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Reoperation on the Aortic Root after Previous Cardiac Surgery: Predictors of Outcome

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Abstract

Background: Reoperations on the aortic root and the ascending aorta are being performed with increasing frequency and remain a challenging problem. The aim of our work is to study the surgical strategy, results and predictors of outcome of aortic root surgery in patients with previous cardiac operations.

Aim of Study: Is to report our experience with patients undergoing re-operation on the proximal thoracic aorta after previous cardiac surgery, to highlight special surgical considerations needed in this particular entity and to identify predictors of outcome.

Patients and Methods: Between 2008 and 2016, 35 patients had reoperation on the aortic root after previous Cardiac Surgery at Kasr Al-Aini Cardiac Surgery Unit, Cairo University. Their age ranged from 9 to 58 years. 4 patients had bicuspid aortic valve and 5 patients had Marfan syndrome. The main indication for reoperation was ascending aortic aneurysm (45.7%), followed by aortic valve pathology (22.9%), infective endocarditis involving the aortic root (17.1%) and type A aortic dissection (14.3%). 13 patients had modified Bentall procedure, 9 had supra coronary conduit replacement of ascending aorta, 5 had aortic valve replacement, 4 patients had supra coronary conduit and aortic valve replacement, 2 patients had biological root replacement with homograft, one patient had David procedure, and one patient had Bentall with Elephant trunk procedure.

Results: The mean cardio-pulmonary bypass time was 163± 10min and the mean cross clamp time 134 ±9min. Re-exploration for bleeding was needed in 2 patients. There was 5 in hospital mortality (14.3%): 3 due to multi organ failure due to sepsis of active endocarditis, 1 due to myocardial failure and 1 due to major uncontrollable bleeding.

Conclusion: Short-term survival following aortic root reoperation is good for patients with degenerative aneurysms and healed infection, acceptable in cases of dissection, poor in patients with active endocarditis.

Long bypass time, active infection, time interval between surgeries less than one year were independent predictors of mortality.

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Key Words: *Re-operation – Root surgery – False aneurysm – Dissection.*

Introduction

RE-OPERATION on patients with previous cardiac surgery, especially with previous aortic root operation, represents a big challenge for cardiothoracic surgeons. Extensive adhesions, manipulation of patent bypass grafts, and management of previously inserted valve prostheses may result in higher mortality and morbidity. Re-operation on thoracic aorta reported to have relatively high mortality rates ranging from 8% to 15% **[1,2]**.

Indications for operation on the ascending thoracic aorta and aortic root after previous cardiac surgery include: Prosthetic valve endocarditis, formation of true or false aneurysm, progressive aortic wall disease, dissection of the native aorta, degeneration of aortic valve substitutes and vascular graft infection. Many factors affect the outcome of these operations including; underlying pathology, type of prior surgery, methods used for organ protection and timing of the operation **[3,4]**.

The aim of this study: Is to report our experience with patients undergoing re-operation on the proximal thoracic aorta after previous cardiac surgery, to highlight special surgical considerations needed in this particular entity and to identify predictors of outcome.

Patients and Methods

This is a retrograde observational study carried out during the period between January 2008 and December 2016 in Cardiac Surgery Unit, Cairo University. The Ethics Committee in the Hospital approved review of the data collected for this study and waived the need for informed patient consent.

We reviewed the records of all the patients who had aortic surgery by our team during the period of study and we found 35 patients who had redo sternotomy for aortic root surgery. The demographic and pre-operative data of these patients are shown in (Table 1). The indications of the first operations are shown in (Table 2) and the previous cardiac procedures are shown in (Table 3).

Pre-operative preparation:

A detailed assessment of all patients was done pre-operatively and included full history taking and lab investigations, trans-thoracic or trans-esophageal echocardiography routinely done, Multi-Slice Computed Tomography (MSCT) scan to assess the extent of the aortic disease and the proximity of the ascending aorta and right ventricle to the sternum. In patients showing reduced distance (<1cm.) or close contact between the sternum and the aorta at preoperative imaging, peripheral cannulation was employed to establish CPB before re-sternotomy. Coronary angiography or multi-slice computed tomography coronary angiography were required in 10 patients (29%), who had previous CABG or any patients older than 40 years.

Surgical technique:

The main indications for reoperation included degenerative ascending aneurysms after previous aortic valve replacement (45.7%), type A aortic dissection after previous CABG (14.3%), severe aortic insufficiency after previous supra coronary conduit replacement of ascending aorta (22.9%), and aortic root infective endocarditis after previous aortic valve replacement (17.1%) as shown in (Table 4).

