Early and Mid-Term Outcomes in Patients Undergoing Aortic Root Replacement in Rajaie Heart Center

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Abstract

Background- Aortic root reconstruction remains a challenging surgical procedure. Although several surgical approaches have been introduced, but their mortality and morbidity rate are still high. This study was carried out to evaluate the early and mid-term outcome of aortic root replacement in a referral center in Iran.

Methods- Between March 1993 and April 2003, 83 patients who underwent Bentall operation were studied. The mean age was 43.2±14 years, ranging from 10 to 78 years old. 78.3% of cases were male. Dyspnea and chest pain were the most common complaints. Aortic dissection (type A) was seen in 28% of cases and 24% had Marfan syndrome. Emergent operation was done in 18.1%. The average cardiopulmonary bypass (CPB) time was 155.3±61 minutes and aortic cross clamp time was 106.8±35 minutes. Follow-up period ranged from 1 to 120 months with a mean of 29.6±28 months.

Results- The overall mortality rate was 15.7% (13 cases). Eleven deaths occurred in the hospital during the early postoperative days, and two deaths occurred within the follow-up period. Severe left ventricular failure, sepsis and bleeding were the most important causes of death. Two deaths occurred as a result of resistant tachyarrhythmia and acute MI. The mortality rate was significantly higher in those who presented with cardiogenic shock, had longer CPB and aortic cross clamping (AOX) time and finally in the cases with concomitant coronary artery bypass graft (CABG) surgery. Age, sex, underlying disease, pathology, ejection fraction, surgeon, emergent operation, Marfan syndrome, surgical techniques, amount of post- operative bleeding and the severity of aortic insufficiency did not affect mortality significantly. The neurological problems and postoperative mediastinal bleeding were the most common complications.

Conclusion- The early mortality rate in our series was relatively higher than the other studies; however, the mid-term survival in our series was excellent. The clear risk factors for early mortality in our investigation were CBP time>180min, AOX>120min, presentation with cardiogenic shock and concomitant CABG. Despite the previous reports, factors like emergent operation, age>65 and LVEF<40% were not predictors for higher mortality rates in our study. We hope to offer a better prognosis by improvement of operative technique, good myocardial and cerebral protection and reducing the CPB and AOX times ***(Iranian Heart Journal 2005; 6 (3): 6-14).***

Keywords: aortic root reconstruction Ë aortic dissection Ë aneurysm of ascending aortaË Bentall procedure.

Aortic root replacement remains a challenging surgical procedure.

Aortic dissection and aneurysm of ascending aorta are the two major indications for this procedure.

The prevalence of thoracic aortic aneurysms is difficult to determine because of underreporting of these aneurysms in mortality statistics.[1]

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Aortic aneurysms are the 13th leading cause of mortality in the United States.[2] The incidence of thoracic aortic aneurysms is estimated to be 5.9 cases per 100,000 person-years, and replacement of the ascending aorta accounts for the majority of thoracic aortic procedures.[2] Although several surgical methods have been introduced, their mortality and morbidity are still high (9-31%).[1,2]

Although some conservative methods such as aneurysm banding, plication and supra-coronary aortic replacement were described for patients with normal aortic valves during the last decade,[1,2] in cases with involvement of the aortic valve, annulus and valsalva sinus, the Bentall technique has been the preferred method in various reports.[2]

This study was performed to evaluate the early and mid term-results, and identification of predictors for early mortality and morbidity of aortic root reconstruction with the Bentall technique in the patients referred to our center.

Methods

This study included 83 patients who underwent aortic root replacement between 1993 and 2003 at Shaheed Rajaie Cardiovascular Medical Center, Tehran. Data were collected retrospectively from medical and operative records. Statistical analysis was done using SPSS software (version 11) and t-test, chi-square and Fisher exact tests. $P<0.05$ was considered significant.

All patients were followed up ranging from 1-120 months (mean 29.6±28). The first control visit was done at one month after surgery and continued every 6 months. Those cases that could not come to medical visits were excluded from the study. Physical examination, transthoracic echocardiography, CXR and ECG were done on all patients. Transesophageal echocardiography, CT-scan or exercise tolerance test were done as indicated. Preoperative characteristics of cases are shown in Table I.

