term outcome data were compared. We exclude Patients subjected to combined surgery, redo surgery, emergency procedures, big heart, a left ventricular aneurysm or aortic surgery. The off-pump beating and conventional surgery were on the basis of the

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preference of the surgeons carrying out the operations. Identification of impaired LV function was based on either the preoperative echocardiography or thallium-201 myocardial scintigraphy that were performed to measure the left ventricular function and to assess myocardial viability. This viability study was done when indicated in some patients according to their clinical, echocardiography and coronary LV angiography data. Euro SCORE was comparable in terms of surgical risk stratification. Outcome measures for this study included ICU and hospital stay, postoperative complications including bleeding, arrhythmias, and renal complications. Duration of inotropic support, the length of mechanical ventilation, hospital mortality and length of ICU and hospital stay were recorded.

Hospital mortality was defined as death after the procedure before patient's discharge regardless of the duration of hospitalization. Patients who died after discharge from hospital but within 30 days after the procedure were also considered as hospital mortality. Postoperative blood loss was defined as total chest tube drainage. Respiratory failure was defined as prolonged ventilator therapy (>72 hours) or need for re-intubation or tracheostomy. Renal complications included acute renal failure needs hemodialysis with creatinine more than 200 mmol/L. Surgical Techniques off-Pump beating (OPCAB) Coronary revascularization: All patients were anesthetized with the same standard manner either OPCAB or Conventional. All patients were hemodynamically monitored by both radial and femoral arterial lines for systemic pressures and Swan- Ganz a catheter for pulmonary artery pressure. Patient required 5 micrograms/ kg/min of Dopamine infusion to support the heart during the procedure, which was discontinued on completion of graft placements.

The median sternotomy is the method of approach for all surgical procedures. Standard technique was used for harvesting of left internal mammary artery (LIMA) and Saphenous vein. Cell saver was used during these procedures. By using 3mg/kg Heparin to achieve activated clotting time more than 350seconds. It should repeat each 20-minutes the activated clotting time to check this. Complete revascularization was the goal in all cases and we performed bypass grafting to all.

Graftable vessels in which the myocardium was vi-

able. The distal anastomosis for left internal thoracic artery graft was constructed with 7-0 polypropylene continuous suture and for the saphenous vein grafts and radial artery grafts 7-0 polypropylene suture was used. All proximal anastomoses of the radial artery, grafts were constructed using 7-0 polypropylene suture and the saphenous vein grafts were constructed using 6-0 poly propylene suture.

Stabilization of the heart to achieve the target coronary artery by Octopus (Medtronic Inc, USA). A humidified carbon dioxide blower/mister (Medtronic Inc, USA) was used to clarify the anastomotic site while constructing the distal anastomosis. Posterior and lateral target coronary arteries were accessed by deep pericardial traction sutures and/or with the use of Starfish cardiac positioner (Medtronic Inc., USA). A mean systemic arterial pressure was maintained around 65-70 mm of Hg throughout the procedure. An intra-coronary shunt was used whenever it was possible while constructing the coronary anastomosis for all the vessels.

The strategies of coronary artery grafting were to graft left internal thoracic artery to left anterior descending artery first, followed by either obtuse marginal arteries or right coronary artery whichever was stenosis is critical. The target vessel was occluded proximally using a 4-0 polytetrafluoroethylene suture passed twice beneath the artery to prevent direct contact between the suture and the anterior coronary wall. Techniques of conventional CABG: After full systemic heparinization to achieve activated clotting time level of at least 400 seconds, CPB was instituted in a usual manner. After aortic cross-clamp, myocardial protection is achieved by blood Cardioplegia in an antegrade fashion combined with systemic hypothermia 28-30°C. Cardioplegia was repeated each 20 minutes and after every distal anastomosis. Distal anastomoses were completed first, then the proximal anastomoses using the single aortic cross-clamp or partial clamp. The release of Aortic cross-clamp, the weaning of CPB, and reversal of heparin was done in a standard manner. The intra-aortic balloon pump was inserted in patients with hemodynamic instability.

### Statistical Analysis:

Using a statistical software package (Graph Pad In

Stat® version 3.00 for Windows, Graph Pad Software Inc., San Diego, California, USA). Data is presented as mean (SD), numbers or ratio as needed. Data were analyzed using the student t-test; Variables that are not normally distributed were compared using the Mann-Whitney test. Nonparametric data were analyzed using Chi-square test or the Fisher exact test as appropriate. Two-tail P values < 0.05 were considered significant.

## Results:

Between September 2010 to July 2013, 150 patients with impaired LV function based on a recorded ejection fraction (EF) equal to or less than 35% subjected to isolated CABG were collected and statistically analyzed. 60 (40%) patients underwent CABG with off-pump beating technique (group1) and 90 (60%) patients with the conventional technique (group2). The mean Euro SCORE for OPCAB patients was  $3.45 \pm 1.8$  and for on-pump patients was  $3.30 \pm 1.4$  ( $p=0.36$ ) and both groups were comparable in terms of surgical risk stratification.

(Table 1), shows the comparison between the demographic patient's data with no significant differences and the preoperative variables in the two groups. (Table 1) shows that Group 2 had higher incidences of diabetes Mellitus, hypertension, congestive heart failure and smoking history with no significant differences except for renal insufficiency (P- value 0.008).

(Table 2), shows Operative data, group 1, had less operative time due to cardiopulmonary bypass time in group 2 with a high significant difference. There is no significant differences concerning the graftable vessels and rate of complete revascularization. (Table3) shows the postoperative data, we did not find a significant differences concerning the reopening for bleeding, stroke, atrial fibrillation, in-hospital mortality and total chest drainage although it was less with OPCAB group. Perioperative Intra-aortic balloon pump (IABP) support was higher in CCAB group (12 patients' vs 4 OPCAB patients:  $P<0.05$ ).

The indication of intra-aortic balloon pump was hemodynamic instability as high pulmonary artery pressure, or hypotension and usage of moderate or higher doses of inotropic support was also higher in the conventional group ( $p<0.005$ ). There is significance dif-

ferences between the two group concerning ,the hours of ventilation time was  $7.2\pm 6.3$  group1 vs  $10.1\pm 7.2$  group2 ( $p<0.05$ ). There is more deterioration of renal function in group 2 patient (renal failure was 7 patients (7.8%) in group 2 vs 1patient (1.7%) ( $p<0.02$ ). Group 2 patients had longer intensive care unit stay and hospital stay with significant differences than group 1. There is no significant differences regarding the in hospital mortality between the two groups.