Special considerations required for all patients include proper preoperative imaging, proper chest re-entry, proper myocardial protection, proper Cardio-Pulmonary Bypass (CPB) strategy. In all patients, femoral artery and vein were exposed and encircled using vascular slings before opening the sternum. In patients showing reduced distance (<1cm.) or close contact between the sternum and the aorta at preoperative imaging, remote (peripheral) cannulation through femoral artery and femoral vein was employed to establish CPB before re-sternotomy and in patients with pseudo-aneurysms complicating endocarditis, arrested sternal reentry is done after systemic cooling with sternal division under hypothermic circulatory arrest.

The aorta was approached through a median re-sternotomy in all cases using oscillating saw. Careful dissection of adhesions around the heart and aorta was done before giving heparin. Arterial inflow for cardiopulmonary bypass was done through the femoral artery in 28 patients (80%) and through the ascending aorta in 7 patients (20%). Venous return was via the right atrium in 27 patients (77.1%) and the femoral vein in 8 patients (22.9%). Myocardial protection was obtained using ante-grade cold crystalloid intermittent cardioplegia every 20-30 minutes and topical ice slush in all case.

The redo surgical procedures are shown in (Table 5). We did a modified Bentall operation in 13 patients (37.1%), supracoronary ascending aortic replacement in 9 patients (25.7%), aortic valve replacement in 5 patients (14.3%) and combined supra-coronary ascending aortic replacement and aortic valve replacement in 2 patients (5.7%).

In patients with active endocarditis, all the infected tissue was resected, the left ventricle outflow tract reconstructed with pericardium as appropriate, and aortic composite grafts were used to replace the diseased proximal aorta.

Fig. (1): MSCT aortography for patient with infective endocarditis complicating previous aortic valve replacement with large vegetations and retrosternal pseudoaneurysm.

In patients with previous CABG, the proximal reattachment of the saphenous vein grafts was performed using an interposition Dacron graft 8mm (modified Cabrol), new interposition autogenous saphenous vein graft, or button (Carrell) patch using part of aortic wall including the old vein proximals as an island to be sutured to the aortic graft.

Statistical analysis:

Continuous variables were expressed as mean and standard deviation ($X \pm SD$), and were analyzed

by using the unpaired *t*-test. Categorical variables were expressed as number and percentage (No. & %) and analyzed using the Pearson's chi-square χ^2 test or Fisher's exact test when appropriate. A *p*-value of less than 0.05* was considered statistically significant. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) 16.0.

Results

This is a retrospective observational study carried on 35 patients with reoperation on the aortic root, during the period between 2008 and 2016. The demographic and preoperative clinical characters of these patients are shown in (Table 1). Of these 35 patients, 26 (74.3%) were males and 9 (25.7%) were females. The mean patient age at the time of reoperation was 41 ±4 years (range 9-58 years). 5 patients had Marfan syndrome and 4 patients had Bicuspid aortic valve disease. Within this group, 33 patients (94%) had one previous cardiac operation, 2 patients (6%) had more than one. The mean time interval between the last previous procedure and the actual operation was 11 ±3 years (ranging from 2 months to 33 years). 10 patients (28.6%) required an emergency operation.

Table (1): Patients' demographics & pre operative clinical characters.

Demographics	Number (%) OR Mean ± SD
Age at reoperation (range-years)	9-58 (41.5±4.4)
Male sex	26 (74.3%)
Marfan syndrome	5 (14.3%)
Bicuspid aortic valve	4 (11.4%)
Previous cardiac operations:	
Once	33 (94.3%)
More than once	2 (5.7%)
Interval since last operation	2months-35 years (11.2±3.1)
Pre-operative NYHA class:	
NYHA I	2 (5.7%)
NYHA II	19 (54.3%)
NYHA III	14 (40%)
Pre-operative ejection fraction EF:	
EF >55%	17 (48.6%)
EF 40-55%	16 (45.7%)
EF <40%	2 (5.7%)

The indications of the first operations are shown in (Table 2) and the previous cardiac procedures are shown in (Table 3). The majority of the patients (57.1%) had either aortic valve repair or replacement (13 patients) or coronary artery bypass grafts (7 patients). 4 patients (11.4%) had supra-coronary ascending aorta replacement, 3 patients (8.6%) had aortic and mitral valve replacement and 2 patients (5.7%) had valve sparing aortic root replacement (David 1 procedure).

