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AORTIC ROOT REPLACEMENT: CLASSICAL BENTALL VERSUS COPELAND'S MODIFICATION

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ABSTRACT

Objective: To compare the aortic root replacement with composite aortic valve graft and to analyze these techniques.

Study Design: Retrospective observational.

Place and Duration of Study: Armed Forces Institute of Cardiology and National Institute of Heart Diseases (AFIC / NIHD) Rawalpindi, between 2007 to 2016.

Material and Methods: Study was conducted at Armed Forces Institute of Cardiology and National Institute of Heart Diseases (AFIC / NIHD) Rawalpindi between 2007-2016, 59 patients underwent Aortic root replacement with composite aortic valved graft. Initial 28 patients underwent the Classical Bentall Procedure and in the last 31 patients Copeland's modification of Bentall procedure was employed.

Results: Mean age was 39.80 ± 14.24 and male to female ratio was 3:1. 13.6% patients had Marfan syndrome, 15.3% patients underwent concomitant Mitral Valve replacement. Statistically significant difference was observed between Classical and modified Bentall procedure in Cross Clamp Time (p=0.02), Total Inotrope Duration (p=0.01), Total Chest Drainage (p=0.04), Total Red Cell Concentrate (RCC) Transfused (p=0.01), Re-opening Rate (p=0.01) and Mortality (p=0.01).

Conclusion: Copeland's Modification of Bentall Procedure provides superior post-operative outcome as compared to the Classical Bentall procedure.

Keywords: Aortic root replacement, Ascending aortic aneurysms, Bentall procedure, Composite valved grafts, Copeland's modification.

INTRODUCTION

Bentall and De Bono pioneered the replacement of aortic root with a Composite Valved Graft (CVG) in 1968[1], and since then the procedure has been widely used for variety of pathologies of the aortic valve, sinuses of Valsalva and ascending aorta[2]. The major complications like post operative bleeding and pseudo aneurysm formation with the classical Bentall procedure lead to various modifications of the procedure[3,4]. All the modifications in classical procedure aimed to reduce the risk of suture line bleeding and its sequel.

At Armed Forces Institute of Cardiology and NIHD Rawalpindi the classical and modified procedures were in practice but more recently the Copeland modification has been adopted[5]. We share our experience of early post-operative outcome of this procedure.

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MATERIAL AND METHODS

From Cardiac Surgery Database of Armed Forces Institute of Cardiology and NIHD Rawalpindi consecutive patients admitted from January 2007 to December 2016, for Aortic Root Replacement with composite aortic valved graft. 59 patients were entered into the present study through purposive conveniance sampling. All the patients with ascending aortic aneurysm and who needed aortic root replacement were included in the study. All the emergency operations were excluded .

Between January 2007 till December 2011, Classical Bentall was in fashion at AFIC-NIHD Rawalpindi, and total 28 patients were operated during this time. Three patients had emergency

procedures for acute aortic dissection and were excluded from the study. From January 2012 till December 2016, the Copeland's modification of Bentall procedure was adopted, and 31 consecutive patients were included in the study excluding patients undergoing emergency procedure. In both the groups, patients with concomitant Mitral Valve replacement were also included. All patients underwent first-time procedure except one patient with Prosthetic Aortic Valve Endocarditis.

Operative Procedure

Cardiopulmonary bypass was established using high ascending aortic cannulation and 2-stage right atrial cannulation. Bicaval cannulation was used where indicated. In classical technique cardiac arrest was achieved by fibrillation followed by ante grade cardioplegia directly in coronary ostia. From January 2012 we used the modified technique and used both ante grade and retrograde cardioplegia. Cardiac venting was done through right upper pulmonary vein. After opening the aorta, the coronary buttons were excised with 5 mm collar of the aortic wall around the Ostia.

Table-I: Baseline patient characteristics.

Parameters	Type of Bentall Procedure	Mean	Std. Deviation	*p*-value
Patient Age	Classical (n=28)	39.80	14.238	0.407
	Copeland (n=31)	37.00	11.579	
Body Mass Index	Classical (n=28)	24.5830	2.58007	0.967
	Copeland (n=31)	24.6110	2.64226	
Body Surface Area	Classical (n=28)	1.7473	.14379	0.959
	Copeland (n=31)	1.7490	.10196	

Table-II: Disease characteristics.

