Original Research Article

AORTA

Aorta, June 2013, Volume 1, Issue 1: 40–44
DOI: http://dx.doi.org/10.12945/j.aorta.2013.13.001

Received: January 4, 2013
Accepted: March 20, 2013
Published online: June 2013

# High-Volume Practice by a Single Specialized Team Reduces Mortality and Morbidity of Elective and Urgent Aortic Root Replacement

Gopal Soppa, Nada Abdulkareem, Jeremy Smelt, Jean-Pierre Van Besouw, Marjan Jahangiri*

Departments of Cardiac Surgery and Anaesthesia, St. George's Hospital, London, United Kingdom

## Abstract

***Background:*** **Elective aortic root replacement (ARR), or the Bentall procedure, is associated with significant mortality and complications. Recent studies have shown that high procedure volume has an inverse association with postoperative mortality. The outcomes of patients undergoing elective/urgent ARR by a single, high-volume surgical team were assessed in this study.** ***Methods:*** **Patients undergoing nonemergency, elective/urgent ARR for non-Marfan aortic root dilatation, from October 2005 to March 2011, were studied. Valve-preserving procedures, extra-anatomic bypass, and arch and descending aortic repairs were excluded. Patient demographics, operative details, and postoperative outcomes were collected prospectively. Surgical techniques included central cannulation and cardiopulmonary bypass (CPB) at 35°C. Following aneurysm excision, a composite valve-conduit reconstruction with coronary button reimplantation was performed. Tissue glue, Teflon pledgets, and blood products were seldom used. Patients were followed locally at 8 weeks, 6 months, and annually thereafter with echocardiography and computed tomographic (CT) scanning.** ***Results:*** **From October 2005 to March 2011, 163 ARRs were performed. Of these, 131 (80%) were isolated first time procedures (four in pregnant women), six were redo (4%), and in 26 (16%) ARR was combined with concomitant valve or coronary artery revascularization procedures. Median age was 63 years (range 19–84). Median cross-clamp and CPB times were 73 (range 69–87) and 86 minutes (range 85–126), respectively. There was one in-hospital death (mortality = 0.6%), one patient underwent resternotomy for bleeding, two required hemofiltration, and there were no strokes. Median hospital stay was 6 days (range 5–11). Median follow-up was 2.9 years (range 6 months–4.3 years) with 100% freedom from reoperation. There was no late distal ascending aorta/arch dilatation. There were two late deaths (1.2%) due to pneumonia and stroke.** ***Conclusions:*** **High-volume surgery, with minimal use of hemostatic adjuncts and sustained follow-up, leads to excellent outcomes, with low morbidity and mortality following ARR.**

Copyright © 2013 Science International Corp.

## Key Words

**Aortic root replacement · Bentall procedure**

## Introduction

ARR, or the Bentall procedure [1], is performed for aortic root pathology, including aneurysm, dissection, connective tissue disorders, and atherosclerosis. In the United Kingdom (UK), according to the Sixth National Adult Cardiac Surgical Database report between 2004 and 2008, there were 765 ARR elective cases with 8.0% mortality and 213 urgent cases with 12.2% mortality in 41 cardiac surgical centers [2]. Similarly, the Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database (ACSD) showed an unadjusted mortality of 11.1% between 1994 and 2003 [3]. However,

Fax +1 203 785 3346
E-Mail: aorta@scienceinternational.org
http://aorta.scienceinternational.org

© 2013 Aorta.
Published by Science International Corp.
ISSN 2325-4637

Accessible online at:
http://aorta.scienceinternational.org

*Corresponding author:
Marjan Jahangiri
Department of Cardiothoracic Surgery
St. George's Hospital
Blackshaw Road
London, SW17 0QT, United Kingdom
Tel. +44 208 672 1255, E-Mail: Marjan.Jahangiri@stgeorges.nhs.uk

previous large single center historical series have demonstrated lower mortality rates for both elective and emergency ARR [4–8].

It is well-known that hospital procedure volume has an inverse association with postoperative mortality for a number of complex cardiovascular and thoracic surgical procedures [9–13]. Hughes et al. reported on 13,358 elective aortic root and aortic valve-ascending aortic procedures performed between 2004 and 2007, obtained from 741 North American hospitals [14]. In this largest study to date, the overall unadjusted operative mortality was 4.5%. However, the unadjusted operative mortality increased with decreasing case volume, from 3.4% in the highest volume centers to 5.8% in the lowest volume centers. The conclusion of this study was increased risk-adjusted mortality for elective ARR or combined aortic valve-ascending aortic surgery at hospitals that performed fewer than 30–40 of such procedures annually [14].