In the short-term follow up period (6 months after the date of surgery), the mean EF% had improvement with statistical significance from  $30\%\pm 2.7$  to  $40.0\% \pm 2.0$  in group 1 and from  $31.8\%\pm 3.0$  to  $39\% \pm 2.3$  in group 2. The functional class improved coincide with improvement of EF%. The mean NYHA class had significant improvement related to the preoperative period in both groups, in group 1 from  $3.4 \pm 0.5$  to  $1.9\pm .7$ , vs  $3.3\pm 0.7$  to  $2.0\pm .2$  in the other group, but in all the post-operative short-term follow up period, there is no statistically significant difference between the two groups.

## Discussion:

The definition of severe left ventricular dysfunction definition is not clear. The choice of ejection fraction < 35% as others defined the severe LV dysfunction although other several authors defined severe LV dysfunction as ejection fraction (EF) <30%<sup>(1,6)</sup>The number of patients with end stage ischemic cardiomyopathy increased, that leads to increase the incidence to operate on patients have severely impaired left ventricular function for coronary revascularization. The challenge is the management of patient impaired LV function due to ischemic heart disease. Coronary artery bypass grafting has been considered as a high risk surgical procedure.<sup>(2)</sup>

In the past decade due to good outcome the OPCAB techniques, it was becoming popular.<sup>(7,8,9-10)</sup> It is noticed by many non-randomized sophisticated statistical methods that the OPCAB technique has lower incidence of re-exploration for bleeding, stroke, prolonged ventilation and acute renal failure.<sup>(11, 12)</sup> OPCAB in-hospital mortality in our study was 3.3% which was comparable to other published series (6.1%; 7%, 6.5% and 4.4%<sup>(13,14,9,15)</sup> respectively. Complete revascularization depends on the suitability of diseased coronary arteries



**Table 1.** Preoperative Data

Characteristic	off-Pump Beating-Heart (OPCAB) (n = 60)	Conventional CABG (n = 90)	p Value
Age (years)	62.0 ± 6.4	59.2 ± 7.5	NS
Sex			
Male	32 (53.3%)	48 (53.3%)	NS
Female	28 (46.7%)	42 (46.7%)	NS
Mean LVEF%	30 %± 2.7	31.8 %± 3.0	NS
Diabetes mellitus	48 (80%)	68 (75.6%)	NS
Smoking	14 (23.3%)	22 (24.4%)	NS
Hypertension	50 (83.3%)	77 (85.6%)	NS
Cerebrovascular disease	4 (6.7%)	5 (5.6%)	NS
Renal insufficiency	16 (26.6%)	13 (14.4%)	0.008
Peripheral vascular disease	5 (8.3%)	8 (8.9%)	NS
Chronic obstructive pulmonary disease (COPD)	2 (3.3%)	4 (4.4%)	NS
Congestive heart failure	7 (11.7%)	10 (11.1%)	NS
NYHA class	3.4 ± 0.5-	3.3 ± 0.7	NS

*LVEF: left ventricular ejection fraction; NYHA: New York Heart Association, NS. Non-significant*

**Table 2.** Operative variables of patients on both groups.

Characteristic	off-Pump BeatingHeart (OPCAB) (n = 60)	Conventional CABG (n 90))	p Value
Operation time (min)	230.5 ± 58.9	339.2 ± 79.1	<0.0001
Cardiopulmonary by-pass time (min)	-	110.3 ± 45.6	-
No. of bypassed diseased vessels			
One	6	7	NS
Two	27	31	NS
Three	26	50	NS
Four	1	2	NS

*No.: Number, Min.: Minutes, NS: Non-significant.*

to be graftable. To reach the targeted vessels, the heart should be elevated. For left anterior descending artery and diagonal branches need light elevation which does not affect the hemodynamics. For the obtuse marginals, posterior descending artery and posterolateral ventricular branches need more elevation of ventricle which affect the coronary blood flow especially the circumflex artery.<sup>(16)</sup>

We noticed this hemodynamic instability in patients grafted for marginal branches especially if the target area is proximal, ramus intermedius which needs many manipulations to decrease it as more deep pericardial suture and tilting the operating table in Trendelenburg position with right tilt. In four cases the insertion of Intra-aortic balloon pump support is mandatory to stabilize the hemodynamics. We noticed that there is no significant difference statistically concerning the number of grafts between the two groups (OPCAB vs CCBG) in comparison to other authors.<sup>(9, 17)</sup> In this study there is no significant difference between the two groups concerning the incidence of atrial fibrillation which is coincide with other results.<sup>(14, 15)</sup> There is significant difference statistically regarding the reduction of use of Intra-aortic balloon pump support that coincide with other authors.<sup>(13, 14, 18)</sup>

Also there is significant reduction in the ICU and hospital stay with OPCAB group that coincide with other authors.<sup>(19, 20)</sup> The pre-existing renal dysfunction get worse, in patients do CCABG (group 2) with impaired left ventricular function ( $p < 0.02$ ). It is proved

that left ventricular end systolic volume index (LVESVI) is an important predictor for short and long term functional improvement.<sup>(21)</sup> The LVESVI of 100 ml/m<sup>2</sup> or less, is associated with favorable outcome and recovery of the LV., but the EF% value has no statistically significant predictor of long-term outcome, so a low EF did not differentiate between hibernation and infarction as the cause of poor contractile function. During short-term follow-up in this study, LVEF in both groups was improved and there is improvement in functional class correlated with improvement of EF%. But in all the postoperative short-term follow up period, there is no statistically significant difference between the two groups.

### **Limitations and recommendations of study:**

We recommend further studies to see the long term outcomes, studies based on the LV. Dimension as LV dilation and extent of scars<sup>(22)</sup> and studies based on classification of Low EF% on symptomatic basis (associated with angina or associated with heart failure or both).

### **In Conclusion:**

Off pump CABG can be performed safely and effectively in critical patients with impaired left ventricular (LV) function. The postoperative morbidity and mortality was less in Off-pump group compared to conventional technique with more renal preservation in cases of impaired renal function.