Parameters		Type of bentall procedure		*p*-value
		Classical (n=28)	Copeland (n=31)	
Gender	Male	23 (82.1%)	22(71%)	0.771
	Female	05 (17.9%)	09(29%)	
Main pathology	AR	26(92.8%)	26 (83.8%)	0.254
	AR+MR	02(7.1%)	05 (16.1%)	
Left ventricular ejection fraction	Good	26 (92.8%)	29 (93.5%)	0.265
	Moderate	02 (7.1%)	02 (6.4%)	
Marfan syndrome	No	25 (89.3%)	26(83.9%)	0.91
	Yes	03(10.7%)	05(16.1%)	
Shortness of breath	Class-I	4 (14.3%)	3(9.6%)	0.271
	Class-II	14 (50%)	13(41.9%)	
	Class-III	10 (35.7%)	15(48.4%)	
Angina score	I	26 (92.8%)	30 (96.8%)	0.315
	II	02 (7.1%)	1(3.2%)	
Concomitant procedure	None	25 (89.3%)	26 (83.8%)	0.472
	MVR	03 (10.7%)	05 (16.1%)	

Classical Bentall: The aortic wall was left intact till last for wrapping around the composite valved graft. Proximally the sewing ring of the aortic valve was sutured to the aortic annulus with interrupted non-absorbable suture. Two circular defects in the composite graft were fashioned for the right and left coronary arteries using ophthalmic cautery. The aortic tissue surrounding the coronary Ostia were directly sutured to these openings in the composite graft with 5/0 polypropylene in continuous fashion. The graft length was sized and distal aortic anastamosis was made within the interior of the aorta with 3/0 polypropylene in continuous fashion. Finally, the aneurysmal aortic wall was tightly wrapped and closed over the conduit.

Table-III: Comparison of classical and modified bentall procedure–quantitative data.

Parameters	Type of Bentall Procedure	Mean	Std. Deviation	*p*-value
Bypass Time (min)	Classical (n=28)	156.80	44.615	0.266
	Copeland (n=31)	205.60	73.791	
Cross Clamp Time (min)	Classical (n=28)	111.20	29.559	0.02
	Copeland (n=31)	150.10	62.637	
Maximum Inotropic Score	Classical (n=28)	20.800	14.5407	0.089
	Copeland (n=31)	17.300	9.5690	
Total Inotrope Duration (Hrs)	Classical (n=28)	127.90	204.829	0.009
	Copeland (n=31)	44.90	10.203	
Duration of Ventilation (Hrs)	Classical (n=28)	51.15	159.703	0.165
	Copeland (n=31)	8.80	3.120	
Total ICU stay (Hrs)	Classical (n=28)	120.15	219.611	0.074
	Copeland (n=31)	39.50	30.519	
Total days stayed in hospital	Classical (n=28)	13.21	5.147	0.403
	Copeland (n=31)	11.67	1.871	
Total Chest Drainage (ml)	Classical (n=28)	1256.00	512.470	0.042
	Copeland (n=31)	619.00	205.775	
Total RCC Transfused (ml)	Classical (n=28)	1212.50	638.228	0.011
	Copeland (n=31)	315.00	303.727	

Table-IV: Comparison of classical and modified bentall procedure–descriptive data.

Parameters	Type of Bentall Procedure	Percentage	*p*-value
Dysrythmias	Classical (n=28)	35.7 (n=10)	0.26
	Copeland (n=31)	25.8 (n=9)	
Re-opening rate	Classical (n=28)	21.4 (n=6)	<0.01
	Copeland (n=31)	3.2 (n=1)	
Mortality	Classical (n=28)	25 (n=7)	<0.01
	Copeland (n=31)	9.7 (n=3)	

Copeland's Modification of Bentall: The diseased aortic wall was removed leaving behind a 3-4 mm cuff of aortic wall proximally above the valve commissures (figure). Distally aorta was transected 2-3 cm proximal to the innominate artery. Proximally the sewing ring of the aortic valve was sutured to the aortic annulus with interrupted non-absorbable suture by passing the sutures through the lower flange of the sewing ring. Then 3/0 polypropylene suture was used in running fashion between the cut edge of the proximal aorta and the upper flange of the sewing ring. The coronary buttons were anastomosed to the openings in the composite graft. The graft length was sized and distal anastomosis was done between the graft and distal aorta. Fibrin Glue was sprayed on all the suture lines 5 minutes before removing the aortic cross clamp in both the groups. De-airing and decannulation were done in standard fashion in both the groups.

The Outcome

The patients were observed for postoperative outcome till discharge from hospital. The major outcomes were mortality, ventilation time, Inotrope score, major bleeding, ICU and hospital stay.

Data analysis was carried out using SPSS 18. Quantitative data was described as mean ± standard deviation whereas qualitative data was described as frequencies and proportions. Various differences between the two groups were compared using students t-test for quantitative data and chi square test for frequencies and proportions, assuming a *p*-value of <0.05 as significant.

RESULTS

The baseline patient characteristics of both the groups are shown in table-I. The disease characteristics are shown in table-II. Operative details, Post operative outcome and comparison between the Classical and Modified Bentall Procedures are shown in table-III and IV.

Mean age was 39.80 ± 14.24 with male to female ratio of 3:1. Overall mortality was 16.95%. Statistically significant difference was observed between Classical and Modified Bentall procedure in Cross Clamp Time, Total Inotrope Duration, Total Chest Drainage, Total Red Cell Concentrate (RCC) Transfused, Re-opening Rate and Mortality.