Table I. Preoperative characteristics of the patients

Variable	Number (%)	
No of Patients:		
Total	83	
Male	65	(78.3%)
Female	18	(21.7%)
Age:		
Mean	43.2	(10-78 yr)
<40 yr.	34	(42.6%)
40-60 yr.	40	(46.6%)
>60 yr.	9	(10.8%)
Length of hospitalization: Days	23.2±15.5	
ICU admission: Days	3.8±3.4	
Chief Compliant of the Patient:		
DOE*	29	(35.4%)
Chest pain	11	(13.3%)
Cardiogenic shock	3	(3.7%)
Height: cm	170.7	(108-193)
Weight: kg	69.4	(45-107)
Underlying Disease:		
Hypertension	28	(32.5%)
Marfan syndrome	21	(25.3%)
CAD	6	(7.2%)
Diabetes mellitus	6	(7.2%)
Type of pathology:		
Acute type A dissection	23	(27.7%)
Annuloaortic ectasia	54	(64.9%)
Infective aneurysm	5	(6.2%)
Traumatic	1	(1.2%)
Emergent operation	16	(18%)
Re-operation	2	(2.4%)
Follow-up mean, months	29.6	(1-120)

* DOE: Dyspnea on exertion

Surgical Technique

Median sternotomy under general anesthesia was performed on all patients. The ascending aorta was cannulated in the majority of patients. Femoral arterial cannulation was done for the patients who had aortic dissection or if the aneurysm of the ascending aorta extended to the aortic arch, and also for the majority of re-operations.

A two-stage cannula was used for venous cannulation via the right atrium except in a few patients whose femoral vein was cannulated because of emergency status.

After establishment of cardiopulmonary bypass (CPB), blood or crystalloid cold cardioplegia and moderate hypothermia were applied to achieve cardiac arrest. Deep hypothermia was induced in two patients who had aortic arch involvement. Intermittent antegrade and retrograde cardioplegia were

applied only in one case. After a longitudinal aortotomy, aortic valve leaflets were excised. However in some cases that had a good native aortic valve, these leaflets were preserved and a modified procedure was performed.

In some instances where a composite graft (valve- conduit) was not available, a suitable size prosthetic valve was sewn to a Dacron tube graft with non-absorbable running sutures before prosthetic valve replacement.

The composite graft was sewn to the aortic annulus with a series of pledgetted mattress sutures of 2-0 Ethibond or with continuous 2-0 polypropylene sutures.

The button technique for coronary artery re-implantation, consisting of end-to-side anastomosis of the proximal end of the coronary arteries to the composite graft was employed in some cases.

In the other patients, the classic Bentall technique was performed, and a side-to-side anastomosis without excision of the coronary artery ostia from the aortic wall was created. For most of these anastomoses, a running 5-0 polypropylene stitch was used.

Early in our series, the Cabrol method for coronary re-implantation was used in four patients.

Selection of these surgical alternatives for coronary re-implantation was mainly based on the surgeon's preference.

Some surgeons supported these suture lines with fibrin glue in selected cases.

After transection of the distal end of the dissecting or aneurysmal segment of the ascending aorta, an end-to-end anastomosis with running 3-0 or 4-0 polypropylene suture was made.

Leakage from the suture lines was the most common problem during the procedure.

In order to control severe surgical bleeding, additional sutures with or without pledgets, application of fibrin glue and wrapping the whole newly formed ascending aorta with another extended Dacron or pericardial patch were used.

One of the surgeons prefers to preserve the native aortic wall and when needed, he supported the hemorrhagic suture lines by wrapping this native wall around the composite graft (as inclusion method), and then created an artificial fistula with a tube graft (Dacron or Goretex No. 6 to 8) to drain blood from the false lumen between the composite graft and native aortic wall to the right auricle. Although this was an iatrogenic left-to-right shunt, it had no significant homodynamic effects and thrombosed after a few days.

Packing of the mediastinum was the last way to control severe uncontrollable bleeding, especially when coagulopathy was the most probable cause of persistent bleeding.