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# Sutureless Aortic Valve Replacement: A Theoretical Analysis of The Effective Orifice Area in Comparison With Stented Valves

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## Abstract

**Objective:** Sutureless aortic valve replacement has recently been introduced as an alternative to conventional surgery to minimize the operative risk in elderly patients, shortening the cardiopulmonary bypass time and enhancing the minimally invasive approach. The aim of our study is to demonstrate that the sutureless bioprosthesis, compared to a conventional sutured prosthesis, has a corresponding larger effective orifice area, resulting in a better hemodynamic performance of the left ventricle.

**Materials and methods:** In this prospective observational study, between January 2014 and September 2015, among our population of 37 sutureless aortic valve replacements, we examined 17 patients (sutureless, A group), in which a second measurement with a standard stented valve sizer has been performed during surgery. As a control group, we analyzed 10 additional aortic valve replacements who received conventional stented bioprosthesis (sutured, B group), in which an additional measurement with the sutureless sizer has been used to compare size and effective orifice areas differences between the sutureless and the sutured valves for any given annulus.

**Results:** The size of the implanted bioprosthesis was  $23,1 \pm 1,9$  mm and  $23 \pm 1,6$  mm for the sutureless and sutured groups, respectively. In both groups, there were significant differences between the effective orifice areas of the implanted and the control sized prosthesis, always in favour of the sutureless valve (sutureless, A group:  $2,6 \pm 0,3$  vs  $1,4 \pm 0,0$  cm<sup>2</sup>,  $p < 0,001$ ; sutured, B group:  $1,5 \pm 0,2$  vs  $2,9 \pm 0,3$  cm<sup>2</sup>,  $p < 0,001$ ).

**Conclusions:** Previous studies compared nominal sizes regardless of the effective orifice areas. For the first time, we analyzed the areas of the sutureless versus sutured bioprosthesis. For every single patient considered, the effective orifice area was significantly larger with the sutureless rather than with the sutured bioprosthesis that could fit. In sutureless aortic valve replacements, the benefits go far beyond the cardiopulmonary bypass and cross-clamp time reduction, providing larger areas and less risk of patient-prosthesis mismatch.

**Keywords:** Sutureless, aortic valve, Perceval, Effective Orifice Area

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## Introduction

Sutureless aortic valve replacement (SU-AVR) with the innovative Perceval bioprosthesis (Sorin Group S.p.A., Saluggia, Italy) has recently been introduced as an alternative to conventional surgery to minimize the operative risk in elderly patients. Advantages consist of both shortening the cardiopulmonary bypass (CPB) time and enhancing the minimally invasive approach.<sup>(1,2)</sup> From 2007, this device underwent successfully to three european trials (the Perceval Pilot trial, the Perceval Pivotal trial and the CAVALIER trial) obtaining the CE mark in 2011. Nowadays, it has been implanted in more than 15.000 patients.

Several studies confirm how the Perceval valve has been widely used even in off-label indications such as in concomitant mitral valve replacement<sup>(3)</sup>, endocarditis<sup>(4)</sup>, bicuspid aortic valve<sup>(5)</sup> and aortic regurgitation.<sup>(6)</sup> However, the advantages of the sutureless device go far beyond the reduction of the CPB time. It is a well-known fact that valvular prosthesis with larger Effective Orifice Areas (EOAs) have a better impact on the hemodynamics of the left ventricle (LV) as shown by Gonzalez et al.<sup>(7)</sup>

The aim of our study is to demonstrate that the sutureless bioprosthesis, compared to a conventional sutured prosthesis, has a corresponding larger EOA, resulting in a better hemodynamic performance of the LV.

## Materials and Methods

### *Study description and patient population*

In this prospective observational study, between January 2014 and September 2015, among our population of 37 SU-AVRs at San Raffaele University Hospital (Milan, Italy), we examined 17 patients (A group), in which a second measurement with a standard stented valve sizer (Medtronic Hancock II) has been performed during surgery. As a control group, we analyzed 10 additional aortic valve replacements (AVRs) (B group) who received a conventional stented bioprosthesis, in which an additional measurement with the Perceval sutureless sizer has been used to compare size and EOA differences between the sutureless and the sutured valves for any given annulus. The prosthesis implanted in the B group included Carpentier-Edwards Perimount

(n = 2), St. Jude Trifecta (n = 2) and Medtronic Hancock II (n = 6). This case/control-like approach should reduce the statistical bias.

### *Perceval sutureless valve*

The innovative sutureless Perceval bioprosthesis (Sorin Group S.p.A., Saluggia, Italy; **Figure 1**) consists of a double sheet bovine pericardium fixed on a nitinol stent (alloy of nickel and titanium) which supports strong deformation and can return to its original shape when the stressor is removed. The stent is made of two rings (outflow ring and inflow ring), connected by 9 struts: 6 sinusoidal and 3 straight commissural ones. It is necessary to support the valve and hold it in place within the aortic root. A thin layer of Carbofilm™ improves biocompatibility. The super-elastic alloy allows the adaption of the device to the anatomy of the aorta. As reported by Della Barbera et al.<sup>(8)</sup>, the valve's atraumatic collapsing system does not affect the integrity of the device's leaflets.

### *Sutureless surgical technique*

In the SU-AVRs population, a partial upper sternotomy (J-sternotomy) in the third intercostal space or in the fourth intercostal space or a full median sternotomy was performed to obtain access to the aorta, according to the surgeon's preference. After systemic hepariniza-