DISCUSSION

Since its introduction in 1968[1], CVG for replacement of the aortic valve and ascending aorta has led to increased life expectancy for patients with Marfan syndrome (MFS). CVG is also indicated in non-MFS annulo-aortic ectasia, ascending aortic aneurysms with concomitant aortic valve disease including mega-aorta syndromes, patients undergoing repair of type A aortic dissection and certain cases of complex endocarditis. It may be an isolated procedure or combined with other aortic procedures such as arch replacement, Coronary Artery Bypass Grafting or with Mitral Valve Replacement.

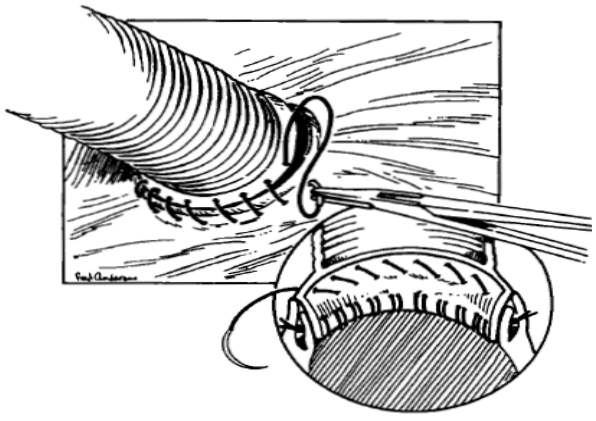

Figure: Running suture line between the cut edge of the aortic wall and the distal portion of the valve sewing ring. The insert shows a cutaway view from the inside.

A major weakness in the replacement of the aortic valve and ascending aorta with CVG is bleeding from the proximal suture line. In the Classical Bentall technique, formation of pseudoaneurysms at sites of tissue to conduit anastomosis, has been a troublesome late complication of this technique[6,7]. Such a complication has been attributed to undue

tension developing at the suture line of the side-to-side coronary anastomosis in large aneurysms, or by blood accumulation inside the aortic wrap[8]. This has in turn led some surgeons[9] to construction of an aorto-right a trial shunt decompression but procedure has been attributed to increased morbidity due to fistula formation.

Various modifications in the classical procedure have been made over time to deal with these complications. Dusko Nezic et al adopted 'a collar technique' to improve hemostasis around coronary buttons and proximal anastomosis[10]. Proximal aorta wall 1cm beyond the coronary anastomosis is left intact. It is then wrapped and anastomosed around the coronary and proximal anastomosis to secure the potential bleeding sites. The author however did not provide a comparison with the classical procedure. Copeland et al[5] abandoned the wrap technique and adopted an uncovered graft technique. Proximally the aorta is transected a few millimeters above the valve commissures and distally 2 to 3 cm proximal to the innominate artery. Horizontal mattress sutures are placed in an aorta to ventricle orientation circumferentially through the aortic valve annulus. These sutures (2-0 ethylene terephthalate–with Dacron pledget) are then passed closely through the lower flange of the aortic prosthesis sewing ring. After sutures are tied down, the lower edge of the prosthesis lies in an intra-annular position. Then a running 3-0 polypropylene suture is used between the cut edge of the proximal aorta and the upper flange of the prosthetic valve (fig). The coronary buttons are anastomosed in the standard fashion keeping them uncovered. Copeland used this technique in 5 patients without giving any comparison with the classical technique.

Till end 2011 we had been using the Classical Technique. Since then surgical paradigm at our centre shifted in the favor of Copeland's modification as a standard technique. Though a small study population, yet a statistically significant difference was observed in the Cross Clamp Time, Total Inotrope Duration, Total Chest Drainage, Total RCC Transfused, Re-opening Rate and Mortality between the two procedures; supporting the paradigm that a water tight proximal suture line is better achieved with Copeland's modification and makes the corner stone of the overall superior outcome. Though not significant but the Copeland's modification had a relatively low inotropic score, shorter duration of ventilation and shorter ICU stay.

Eight patients (13.5%) had concomitant Mitral Valve disease and underwent mitral Valve replacement in addition to Bentall. All the patients did well post operatively without any significant complication. One patient presented with Prosthetic Aortic Valve Endocarditis. Per operatively the ascending aorta was involved in the disease process having abscesses and sinuses. The aortic wall was fragile and necessitated root replacement. The previous prosthesis was explanted, ascending aorta removed and Composite Aortic Valved Graft was used. The patient died due to excessive bleeding from the suture line postoperatively. This patient was not included in the study, and all patients with emergency root replacements for aortic dissections to remove any bias.

The study has its limitations. The patient population is small. Also we could not provide long term results with this procedure. We recommend a study with larger patient population, studying the outcome at 06 and 12 months post operatively.

CONCLUSION

Copeland's modification of the Bentall Procedure provides more hemostatic proximal suture line which results in less post operative bleeding thus less transfusion requirement improving the overall early post-operative outcome.

The procedure is easy to reproduce and expected to avoid the post-operative pseudo-aneurysm formation which was one of the major long term sequels of the classical technique. A long term follow up is required to compare both the procedures for such complications.

CONFLICT OF INTEREST

This study has no conflict of interest to declare by any author.

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