De-airing, weaning from CPB, de-cannulation and wiring of sternum were done as usual. The operative data are shown in Table II.

Results

There were 83 cases in this series. The majority were male with a mean age of 43.2 years. Most patients presented with dyspnea on exertion (DOE) and chest pain. Hypertension and Marfan syndrome were the most common underlying disorders.

Approximately 28% of the cases were operated because of acute type A aortic dissection. We had one patient with traumatic ascending aortic aneurysm who needed aortic root reconstruction. Emergent operation was carried out in 18% of patients.

Table I and Figures 3 and 4 show the details of pre-operative characteristics of the patients. The operative data were shown in Table II.

Table II. Operative data

Variable	Number (%)
CPB time (min)	Mean: 155±61 (range 54-452)
Aortic cross clamp time (min)	Mean: 106±35 (range 39-276)
Deep hypothermic TCA (min)	2 Cases
Bentall technique:	69 (83.2%)
Modified technique:	13 (15.6%)
Cabrol method	4 (4.8%)
Supracoronary method	9 (10.8%)
Concomitant arch replacement	1 (1.2%)
Concomitant CABG	6 (7.2%)
Concomitant mitral valve repair or replacement	3 (3.6%)
Arterial Cannulation:	
Femoral	51 (60.8%)
Aortic	32 (39.2%)
Suture technique:	
Continuous sutures	51 (60.8%)
Interrupted sutures	32 (39.2%)

Mortality

The overall mortality rate was 15.7% (13 cases). The hospital death rate was 13.3% (11/83), which is significantly higher than the late mortality (2.4%).

The mortality rate for patients with Marfan syndrome was 10.5%, and 26.3% for acute aortic dissection (type A). Death rate for emergency operation was 26.6% versus 13.2% for elective surgeries. Although it seems the death rate is higher in emergency operations for acute aortic dissections, but this difference was not statistically significant (P>0.05, see Fig 1).

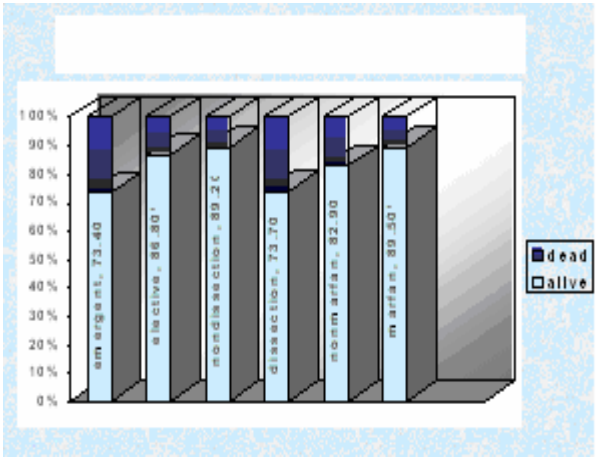

Fig.1. Mortality in patient subgroups.

The causes of death are presented in Table III. As seen, one of the late mortalities occurred due to acute myocardial infarction in a 78 year old male two years after surgical operation. The other one was a 49 year old man with Marfan syndrome, who died two months later of an unknown cause.

Table III: Causes of death (early and late mortality)

Cause	Number (%)
Early (hospital) death:	
-Cardiac failure (inability to wean from CPB*)	5 (38.4%)
-Sepsis and MOF**	3 (23.1%)
- Postoperative bleeding (severe, uncontrolled)	2 (15.4%)
-Refractory tachyarrhythmia	1 (7.7%)
Late death:	
-myocardial infarction	1 (7.7%)
-unknown	1 (7.7%)

*cardiopulmonary bypass
**multiple organ failure

The actuarial 5-year survival rate according to Kaplan-Mayer method was 82.1% (Fig. 2).