However, one limitation of the STS database is the inability to adjust for individual surgeon volume, thus, the effect may be due to high-volume surgeons or a high-volume center. The aim of this study was to assess the outcomes of patients undergoing elective or urgent ARR by a single, high-volume surgical team in a tertiary cardiac surgical unit performing 30–40 ARR annually.

## Materials and Methods

### *Study Population*

From October 2005 to March 2011, demographic, clinical, and operative data were collected prospectively for patients undergoing elective or urgent (within the same hospital admission for the presenting complaint) ARR for non-Marfan aortic root dilatation by a single surgical team at our institution. Patients who underwent emergency surgery, aortic valve preserving procedures, extra-anatomic bypass, and arch and descending aorta repairs were excluded from this study. The Marfan group of patients were excluded because the majority of them underwent a valve-sparing procedure ± ascending aorta or arch replacement. Therefore, they are a heterogeneous group not undergoing pure aortic root replacement.

The definition of high volume, for the purpose of this study, is derived from the publication by Hughes et al. [14]. They have shown that patients undergoing elective aortic root surgery at North American hospitals that performed fewer than 30–40 of such procedures annually have greater risk-adjusted mortality than those undergoing surgery in higher-volume hospitals.

The following definitions were used to classify the timing of surgery for this study. Elective surgery was defined as planned, nonemergency procedures that were performed greater than 1 week from decision to operate. Urgent surgery was defined as surgery being performed at greater than 24 hours but within the same hospital admission. Emergency surgery was defined as procedures performed within 24 hours of hospital admission.

### *Operative Technique*

Following a median sternotomy, cardiopulmonary bypass was established at 35°C through central cannulation. Aortic cannulation was always performed via the distal ascending aorta or proximal aortic arch for all cases. Venous return was obtained using right atrial or bicaval cannulation. A vent was placed in the left ventricle through the right superior pulmonary vein. Myocardial protection was achieved using antegrade, cold blood cardioplegia solution. None of the patients required deep hypothermic circulatory arrest.

The surgical procedure was performed as follows. After cross-clamping the distal ascending aorta, the aneurysm was excised using a combination of sharp and electrocautery dissection. Both coronary ostial buttons were mobilized. For patients requiring a biosprosthetic valve, a composite graft was constructed intraoperatively from porcine or pericardial valve and collagen impregnated, woven polyester graft (Hemashield™, Maquet Cardiovascular). For patients requiring a mechanical valve, a composite aortic valved graft (SJM™ Masters Series™, St. Jude Medical) was used. All valves were implanted using 2/0 buttressed, interrupted, polyester sutures (TI●CRON™, Covidien). The mobilized coronary buttons were implanted in an end-to-side fashion using a continuous 5/0 Prolene™ suture (Ethicon). The distal aortic anastomosis was performed using a continuous 4/0 Prolene™ suture (Ethicon). Hemostatic adjuncts, such as glue or Teflon, were seldom used.

### *Clinical Data and Follow-Up*

Clinical and operative data were prospectively recorded for all patients. Echocardiograms were routinely performed on all patients prior to discharge. Patients were followed up at 8 weeks, 6 months, and then on an annual basis with echocardiogram and computed tomography (CT) scanning.

### *Statistical Analysis*

All descriptive statistical analysis was performed in Microsoft Excel 2003. Distribution for normality was not performed as the results are descriptive only. No comparison of patient groups or outcomes was made. Continuous data are expressed as mean ± standard deviation (SD). Categorical data are expressed as percentages.

## Results

Between October 2005 to March 2011, 163 ARRs were performed on an elective/urgent basis (approximately 30 cases per year). In this same period, the total aortic surgery volume was approximately 69 cases per year. In addition to elective/urgent ARR,

**Table 1.** Patient Characteristics

| Characteristic | Mean ± SD |
|---|---|
| Total no. of ARR | 163 |
| Age (years) | 63 ± 16 |
| Male (%) | 69 |
| New York Heart Association (NYHA) III/IV (%) | 10 |
| Logistic Euroscore | 9 ± 3 |
| Aortic valve pathology | |
| Stenosis (%) | 81 |
| Regurgitation (%) | 19 |
| Peak aortic valve gradient (mm Hg) | 74 ± 11 |
| Mean aortic valve gradient (mm Hg) | 44 ± 5 |
| Mean aortic valve orifice area ($cm^2$) | 0.7 ± 0.2 |
| Mean ascending aorta diameter (cm) | 5.05 (range 4.5–7.2) |
| Left ventricle (LV) function | |
| Good (%) | 50 |
| Moderate (%) | 41 |
| Poor (%) | 9 |
| Type of prosthetic valve implanted | |
| Biological (%) | 67 |
| Mechanical (%) | 33 |

these included emergency ARR, arch/hemiarch replacement, extra-anatomic bypass, and repair of Type-A aortic dissection.