Table (2): First surgery indication (original pathology).

Indication	Count	Percentage
• Aortic valve disease (stenosis/ insufficiency)	14	40%
• Double valve disease (aorta and mitral)	3	8.6%
• Ischemic heart disease	7	20.0%
• Ascending Aortic Aneurysm	4	11.4%
• Acute Aortic Dissection (A)	4	11.4%
• Atrial septal defect ASD	1	2.9%
• Ventricular septal defect VSD	1	2.9%
• Coronary fistula	1	2.9%

Table (3): Previous cardiac procedure.

Procedure	Count	Percentage
Aortic valve repair/replacement	13	37.1%
CABG	7	20.0%
Others:		
Supracoronary	4	11.4%
AVR & MVR	3	8.6%
Tirone David 1	2	5.7%
ASD closure	1	2.9%
AVR & supracoronary	1	2.9%
Freestyle bio root	1	2.9%
Homograft root	1	2.9%
VSD closure	1	2.9%
Cor fistula repair	1	2.9%

The main indications for reoperation included degenerative ascending aneurysms after previous aortic valve replacement (45.7%), type A aortic dissection after previous CABG (14.3%), severe aortic insufficiency after previous supra coronary conduit replacement of ascending aorta (22.9%), and aortic root infective endocarditis after previous aortic valve replacement (17.1%) as shown in (Table 4).

Table (4): Indications for re-operation.

Indication	Count	Percentage
Ascending aortic aneurysm	16	45.7%
Aortic valve pathology	8	22.9%
Infective endocarditis involving A root	6	17.1%
Type A dissection	5	14.3%

Operative data: Redo surgical procedure (Table 5): Different surgical techniques were employed according to aortic pathology. 13 patients had modified Bentall procedure, 9 patients had supra coronary conduit replacement of ascending aorta, 5 patients had aortic valve replacement, 4 patients had supra coronary conduit and aortic valve replacement, 2 patients had bioroot replacement with homograft, one patient had David procedure, and one patient had Bentall with Elephant trunk procedure.

Table (5): Redo surgical procedure.

Redo procedure	Count	Percentage
Bentall	13	37.1%
Supracoronary with sinus replacement	9	25.7%
AVR	5	14.3%
Supracornary + AVR	2	5.7%
Supracoronary + AVR + Hemiarch	1	2.9%
Supracoronary + AVR + MVR	1	2.9%
Bentall + Elephant trunk	1	2.9%
Freestyle bio root	1	2.9%
Homograft root replacement	1	2.9%
Tirone David I	1	2.9%

Table (6): Operative data.

	Number (%) OR Mean ± SD
Timing of operation:	
Elective	25 (71.4%)
Emergency	10 (28.6%)
Arterial inflow:	
Ascending aorta	7 (20%)
Femora artery	28 (80%)
Venous return:	
Right atrium	27 (77.1%)
Femoral vein	8 (22.9%)
CPB duration (minutes)	163.1±10.7
Cross clamp duration (minutes)	134.3±9.2
TCA	9 patients
TCA time (min)	25±1 0mins
Coronary implantation & proximal reattachement:	
None	12 (34.3%)
Modified cabrol	12 (34.3%)
Carrell patch	7 (20%)
Direct button	4 (11.4%)

- Cannulation sites for Cardiopulmonary Bypass (CPB): Arterial inflow for cardiopulmonary bypass was done through the femoral artery in 28 patients (80%) and through the ascending aorta in 7 patients (20%). Venous return was via the right atrium in 27 patients (77.1%) and the femoral vein in 8 patients (22.9%).
- The mean cardiopulmonary bypass time was 163 ± 10min and The mean cross clamp time was 134±9min.

Mode of coronary reimplantation and proximal reattachment:

With previous CABG, the proximal reattachment of the saphenous vein grafts was performed using an interposition Dacron graft (modified Cabrol), new interposition autogenous saphenous vein graft, or button (Carrell) patch direct button in 4 patients (11.4%), modified cabrol in 12 (34.3%), carrel patch in 7 (20%).

Post-op data: (Table 7).

Table (7): Post-operative data.