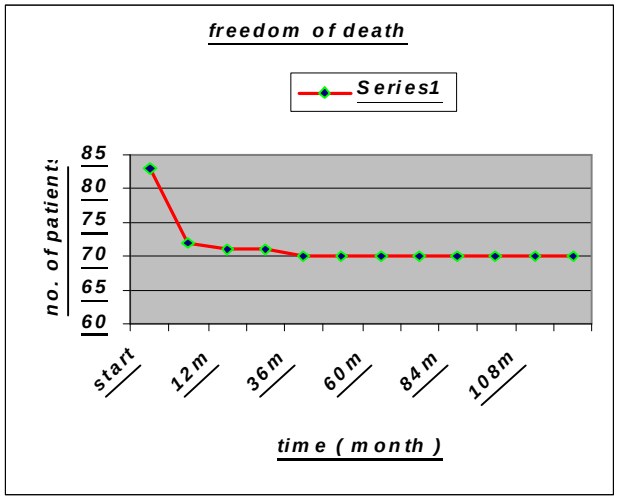

Fig. 2. Freedom from death during follow-up.

Morbidity

Intraoperative and postoperative bleeding were the most common problems in this series. Important mediastinal bleeding (defined as drainage of more than 1000cc during the first 12 hours) was seen in 20 patients (24%). Sixteen cases (18%) required additional measures for achievement of hemostasis. Mediastinal packing was required in 10 (62.5%) of these patients to achieve hemostasis. As you can see in Table III, severe uncontrollable bleeding resulted in intra-operative death in 2 cases. The mean postoperative mediastinal bleeding volume was 830.5±685 cc, ranging from 130 to 3850cc. Eighteen percent of them needed surgical intervention for control of bleeding, and in the other cases correction of coagulation defects was sufficient to achieve hemostasis.

Seventeen patients (20.5%) experienced temporary neurocognitive disorders and cereberovascular accidents were seen in 4.8%. Table IV shows the details of postoperative complications.

We had no cases of prosthetic valve malfunction, prosthetic valve endocarditis and mediastinitis that needed surgical intervention (TableIV).

Table IV: Incidence of postoperative complications

Variable	No (%)
Post-op bleeding(more than 1000cc/12h)	20 (24)
Re-operation for bleeding	16 (18)
Neurocognitive problems	17 (20.5)
Cerebrovascular accident	4 (4.8)
Tachyarrhythmia	14 (16.8)
Acute renal failure	10 (12.3)
Wound infection	2 (2.4)
Mediastinitis	None

Discussion

Contemporary surgical series on ascending aortic aneurysm using modern grafting techniques and methods of cerebral and myocardial protection report hospital mortality rates of 1.7% to 17.1%.[1,2,11,21] Comparison of outcomes is difficult, however, because of heterogeneity of patients, the proportion of aortic dissection emergent operations, re-operations and arch replacement is highly variable.[2] On the other hand the operative mortality for repair of acute aortic dissection has fallen since DeBakey's original 40% mortality was reported in 1965.[1,2] Improved ICU care of these patients, earlier recognition of dissection through improved imaging modalities, development of hemostatic vascular graft material, more effective hemostatic agents, and improvements in safety of cardiopulmonary bypass are likely responsible.[1,2,3] The introduction of aortic root replacement (ARR) with a composite graft according to the classic and modified Bentall techniques improved significantly the postoperative outcome, providing satisfactory early and long-term results, especially in patients with aortic dissection.[3,4] The alternative may be the ARR using an aortic homograft or pulmonary autograft with acceptable long-term results, but unfortunately such materials are not easily available in many cardiac surgical centers.[3] We used an aortic homograft in a 10 year- old girl who had severe aortic stenosis and severe calcified small aortic root, but unfortunately she died as a result of pump failure following

a prolonged cardiopulmonary bypass (>250 min) and aortic clamping times (>150 min). Although we use these homografts for RVOT reconstruction routinely, but our experiences in aortic position is limited. Omrani et al.[6] have shown excellent results using aortic homografts for aortic root replacement with zero rate of thromboemboli, endocarditis and re-operation after 35 months of follow-up, however, because of low availability of homograft in many patients we used composite grafts in the form of Bentall procedure. Complete ARR with composite graft has a number of advantages: [1,3,9]

1) All diseased aortic tissue is eliminated from the aortic root.
2) The operation is conceptually simple, feasible and well polarized [.3,8]
3) Composite grafts may be available in various sizes in all cardiac - surgery centers

The main disadvantage of such a technique may be a false aneurysm at the coronary artery re-implantation sites, due to coronary detachment from the composite graft, or obstruction and thrombosis when the Cabrol method is employed [.1,3,12]

False aneurysms were suggested in TTE during follow up for 2 cases in our series that inclusion technique was employed for them, but fortunately according to further evaluation (i.e. TEE and Chest CT scan) this complication was ruled out and surgical intervention was not indicated.