Median age of the patients was 63 years (range 19–84) and 112 (69%) were male. Preoperative patient characteristics are shown in Table 1. Indications for ARR were annulo-aortic ectasia or aneurysm of the aortic root in 155 (95%) patients, active endocarditis in seven patients, and a small aortic annulus in one patient. A majority of the patients had aortic stenosis with preserved left ventricular function (Table 1).

Of these, 131 (80%) were isolated first time procedures (four in pregnant women), six were redo (4%), and in 26 (16%) ARR was combined with concomitant valve or coronary artery revascularization procedures (Table 2). Bioprosthetic valve was used in 110 (67%) patients and a mechanical valve was used in 53 (33%) patients. Median cross-clamp and CPB times were 73 (range 69–87) and 86 minutes (range 85–126), respectively (Table 3). The incidence of bailout coronary artery bypass surgery for possible coronary insufficiency after reimplantation was zero.

There was one in-hospital death (mortality = 0.6%). This patient underwent an urgent root replacement for severe prosthetic valve endocarditis. At the time of surgery, he was in severe septic shock with profound pulmonary edema. He died of severe postoperative sepsis with multiorgan failure. One patient underwent resternotomy (0.6%) for bleeding, two required hemofiltration (1.2%), and there were no strokes. Median hospital stay was 6 days (range 5–11).

**Table 2.** Concomitant Procedures

| Type of procedure | No. | Percentage (%) |
|---|---|---|
| Total no. of ARR | 163 | |
| Isolated first time, ARR | 131 | 80.4 |
| Redo ARR | 6 | 3.7 |
| Combined procedures | | |
| ARR+CABG | 15 | 9.2 |
| ARR+radiofrequency ablation | 6 | 3.7 |
| ARR+mitral valve repair | 3 | 1.8 |
| ARR+mitral valve replacement | 2 | 1.2 |

**Table 3.** Postoperative Outcomes

| Outcome | No. (n=163) |
|---|---|
| *Operative* | |
| Median X-clamp time (minutes) | 73 (range 69-87) |
| Median CPB times (minutes) | 86 (range 85–126) |
| *Postoperative* | |
| Resternotomy for bleeding | 1 (0.6%) |
| Hemofiltration for renal failure | 2 (1.2%) |
| Strokes | 0 |
| Median hospital stay (days) | 6 (range 5–11) |
| In-hospital deaths | 1 (0.6%) |
| *Median follow-up (years)* | 2.9 (range 0.5–4.3) |
| Late distal ascending aorta/arch dilatation | 0 |
| Late reoperation | 0 |
| Late deaths | 2 (1.2%) |

Median follow-up was 2.9 years (range 6 months–4.3 years) with 100% freedom from reoperation and prosthetic valve dysfunction. There was no late distal ascending aorta/arch dilatation. There were two (1.2%) late deaths. One patient died of pneumonia and the other following a stroke.

## Discussion

This contemporary series demonstrates the effectiveness of ARR in the treatment of aortic root pathology and that high-volume practice results in low operative mortality and morbidity.

Between 2001 and 2008, mortality rates in the United Kingdom for isolated coronary artery bypass grafting (CABG), isolated valve surgery, and valve surgery with concomitant CABG have shown statistically significant reductions in spite of greater preoperative comorbidities [2]. It is difficult to compare the results with previously published ARR series due to differences in aortic root pathology, patient population, and operative management. However, the average mortality rate of 8.0% for elective cases and 12.2% for urgent cases in the UK is similar to other contemporary series but significantly higher than the mortality rate in other historical series from high-volume centers [4–6,14].

There was a similar unadjusted mortality rate of 11.1% for ARR between 1994 and 2003 in the STS database [3]. This high-mortality figure was not accounted for by emergency cases since only 4% of cases were for aortic dissection (mortality 23.7%). In this series, nearly half of the ARR cases were performed for cases without aortic root pathology, hence inappropriate ARR for no root pathology was discouraged [3]. Analysis of data between 2004 and 2007 from the STS database demonstrated that increased center volume was associated with reduced mortality and when center volume was assessed as a continuous variable, mortality was significantly higher in the less than 30–40 procedures a year group [14]. However, the major limitation of the database is an inability to adjust for individual surgeon volume so it is not known whether this effect is due to a high-volume surgeon or center. However, more contemporary data from the STS database between 2004 and 2009 showed an unadjusted mortality rate of 2.72% for elective ARR and 13.74% for nonelective ARR and the procedure volume remained stable at approximately 12 cases per center [15].

It is standard practice at our institution to maintain team stability with the same operating team, cardiothoracic anesthetist, perfusionist, and standardized operative technique. Team familiarity is a key factor in reducing technical error and good teamwork with team stability improves operative performance and significant reductions in operative times [16]. Although there is limited data relating systemic and organizational factors to outcomes, there is some evidence that higher levels of communication in a familiar team is associated with decreased postoperative morbidity [17].