**Figure 1.** The innovative sutureless Perceval bioprosthesis (Sorin Group S.p.A., Saluggia, Italy).

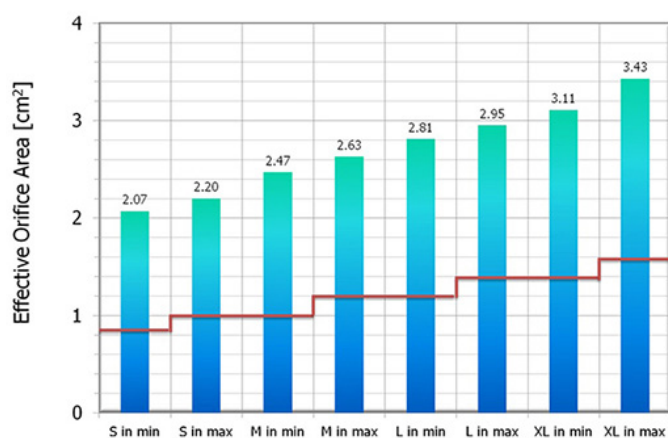
tion, a standard CPB was performed, cannulating the aorta, the right atrium and using a vent into the right superior pulmonary vein. After cross-clamping and the cardioplegia delivery, a transverse aortotomy was performed 1 cm distal to the sinotubular junction to avoid the device interference during the closure of the aortotomy. The native valve was removed and the annulus decalcified. The sizing of the annulus was performed using the designed Perceval sizer. The Perceval valve is available in 4 sizes: size S, to be implanted in annuli from 19 to 21 mm; size M, to be implanted in annuli from 21 to 23 mm; size L, for patients with annuli of 23 to 25 mm; and size XL, for diameters varying from 25 to 27 mm. Three 3-0 Prolene guiding sutures were positioned 2 mm below the nadir of the each native leaflet insertion line and then passed through the prosthesis' button hole to obtain a perfect alignment of the device. The valve was loaded onto an holder through a collapsing system and then deployed into the aortic root. A post-dilation with a balloon catheter at 4 Atm for 30 seconds and the instillation of warm saline solution guarantee the perfect positioning of the device. Then the guiding sutures are removed and the aorta is closed in the usual fashion (Prolene 5-0). The cross-clamp and the CPB are finally dismissed. Perceval and sutured implants were performed by two trained surgeon. In the B group, patients underwent a conventional AVR. The decision whether to implant the sutureless prosthesis or

the conventional one was left to the surgeon's current practice. All the patients, even in B group, were suitable for the Perceval device, accordingly to the anatomical criteria of implantation.

### Prosthesis comparison

Previous studies compared the sizes of the prosthesis to determine which valve is a better option for the patient and to prevent a patient-prosthesis mismatch. However, in most cases, the measures of the sizes provided by the manufacturers refer to the internal or the external diameter of the stent, regardless of the functional valve area.

Therefore, to give a precise theoretical analysis of the valve areas, we used the echographic projected EOA provided by the manufacturers (in vivo EOA for sutured bioprosthesis and in vitro EOA for Perceval valve). For the Perceval bioprosthesis, each size covers a range of 2 annular diameters, therefore the EOA reported by Sorin (Sorin Group S.p.A.) varies from 2,07 to 2,20 cm<sup>2</sup> for the S size; from 2,47 to 2,63 cm<sup>2</sup> for the M size; from 2,81 to 2,95 cm<sup>2</sup> for L size and from 3,11 to 3,43 for the XL size (Figure 2). The EOAs of the Hancock II valve provided by Medtronic (Medtronic, Minneapolis, MN, USA) were: 1,40 ± 0,50 cm<sup>2</sup> for size 21; 1,30 ± 0,20 cm<sup>2</sup> for size 23; and 1,40 ± 0,30 cm<sup>2</sup> for size 25. The EOAs of the Trifecta prosthesis defined by St. Jude (St. Jude Medical, Minneapolis, MN, USA) were 1,58 cm<sup>2</sup> and 1,94 cm<sup>2</sup> for size 19 and 23 respectively. The EOA of the Perimount valve size 23 provided by Carpentier-Edwards (Edwards Lifescience, Inc., Irvine, CA, USA) was 1,87 ± 0,28 cm<sup>2</sup>.



**Figure 2.** The image shows the Effective Orifice Areas of the Perceval bioprosthesis provided by Sorin Group S.p.A. For each prosthesis' nominal size (S-M-L-XL), the EOAs are expressed as a range (min-max) considering that each size covers a range of 2 annular diameters. The red line refers to the ISO 5840 minimal requirement. (Courtesy of Sorin Group S.p.A.).

### Statistical analysis

The statistical analysis was performed on the EOAs given by the manufacturers. In the sutureless bioprosthesis, the EOA is provided as a range, therefore, for a more convincing analysis, we used the smallest and less favourable EOA value for each size. However, the numerical diameter value of the Perceval prosthesis is reported as mean of the range (i.e. for S size, range 19-21 mm, we used 20 mm).

For the data analysis the IBM SPSS Statistic Version 22 software was used (Armonk, NY, USA). Continuous variables are reported as mean ± SD or median and

interquartile range [IQR], while categorical variables are expressed as absolute value and by frequency (%). For continuous variables, the normality of distribution was assessed with the Kolmogorov-Smirnov test. Differences between groups are calculated using Student's T test or Mann-Whitney's U test for normal and skewed variables respectively. Categorical variables were analyzed using the Fisher and  $\chi^2$  tests. A p-value  $<0,05$  was considered to indicate statistical significance.

## Results

### Patients' Characteristics

Patients' demographic is summarized in **Table 1**. Male patients were 41% and 80% in group A and B, respectively ( $p=0,1$ ). Patients' ages were similar between groups (A group:  $79,3\pm 3,5$  y.o. vs B group:  $74,2\pm 5,3$  y.o.;  $p=0,5$ ). The mean  $\pm$  SD Logistic EuroSCORE and STS mortality score were  $8,9\pm 2,7\%$  vs  $6,0\pm 2,3\%$  ( $p=0,3$ ) and  $2,7\pm 1,2$  vs  $1,9\pm 0,8\%$  ( $p=0,2$ ) for the sutureless and sutured groups, respectively. No differences were found analyzing obesity (30% vs 1%;  $p=0,4$ ), chronic obstructive pulmonary disease (COPD, 18% vs 20%,  $p=0,9$ ), diabetes (35% vs 20%;  $p=0,7$ ), stroke rate (6% vs 0%;  $p=0,4$ ) and polivascular disease (18% vs 20%;  $p=0,9$ ). In the sutureless group, 6 patients (35%) were admitted with a III-IV NYHA functional class, while in the sutured one there was only 1 patient (10%;  $p=0,2$ ). Preoperative transoesophageal echocardiograms reveal similar transvalvular mean ( $41,1\pm 13,0$  vs  $51,4\pm 11,8$  mmHg;  $p=0,5$ ) and peak gradients ( $66,3\pm 22,0$  vs  $79,4\pm 16,2$  mmHg;  $p=0,6$ ).

### Intraoperative Data

A minimally invasive access (III-IV intercostal space J-sternotomy) was adopted in 8 patients (47%) of the sutureless group ( $p=0,012$ ; **Table 1**). In all the patients who received a conventional sutured bioprosthesis, a full median sternotomy approach was performed. The cardiopulmonary bypass (CPB) time and cross-clamp time (XCT) were 61 [54; 89] vs 70 [61; 79] minutes ( $p=0,4$ ) and 44 [41; 68] vs 49 [47; 68] minutes ( $p=0,2$ ) in group A and B, respectively.