We used a modification of the classic Bentall's technique in 7 patients by creating a fistula with a Gore-tex tube graft (6-8mm) from the perigraft space to the right atrium, which would reduce the bleeding and probably late false aneurysm incidence. We recommend this additive procedure in selected cases, especially in dissecting aortic aneurysm and Marfan syndrome, because achievement of good hemostasis is a major problem in such patients. Usually this induced fistula obliterates after a few days and does not result in any complications.

Initially we believe that in patients undergoing A.R.R according to the classic Bentall technique, wrapping the native aortic wall (aneurysmal sac) around the prosthesis, as an inclusion method may reduce further tension between the graft and coronary artery and also may prevent catastrophic hemorrhagic complications. However, statistical analysis did not support this hypothesis and showed no significant difference between inclusion method and button technique with en-bloc resection in our study.

The overall mortality rate was 15.7% (11/83) in our series. This is higher than the previous reported studies.[1,2,21,22]

The hospital (early) mortality rate for patients undergoing emergency operation was 26.6% versus 13.2% for elective surgeries and 26.3% for those with aortic dissection.

The high early mortality rate in patients with aortic dissection is closely related to the complex type of aortic disease leading to complex surgical procedure, poor preoperative hemodynamic state, emergency status and presence of acute myocardial infarction due to dissected coronary sinuses.

In other reports, emergent operation, age>65 years, presence of aortic dissection, concomitant CABG, poor preoperative NYHA functional class, LVEF<35%, aortic arch replacement and prolonged CPB time were strong predictors of early death.[2,3,15,20,22] Such risk factors seem to be similar to our findings, although with some differences. We observed that the CPB time>180 min, aortic clamping time>120min, cardiogenic shock, concomitant CABG were the independent factors for early mortality (Table V). Although we have seen the correlation between the other known risk factors, such as age>65, aortic dissection, emergent operation and early death, but these findings were not confirmed statistically (see Table VI).

These differences may be due to the limited number of our cases.

Table V. Independent predictors for early hospital mortality.

Variable	P. Value
CPB* time > 180min	P<0.0001
AOX** time > 120min	P<0.0001
Cardiogenic shock	P<0.002
Concomitant CABG	P<0.02
Aortic dissection	P= 0.06 NS
Emergent operation	P= 0.07 NS
Operation technique	P=0.34 NS
Age > 65	P=0.08 NS
Aortic root diameter	P=0.98 NS
Marfan syndrome	P=0.37 NS
Pre operative LVEF*** < 40	P=0.69 NS

* Cardiopulmonary bypass time
** Aortic cross clamping time
*** Left ventricular ejection fraction

Also we found a strong correlation between coronary artery involvement and early mortality (P<0.001). Only 18.2% (2/11) of patients who died in hospital had normal coronary arteries. Table VII shows that all cases that died due to cardiac (Pump) failure had either coronary arteries involved in the dissection or coronary angiography was not performed in them.

Table VI: Correlation between perioperative variablesand early postoperative morbidity and mortality.

Mortality / Intraoperative variables	Early death11	Neurocognitive complications N=17	Myocardial infarction N=5	Respiratory failure N=6	Renal failure N=10	Arrhythmia N=23	Coagulopathy and surgical bleeding N=16
CPB>180 min N=15	6	3	3	3	3	3	8
AOX>120 min N=23	5	4	3	2	3	2	5
LVEF<35 N=8	3	3	1	3	1	2	1
Age>65 N=9	3	3	1	1	2	1	2
Surgical bleeding N=16	2	6	2	1	2	3	16
Concomitant CABG N=9	5	2	1	-	-	4	1
Aortic dissection N=22	4	7	3	4	3	3	9
Marfan syn. N=21	1	4	1	-	1	4	3

Table VII: Correlation of early hospital death and coronary artery involvement.