	Number (%) OR Mean ± SD
Mechanical ventillation duration (hours)	19±5.4
ITU stay duraion (hours)	84.6± 13.5
Hospital stay duration (days)	13.2±3.6
Blood loss	1000±400cc
Re-exploration for bleeding	2 (5.7%)
Acute renal failure requiring dialysis	4 (11.4%)
CVA/stroke	4 (11.4%)
Mediastinitis	1 (2.9%)
Mortality	5 (14.3%)

Regarding post-operative complications, two patients needed re-exploration due to excessive post-operative bleeding (5.7%), 4 patients (11.4%) were complicated by acute renal failure that required dialysis and 1 patients had mediastinitis (2.9%).

The mean duration of post-operative mechanical ventilation in the ICU was 19 ±5.4 hours. The mean of the total ICU stay was 84.6 ± 13.5 hours, ranging from 40-240 hours. The mean of the total hospital stay for discharged patients was 13.2 ±3.6 days.

There was 5 in hospital mortality (14.3%): Causes of death were 3 due to multi organ failure due to sepsis of active endocarditis, 1 due to myocardial failure and 1 due to major uncontrollable bleeding. Mortality was strongly correlated with active endocarditis, long cross clamp time, need for high inotropic support after weaning from bypass, and time interval from initial surgery.

Hospital mortality according to aortic pathology was least in patients with degenerative aneurysms, and chronic dissections, higher in patients with acute dissections and worst in cases of active endocarditis complicated by pseudo aneurysms.

Discussion

Re-operations on the proximal thoracic aorta are being performed with increasing frequency and remain a challenge. Chest re-entry is a crucial moment of the procedure and adequate preoperative imaging is mandatory to assess the distance between the sternum and ascending aorta and right ventricle and to plan a safe resternotomy [5].

In our study carried out during the period between 2008 and 2016 on 35 patients, we could avoid catastrophic chest re-opening and operative deaths by establishing cardio-pulmonary bypass and circulatory arrest before resternotomy based on imaging information.

Regarding our study population, 26 (74.3%) were males and 9 (25.7%) were females. The mean patient age at the time of reoperation was 41 ±4 years (range 9-58 years). 4 patients had bicuspid aortic valve and 5 patients had Marfan syndrome. The main indication for reoperation was ascending aortic aneurysm (45.7%), followed by aortic valve pathology (22.9%), infective endocarditis involving the aortic root (17.1%) and type A aortic dissection (14.3%).

13 patients had modified Bentall procedure, 9 had supra coronary conduit replacement of ascending aorta, 5 had aortic valve replacement, 4 patients had supra coronary conduit and aortic valve replacement, 2 patients had biological root replacement with homograft, one patient had David procedure, and one patient had Bentall with Elephant trunk procedure.

Re-exploration for bleeding was needed in 2 patients. There was 5 in hospital mortality (14.3%): 3 due to multi organ failure due to sepsis of active endocarditis, 1 due to myocardial failure and 1 due to major uncontrollable bleeding.

Our data are matched with the Bologna group (Di bartolomeo and colleagues, 2011) in a series of 174 redo patients The patients' mean age was 58 years, 132 (75.9%) were men. The mean time from last operation was 9.9 years. An urgent operation was performed in 35 (20.1%) patients. Indications for surgery included degenerative and chronic post-dissection aneurysm (65%), acute dissection (10%), false aneurysm (10%), and active prosthetic infection (15%). So degenerative and chronic post-dissection aneurysms represented the most frequent indication for re-operation. Root procedures were performed in 65 (37.3%) patients, ascending aorta replacement in 27 (15.5%).

On multivariate analysis, Cardiopulmonary Bypass (CPB) time (Odds Ratio (OR)=1.1018 per min), New York Heart Association (NYHA) class III-IV (OR=3.86), and active endocarditis (OR= 5.15) emerged as independent predictors of hospital mortality. Hospital mortality was considerable and significantly higher in patients requiring CPB institution before sternotomy as compared with the others (35.3% vs. 10.3%; p=0.003). Notably, and predictably, these patients were associated with increased duration of CPB [5].

Overall hospital mortality was 12.6% and was greatly influenced by the underlying pathology being only 3.4% in patients with degenerative aneurysms and 25.0% and 45.5% in patients with acute dissections and active endocarditis, respectively [5].

In our study, among patients who had undergone previous aortic valve replacement and came for reoperation on aortic root, bicuspid aortic valve had been reported in many cases, being associated with aortopathy and ascending aneurysm formation.