### Postoperative Results

Postoperative transthoracic echocardiograms show

a reduction of the transvalvular mean gradients (sutureless:  $11,9\pm 2,0$  vs sutured:  $13,8\pm 7,2$  mmHg;  $p=0,7$ ) and peak gradients (sutureless:  $21,7\pm 4,2$  vs sutured:  $22,2\pm 10,3$  mmHg;  $p=0,7$ ) in both groups. After surgery, only 1 case of more-than-mild aortic regurgitation was reported in the A group (6% vs 0%;  $p=0,4$ ), while no paravalvular leak (PVL) occurred (Table 1). A statistical difference between groups was found to be significant when analysing the need of transfusions ( $p=0,023$ ). No differences were registered when the rates of pacemaker implantation (PM, sutureless: 6% vs sutured: 0%;  $p=0,4$ ), acute kidney injury (AKI, 0%) and stroke (0%) were analyzed. The durations of total postoperative hospital stay (sutureless: 6 [6; 7] vs sutured: 4 [4; 7];  $p=0,4$ ) and the intensive care unit (ICU) stay (sutureless: 1 [1; 2] vs sutured: 1 [1; 1];  $p=0,6$ ) did not differ among groups. No in-hospital deaths were registered in both groups.

### Effective Orifice Area Analysis

The mean  $\pm$  SD size of the implanted bioprosthesis was  $23,1 \pm 1,9$  mm and  $23 \pm 1,6$  mm for group A (Perceval implanted, conventional valve measured) and B (conventional valve implanted, Perceval measured) respectively. In both groups there were significant differences between the EOAs of the implanted and the control sized prosthesis, always in favour of the sutureless Perceval valve. In fact, in the A group ( $n = 17$ ), the mean EOA of the Perceval implanted valve was  $2,6 \pm 0,3$  cm<sup>2</sup>, while the EOA of the measured conventional stented prosthesis which could fit the same annulus was only  $1,4 \pm 0,0$  cm<sup>2</sup>, with a significant statistical difference of  $p < 0,001$ . On the other side, in the B group ( $n = 10$ ), the mean EOA of the conventional stented prosthesis implanted was  $1,5 \pm 0,2$  cm<sup>2</sup>, while the EOA of the measured Perceval prosthesis which could fit the same annulus was  $2,9 \pm 0,3$  cm<sup>2</sup>. Even for group B, the statistical difference was significant ( $p < 0,001$ ) (**Figure 3**).

## Discussion

In this prospective observational study, we presented our population of 37 patients who underwent a SU-AVR at San Raffaele University Hospital, focusing on 17 patients (A group) who received a second sizing during surgery with a conventional valve sizer. In

**Table 1.** Patients' characteristics, intraoperative data and postoperative results.

Patients' demographics	A group (Perceval) (n=17)	B group (Sutured) (n = 10)	p-value
Age (y.o.)	79,3 ± 3,5	74,2 ± 5,3	0,5
Male patients (%)	7 (41)	8 (80)	0,1
Obesity (%)	5 (30)	1 (1)	0,4
BSA (m2)	1,79 ± 0,11	1,87 ± 0,09	0,9
COPD (%)	3 (18)	2 (20)	0,9
REDO (%)	0 (0)	0 (0)	-
Diabetes (%)	6 (35)	2 (20)	0,7
Preop Stroke (%)	1 (6)	0 (0)	0,4
Polivascular disease (%)	3 (18)	2 (20)	0,9
STS mortality score (%)	2,7 ± 1,2	1,9 ± 0,8	0,2
Logistic EuroSCORE (%)	8,9 ± 2,7	6,0 ± 2,3	0,3
NYHA III-IV (%)	6 (35)	1 (10)	0,2
Preop transaortic mean gradient (mmHg)	41,1 ± 13,0	51,4 ± 11,8	0,51
Preop transaortic peak gradient (mmHg)	66,3 ± 22,0	79,4 ± 16,2	0,62
Annulus (mm)	22,5 [20,0; 23,3]	21,0 [20,5; 24,3]	0,6
Preop Aortic regurgitation ≥ 2+ (%)	4 (24)	3 (30)	0,7
Ministernotomy (%)	8 (47)	0 (0)	0,012
CPB time (min)	61 [54; 89]	70 [61; 79]	0,4
XCT (min)	44 [41; 68]	49 [47; 68]	0,2
Postop transaortic mean gradient (mmHg)	11,9 ± 2,0	13,8 ± 7,2	0,7
Postop transaortic peak gradient (mmHg)	21,7 ± 4,2	22,2 ± 10,3	0,7
Postop Aortic regurgitation ≥ 2+ (%)	1 (6)	0 (0)	0,4
PVL (%)	0 (0)	0 (0)	-
Acute Kidney Injury (%)	0 (0)	0 (0)	-
Postop Stroke (%)	0 (0)	0 (0)	-
Bleeding requiring surgical revision (%)	1 (6)	0 (0)	0,4
PM (%)	1 (6)	0 (0)	0,4
Blood Units transfusions	0 [0; 3]	0 [0; 0]	0,023
ICU stay (days)	1 [1; 2]	1 [1; 1]	0,6
Postoperative hospital stay (days)	6 [6; 7]	4 [4; 7]	0,4
In-hospital death (%)	0 (0)	0 (0)	-

BSA = Body Surface Area; COPD = Chronic Obstructive Pulmonary Disease; NYHA = New York Heart Association functional class; CPB = Cardiopulmonary Bypass; XCT = Cross-Clamp Time; PVL = Paravalvular Leaks; PM = Pacemaker; ICU = Intensive Care Unit