Cause of hospital death / Coronary angiography	Not studied 4 cases (36.3%)	Involved coronary artery 5 cases (45.5%)	Normal coronary artery 2(18.2%)
Cardiac failure	3	2	-
Surgical bleeding	-	1	1
Sepsis	-	1	1
M.O.S.F	1	-	-
Refractory Tachyarrhythmia	-	1	-

We evaluated the patients with Marfan's syndrome as a subgroup. The overall hospital mortality rate in this group was 4.4% which is similar to the previous reports.[3,7,16,17] We did not find significant correlation in mortality rates between patients with Marfan syndrome and non-marfanoid cases.

Late mortality in our series was only 2.4% (2/83) and we did not find any predictor factors for late death. The overall survival at mean follow-up of 5 years was 82.1% (Table VIII).

The higher rates of postoperative mediastinal bleeding and neurological complications in our patients may be resulted from more prevalence of aortic dissection.

The incidence of the other morbidities were similar, or even lower than the other reports.[1,3,9,11,17]

We observed that the early postoperative morbidities were correlated with prolong CPB and aortic clamping times, LVEF<35, concomitant CABG and aortic dissection.

The most common late morbidity was homodynamically non-significant paravalvular leak (7.2%) that occurred in those cases where composite graft was constructed by the surgeon himself.

There was no case of prosthetic valve malfunction, thromboembolic events or prosthetic valve endocarditis that needed re-operation during the follow up.

This means that the long term outcome in our series is better than the other

reports.[1, 3, 4, 15, 19, 22]

All survivors demonstrated a significant improvement of NYHA functional class, similar to other studies.[3,4,5,9]

Table VIII. Comparison of results between previous reports and our investigation.

Variable / Author & Date	Number of patients	Mean age (year)	Aortic dissection (%)	Marfan syndrome (%)	Early mortality (%)	Late survival 5-10 year (%)	Follow up mean (month)
Pacini(4) 2003	274	53.5	16.8	-	6.4	77.7	-
Ruvolo(24) 2002	105	?	16.4	26	7.6	84.7	-
Prifti(3) 2002	212	56	24.5	17.5	7.5	81.5	59±35
Gelsomino (5) 2002	72	58.3	26.3	12.5	6.9	91.7	86±23
Kirali(13) 2002	96	48.8	2.1	?	8.3	82.6	?
Houel(9) 2002	117	?	15.3	-	7.7	77.7	40±36
Westaby(11) 2000	140	53	-	23.5	5.7	79	?
Goudot(17) 1997	251	46.6	19.1	20.3	7.2	77.9	38±15
Bachet(18) 1996	203	44.8	17.2	22.6	7.3	77.9	46±10
Karl(14) 1999	244	54.8	-	-	7.8	76	Median =90
Fukada(7) 2002	72	?	31.1	100	7.9	80.6	?
Apaydin(15) 2002	86	48	14	-	6.9	77	33.23
Mingke(16) 1998	79	33.8	24	100	10.5	84.4	68±25
Aoyagi(21) 1994	66	42.5	7.6	51.5	10.6	79.7	?
Our study 2003	83	43.2	28	24	13.3	84.3	28.1±14

Conclusion

1) Aortic root replacement with composite grafts according to the Bentall's technique, is the best alternative in the centers that use of allograft has some difficulties such as technical problems in preservation , low experience of surgeon and poor availability.

2) The early mortality rate in our series was relatively higher than the other studies; however, we achieved excellent mid-term outcomes.

3) The clear risk factors for early mortality in our investigation were CPB time>180min, aortic clamping time>120min, presentation of patient with cardiogenic shock and concomitant CABG.

4) There were no correlation between surgical technique, type of prosthetic valve and graft, sewing method and early mortality and morbidity.

5) Despite previous reports, although we have seen a correlation between age>65, aortic dissection, emergent operation and early hospital death, but statistical analysis did not confirm these findings.

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