Schepens et al., 2010 reviewed retrospectively data of 46 patients (38 men; mean age, 57 years) who underwent aortic root reoperations in the previous 7 years. Of these, 42 had received prior aortic root replacement. The indications for reoperation included prosthesis infection in 16, false aneurysm in 16, and degenerative or post dissection aneurysm and valve prosthesis failure. Aortic root re-replacement was performed in 39 patients (85%). In-hospital mortality was 6.5% (3 patients). Predictors of hospital death were preoperative functional class III or IV, an interval of less than 6 months between the primary and actual operation, preoperative creatinine level of more than 200 mmol/L, acute aortic dissection, active endocarditis, and post-operative dialysis (p<0.001) [6,7].

David and colleagues reported their experience with 31 patients (mean age 45 years) of Redo Aortic Root Replacement between 1980 and 1999, and conclude that Redo aortic root replacement can be performed with good early results but patients operated on for prosthetic root endocarditis may have an increased risk of recurrent late endocarditis [8].

Indications for reoperation were prosthetic valve endocarditis in 12 patients (39%), failed biological valve in 17 (55%), and false aneurysm in 2 (6%). At reoperation, mechanical valves were implanted in 24 patients and biologic valves in 7. All patients with endocarditis had annular abscess and required reconstruction of the left ventricular outflow tract before implantation of a new valved conduit. The coronary button technique was used to reimplant the coronary arteries whenever possible. Extension of one or both coronary arteries with a short segment of saphenous vein or a synthetic graft was used in 16 patients (52%). There were five late deaths (16%), three of which were cardiac related. Three patients experienced recurrent prosthetic valve endocarditis after operation [8].

In our patients with previous CABG, the proximal reattach-ment of the saphenous vein grafts was performed using an interposition Dacron graft (modified Cabrol), new interposition autogenous saphenous vein graft, or button (Carrell) patch.

This is the same technique used by Texas group (Estrera and colleagues) [9].

In our study, the mean cardio-pulmonary bypass time was 163±10 minute and the mean cross clamp time 134±9 minute. This is nearly matched with the work of other groups as Dibartolomeo, Estrera, David, and Schepens [5-9].

Our study showed that the overall mortality was 5 of the 35 patients (14%). This is similar to the results of DiEusanio et al., (2011) 12.6% [5], but different from Schepens et al., (2010) 6.5% [7].

Conclusion:

- Aortic root reoperations are always challenging and never straightforward. Special considerations required for all patients include proper pre-operative imaging, proper chest re-entry, proper myocardial protection, proper Cardio-Pulmonary Bypass (CPB) strategy.
- The overall short term survivals is satisfactory in patients with degenerative aneurysms and healed infection, acceptable in cases of dissection, poor in patients with active Endocarditis.
- Low ejection fraction, hemodynamic instability, long operative time, prolonged bypass time, active endocarditis were especially associated with increased mortality.

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العوامل المنبئة بنتائج إعادة إجراء جراحات جزع الشريان الآورطى عقب جراحة قلب سابقة

مقدمة: عمليات إعادة جراحة الجذر الآبهر والشريان الآبهر الصاعد يجرى تنفيذها بزيادة وتيرة وتظل مشكلة صعبة. الهدف من عملنا هو دراسة الإستراتيجية الجراحية والنتائج والتنبؤات بنتيجة جراحة الجذر الآبهرى فى المرضى الذين يعانون من عمليات القلب السابقة.

المرضى والطرق: بين عامى ٢٠٠٨ و٢٠١٦، كان ٣٥ مريضاً – يخضعون لعملية جراحية فى جذر الآبهر بعد جراحة القلب السابقة فى وحدة قصر العينى لجراحة القلب، جامعة القاهرة. كان السبب الرئيسى لإعادة الجراحة تمدد الآبهرى الصاعد (٤٥.٧٪)، تليها آمراض الصمام الآبهرى (٢٢.٩٪)، ثم شرخ الشريان الآبهر وعدوى إلتهاب الصمامات.

النتائج: كانت هناك حاجة لإعادة إستكشاف للنزيف فى ٢ المرضى. كان هناك ٥ وفيات (١٤.٣٪)، ٣ بسبب فشل متعدد الأعضاء بسبب إلتهاب الصمامات النشط، ١ بسبب فشل عضلة القلب و١ بسبب نزيف حاد لا يمكن السيطرة عليه.

الخلاصة: نتائج جراحة إعادة فتح الجذر الآبهرى جيدة للمرضى الذين يعانون من تمدد الآوعية الدموية والعدوى الشافية، ومقبول فى حالات شرخ الشريان، وسئ فى المرضى الذين يعانون من إلتهاب النشط.