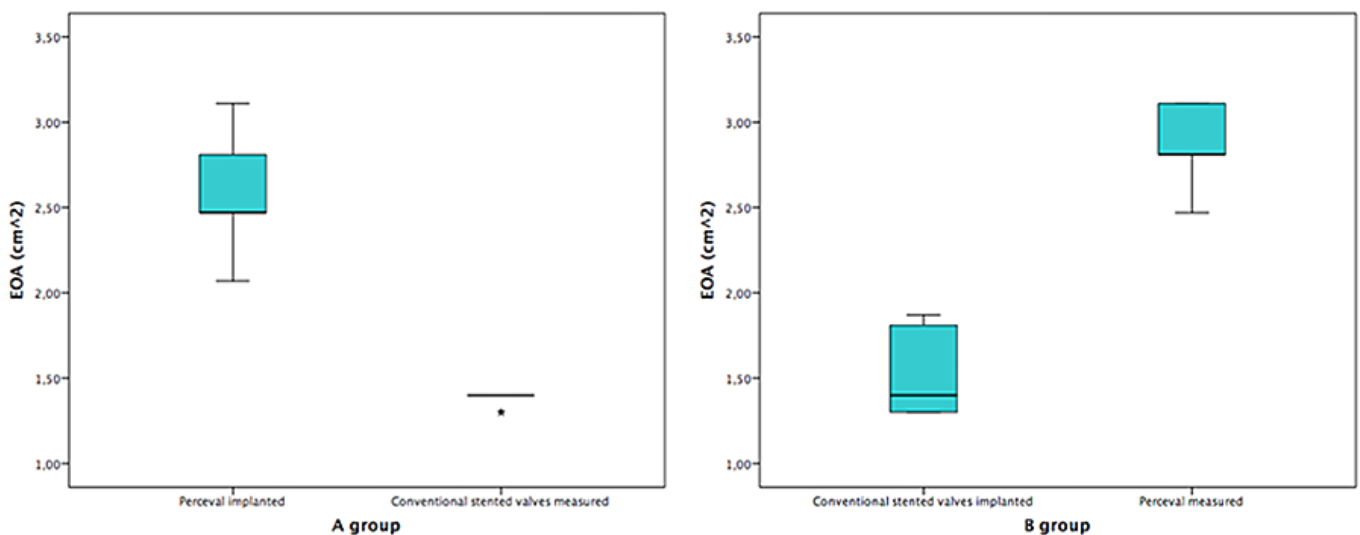
addition, during 10 conventional sutured AVRs which took place in the same period (B group), another sizing with the Perceval dedicated sizer was performed. The idea of a sutureless valve prosthesis was first described by Magovern and Cromie in 1962.<sup>(9)</sup> The Perceval bio-prosthesis does not need to be sutured, therefore it can be rapidly deployed, with the consequent reduction of cross-clamp time and CPB, minimizing the patients' risk.<sup>(10,11)</sup> However, the advantages of the innovative sutureless bioprosthesis seem to go far beyond. The groups of Santarpino et al. and König et al. were the first to analyze the differences between sizes of the Perceval sutureless and the conventional stented valves.<sup>(1,12)</sup> However, in most cases, the measures provided by the manufacturers refer to the internal or the external diameter of the stent, without specifying the functional valve area. There is no correspondence among the sizes of different sutured valves. In fact the numerical prosthetic diameter is not standardized.<sup>(13)</sup> Any previous analysis focusing on the prosthesis nominal size appear to be reductive for our purpose. Therefore, to have a more precise theoretical comparison of the valve areas and their performance, we used the echocardiographic EOA provided by the prosthesis' producers in a case/control fashion study to reduce the bias. To the authors' knowledge, considering the design of the study, this is the first theoretical analysis which compares the EOAs of the sutureless and the conventional prosthesis. Furthermore, in the transcatheter implantation era, the choice

of a sutureless device with a larger EOA ensures a great Valve-in-Valve feasibility.<sup>(14)</sup>

A limitation to our analysis consists of the use of projected EOAs values provided by the manufacturers. As a matter of fact, in the immediate intraoperative/postoperative period, considering the hemodynamic variability due to the surgical catecholamine stress and volume load, the use of the continuity equation as a reliable method to estimate the EOA is still debated. However, during the follow-up, the 3-6 months transthoracic ecocardiography of the first patients in group A showed that the measured EOAs are quite similar to those provided by the manufacturers. Another major drawback of our study is the relatively small number of patients. The use of three different types of sutured valves in the AVR group could be considered as a possible limitation because each valve has a different design and EOAs. On the other hand, it confirms the largest Perceval areas compared to various sutured valves considered. A longer follow-up of the patients included in this study is necessary to determine clinical outcome differences among groups. Finally, this is an observational prospective study not of randomized design, therefore not recognized bias could occur.

## Conclusion

Previous studies compared nominal sizes regardless of the EOAs. For the first time, we analyzed the theoret-



**Figure 3.** The boxplots show the significant statistical difference between the EOAs of the implanted and the measured valves in both groups (A-B) always in favour of the sutureless Perceval bioprosthesis.

ical EOAs of the sutureless versus sutured bioprosthesis. For every single patient considered, the EOA was significantly larger with the sutureless rather than with the sutured bioprosthesis that could fit. In SU-AVRs, the benefits go far beyond the CPB and cross-clamp time reduction, providing larger EOAs resulting in a better hemodynamics performance and less risk of patient-

prosthesis mismatch. However, well-designed clinical randomized trials are necessary to confirm this trend and to fully compare the hemodynamic parameters.

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# Surgical Resection of Myxoma with Treated Pulmonary Hypertension: Case Report

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## Introduction

Pulmonary arterial hypertension (PAH), can be defined as mean pulmonary artery pressure (PAP) is higher than 25 mmHg during resting whereas higher than 30mmHg during exercising. Although it progresses asymptotically for years, most frequently comes out as exertional dyspnea.<sup>(1)</sup> Since prognosis changes depending on the reason beneath, its mortality is high if it is not treated. Right ventricle dilatation and right ventricle failure is inevitable in untreated facts. As there are various classification methods, in 2008 at last DANA Classification was developed by protecting general philosophical approaches and structure. (**Table 1**)<sup>(2)</sup> As it is seen in this classification pulmonary arterial hypertension (PAH) confronts us rarely depending on left atrial myxoma. In this article in a fact applied with respiratory disorder, giant left

atrial myxoma causing pulmonary hypertension was obtained in echocardiographic examination (EKO). A fact that the complaints recovered after myxoma surgical treatment was presented.

## Case

40 year old female patient was admitted to department of chest diseases intermittently with dyspnea for 3 months. She was applied to bronchodilator therapy (**Picture 1**). After treatment there was not any regression in complaints of patient. The patient does not have any known disease. The patients was sent to our clinic for advance inspection and treatment. In her echocardiographic examination left ventriculous fraction (LVEF) was 50%, systolic PAB was measured as 80mmHg and a bulk in left atrium with 77x29mm size, moving, compatible with myxoma was obtained (**Picture 2**). Coronary angiography was performed and reported normal.

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The patient was decided to have surgical resection of myxoma via right atriotomy under cardiopulmonary by-pass (**Picture 3**). The pathological examination of bulk was reported as myxoma morphology involving calcification centres. After intensive care and clinical follow ups the patient was discharged from hospital with healing. In echocardiography done after 2 months from operation, no bulk recurrence was obtained. The complaints of respiratory disorders regressed. As LVEF: 50% and sPAB:33 mmHg was reported. In the result of EKO done in 2nd year control of patient that continued routine polyclinical follow ups, as sPAB<35mmHg, LVEF: 50% was reported.

## Discussion

PAH is a slowly progressing disease that is diagnosed late and it is most frequently seen in 3rd-4th decade of women.<sup>(1)</sup> PAH patients are defined as primary since there was no other disease beneath. In secondary PAH left heart failure, chronic lung diseases, hypoxemia reasons, infections, rheumatic diseases can be counted. In a study done with 187 patients the most frequently seen symptom was reported as exertional dyspnea. Fatigue, chest pain, syncope, leg oedema and tachycardia were reported as other symptoms.<sup>(1,3)</sup> Various classifications were done by updating datas regarding disease. Some regulations were done by protecting structure and general philosophic approach in Evian-Venice classification modified in 2004 with taking new datas in Dana Point, California in 2008 into consideration.

In this classification that is called as DANA Classification PHT obtained clinical situations were separated into five groups according to pathological, physiopathological and therapeutic properties. Although there are same level of increases in PAP values of different clinical groups and pulmonary vascular resistance values, mechanisms, diagnostic approaches beneath them and their prognostic and therapeutic results are completely different from eachother.<sup>(2)</sup> PAH in the second group of DANA classification that is connected with left heart diseases, is seen in frequently protected and low LVEF cardiac insufficiency patients.<sup>(4)</sup>

The patients in this group are formed of generally old, female gender, having systemic hypertension histo-

ry and metabolic syndrome properties in most of them.<sup>(5,6)</sup> Some of the rare conditions within this group are left atrial myxoma or conditions following pulmonary venous flow resistance increase that develop depending on cor triatum.<sup>(7)</sup>

Myxoma that is rarely seen, comes out in our fact as the reason of pulmonary hypertension. Myxomas are most frequently seen in left atrium (75%) can also be seen in right atrium (15-20%), right ventricle (6%) and rarely in left ventricle. They do not generally show symptoms.<sup>(8)</sup> Symptoms cause systemic embolies in cardiac cavities they place in by making obstruction or deformation on valves. In the study that Yıldırım et. al published, left atrial myxoma in EKO of 2 facts having respiratory disorder, was obtained. Respiratory disorder complaint of patient got better after a successful surgery.<sup>(9)</sup> Zaher et. al presented a patient having stomachache and respiratory disorder which they found myxoma accidentally in tomography.

They reported that the symptoms of patient got better after a successful surgery.<sup>(10)</sup> Again Schauer et. al. found myxoma as an etiologic reason in a patient having dyspnea and hemoptysis. The patient was treated with a successful surgery.<sup>(11)</sup> Also in our case the symptoms of patient disappeared dramatically after surgical resection. In transthoracic echocardiography done for follow ups, it was seen that PAH got better. In addition to the inspections, transthoracical echocardiography done to the patient that his symptoms came out in the last two years. In detection of PAP, echocardiography the sensitivity was in 0,79-1, specificity was in 0,69-0,98 interval.<sup>(1)</sup> Since it is an easy used method after a detailed physical examination, it comes out as a beneficial method in patients having respiratory disorder. Also the complaint of our patient was respiratory disorder.

In addition to inspections the patient was evaluated with echocardiography and systolic PAP was obtained as 80 mmHg. A severe PAH was observed in patient. In addition to this, when the reasons beneath were examined any reason could not obtained except left atrial myxoma. After surgical myxoma resection, in his follow ups it was seen that exertional dyspnea regressed. Systolic PAP values of patient were observed normal in echocardiographies done after 6 months and 2 year.

As it is seen from the fact that left atrial myxoma that is mentioned in the second group of DANA classification can come out rarely as being the reason of PAH. The treatment of cardiac myxomas are surgical with very successful results.<sup>(7,10,11)</sup> We believe that taking the result of echocardiography which is a simple technique, into consideration will be life saving in order not to miss out the reasons beneath respiratory disordered patients.

**Declaration of Conflict of Interests**

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<b>Group 1</b>	<b>Pulmonary Arterial Hypertension</b>	<b>Idiopathic, Genetic, Depending on medicine and toxins or other diseases (Collagenosis, HIV, Portal Hypertension, Chronicle Hemolytic Anemia, Congenital Heart Disease)</b>
<b>Group 2</b>	<b>Depending on Left Heart Disease</b>	<b>Systolic disfunction, Diasytolic disfunction, valvular disease</b>
<b>Group 3</b>	<b>Pulmonary hypertension depending on lung diseases and / or hypoxy</b>	<b>COLD, Interstitial lung disease, Respiratory disorders during sleep, luns diseases such as Alveolar hypoventilation disorders</b>
<b>Group 4</b>	<b>Chronical thromboembolic pulmonary hypertension</b>	
<b>Group 5</b>	<b>PH with aspecific mechanisms and / or multi factored</b>	<b>a. Hematological disorders b. Systemic disorders c. Metabolic disorders d. Others (tumoural obstruction, fibrous mediastinitis, depending on dialysis CRI)</b>

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# Aneurysm of The Ascending Aorta in A Six Year Old Girl: Case Report

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## Introduction

The aorta is the largest artery in the body and is the blood vessel that carries oxygen-rich blood away from the heart to all parts of the body. An aortic aneurysm is bulging out of the walls of the aorta. Aortic aneurysm is exceptional in children. It is a serious condition because of the risk of rupture requiring urgent surgery.

Diagnosing a thoracic aneurysm is difficult because often there are no symptoms, and often the condition goes undiagnosed until a rupture occurs. The diagnosis is based on the Computed tomography (CT) scan and Magnetic resonance imaging (MRI).

## Case

This case is for us an opportunity to show that children are not save this disease.

We report the case of 06 years old children school girl 3<sup>rd</sup> a sibling of four children from a non consanguineous marriage without a history who presents since some moths a turgor of jugular vein.

### *Physical examination without Abnormalities:*

Without hypermobile joints, chest deformities, long and thin fingers, kyphoscoliosis, high palate, inguinal hernias, and/or arachnodactilia.

*Weight:* 16kg. / *Size:* 117cm.

**X ray radiograph:** Showed a CTI: 0, 44 with enlargement of the upper mediastinum.

**Electrocardiogram:** Showed regular sinus rhythm and heart rate to 80 beats per minute.

### **Echocardiography:**

*Aortic ring:* 15 mm;

*Valsalva Sinus:* 19 mm;

*Sinotubulaire:* 17 mm ;

*Ascending aorta:* 50 mm ;

*Left ventricle:* 35 /21 mm;

*Left atrium:* 21 mm;

*EF:* 71%, *RF:* 39%;

*Systolic pulmonary artery pressure:* 31 mm hg.

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**Computed tomography (CT) angio scan:** was realized showing: Fusiform aneurysm of the ascending aorta, aortic arch and descending aorta's normal caliber. Trunk innominate artery place left to return to right jugular. Right jugular vein dilated by compression of SVC. Emphysema under pleural right bubble.

The patient was operated under cardiopulmonary bypass established between the superior ascending aorta aneurysmal and right atrium. The approach was sternotomy. The per operative exploration was aortic aneurysm with normal size of sinus and aortic cusps three non-revised. The intervention had after resection of the superior ascending aorta aneurysmal in restoration of aortic continuity by Dacron tube implanted in termino terminale.

*Aortic clamping:* 36 mn, duration of CPB: 58 mn. The suite immediate post operating was unfavorable with death of patient with inflammatory syndrome and vasomotor refractory shock.

## Comments

The causes of ascending aortic aneurysm in children are varied. There are no real data about the incidence of aortic aneurysm in childhood. The low incidence of aortic aneurysm among children and young adults limits information about etiology, surgical indications, procedures of choice, and operative results. Aortic aneurysm can be important cause of mortality in children and adolescents.

Aortic aneurysm may be related to hereditary diseases (Marfan syndrome, Loeys –Dietz syndrome, Ehler-Danlos syndrome, Arterial Tortuosity Syndrome,

Cutis laxa syndrome, Alagille syndrome, and Noonan syndrome), or non genetic diseases (bicuspid aortic valve, coarctation of aorta, tetralogy of Fallot, and aortitis syndromes).

Among children who have aortic aneurysm, timing of surgical treatment should be weighed against life expectancy, underlying disease, the size and location of aneurysm and presence of dissection. It has been showed that beta blocker and ACE inhibitor therapy delay aortic surgery in patients with aortic aneurysm related Marfan syndrome.

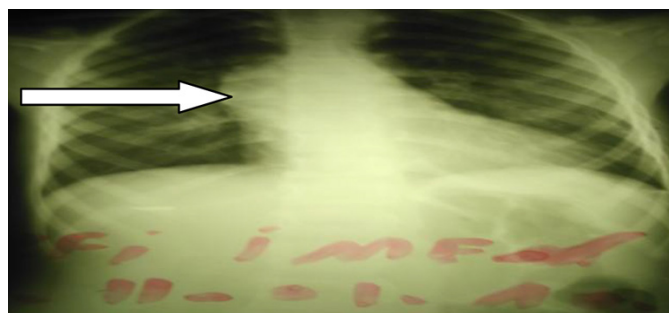
The indications of surgical treatment are aortic size over 5 cm, aneurysm growth rate exceeding 1 cm per-year, progressive aortic insufficiency, and familial history of early aortic dissection for most of aortic aneurysm patients. However, since the risk of dissection is higher in Loeys-Dietz syndrome, surgery is indicated even at lower diameters of the aorta.

## Conclusion

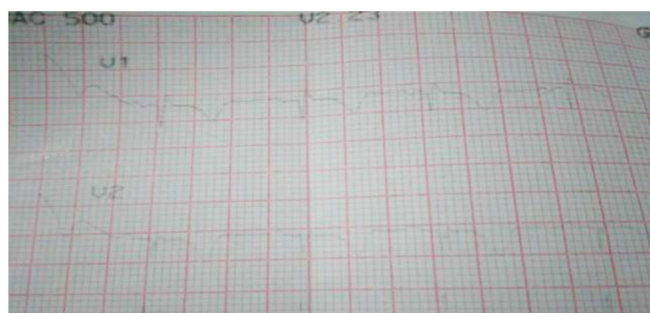
Aortic aneurysm is a rare but a life threatening condition in childhood. The CTangio and MRI angio are the examinations choice in detection of aortic aneurysm. The operative indication is formal in all cases of aneurysms of the ascending aorta. Spontaneous evolution is fatal. In fact there are treatments are the surgery.

We note the severity of the inflammatory syndrome in children. It is generally related to genetic hereditary syndromes. The patients who have predisposition to aortic aneurysm should be followed-up closely.

**Figure 1.** X ray radiography showing the enlargement of the upper mediastinum and convex right top edge.



**Figure 2.** Electrocardiogram showing a regular sinus rhythm.

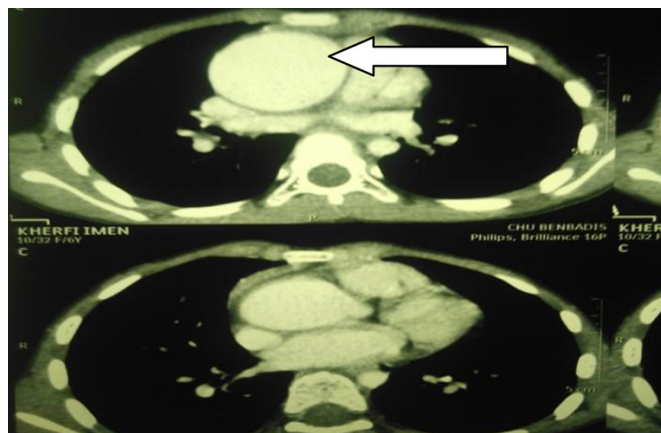




**Figure 3.** Echocardiography showing dilatation of ascending aorta.



**Figure 4.** CTAngio showing the aneurysm of the ascending aorta.



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