## Conclusions

In a contemporary series, we have demonstrated that high-volume surgery, with minimal use of hemostatic adjuncts and sustained follow-up, reduces morbidity and mortality following ARR.

**Comment on this Article or Ask a Question**

## References


1. Bentall H, De Bono A. A technique for complete replacement of the ascending aorta. Thorax. 1968;23:338–39. 10.1136/thx.23.4.338
2. The Society for Cardiothoracic Surgery in Great Britain & Ireland. Sixth National Adult Cardiac Surgical Database report 2008—Demonstrating quality, 2008.
3. Rankin JS, Hammill BG, Ferguson TB Jr., Glower DD, O'Brien SM, DeLong ER, et al. Determinants of operative mortality in valvular heart surgery. J Thorac Cardiovasc Surg. 2006;131:547–557. 10.1016/j.jtcvs.2005.10.041
4. Zehr KJ, Orszulak TA, Mullany CJ, Matloobi A, Daly RC, Dearani JA, et al. Surgery for aneurysms of the aortic root: A 30-year experience. Circulation. 2004;110:1364–1371.
5. Cameron DE, Alejo DE, Patel ND, Nwakanma LU, Weiss ES, Vricella LA, et al. Aortic root replacement in 372 Marfan patients: Evolution of operative repair over 30 years. Ann Thorac Surg. 2009;87:1344–1350. 10.1016/j.athoracsur.2009.01.073
6. Kindo M, Billaud P, Gerelli S, Levy F, Mazzucotelli JP, Eisenmann B. Twenty-seven-year experience with composite valve graft replacement of the aortic root. J Heart Valve Dis. 2007;16:370–377.
7. Lima B, Hughes GC, Lemaire A, Jaggers J, Glower DD, Wolfe WG. Short-term and intermediate-term outcomes of aortic root replacement with St. Jude mechanical conduits and aortic allografts. Ann Thorac Surg. 2006;82:579–585. 10.1016/j.athoracsur.2006.03.068
8. Dapunt OE, Easo J, Holzl PP, Murin P, Sudkamp M, Horst M, et al. Stentless full root bioprosthesis in surgery for complex aortic valve-ascending aortic disease: A single center experience of over 300 patients. Eur J Cardiothorac Surg. 2008;33:554–559. 10.1016/j.ejcts.2007.12.053
9. Cheung MC, Hamilton K, Sherman R, Byrne MM, Nguyen DM, Franceschi D, et al. Impact of teaching facility status and high-volume centers on outcomes for lung cancer resection: An examination of 13,469 surgical patients. Ann Surg Oncol. 2009;16:3–13. 10.1245/s10434-008-0025-9
10. Schermerhorn ML, Giles KA, Hamdan AD, Dalhberg SE, Hagberg R, Pomposelli F. Population-based outcomes of open descending thoracic aortic aneurysm repair. J Vasc Surg. 2008;48:821–827. 10.1016/j.jvs.2008.05.022
11. Allareddy V, Allareddy V, Konety BR. Specificity of procedure volume and in-hospital mortality association. Ann Surg. 2007;246:135–139. 10.1097/01.sla.0000259823.54786.83
12. Knipp BS, Deeb GM, Prager RL, Williams CY, Upchurch GR Jr., Patel HJ. A contemporary analysis of outcomes for operative repair of

type A aortic dissection in the United States. Surgery. 2007;142:524–528.
13. Cowan JA Jr., Dimick JB, Henke PK, Huber TS, Stanley JC, Upchurch GR Jr. Surgical treatment of intact thoracoabdominal aortic aneurysms in the United States: Hospital and surgeon volume-related outcomes. J Vasc Surg. 2003;37:1169–1174. 10.1016/S0741-5214(03)00085-5
14. Hughes GC, Zhao Y, Rankin JS, Scarborough JE, O'Brien S, Bavaria JE, et al. Effects of institutional volumes on operative outcomes for aortic root replacement in North America. J Thorac Cardiovasc Surg. 2013;145(1):166–170. 10.1016/j.jtcvs.2011.10.094
15. Williams JB, Peterson ED, Zhao Y, O'Brien SM, Andersen ND, Miller DC, et al. Contemporary results for proximal aortic replacement in North America. J Am Coll Cardiol. 2012;60:1156–1162. 10.1016/j.jacc.2012.06.023
16. El Bardissi AW, Sundt TM. Human factors and operating room safety. Surg Clin North Am. 2012;92:21–35. 10.1016/j.suc.2011.11.007
17. Davenport DL, Henderson WG, Mosca CL, Khuri SF, Mentzer RM Jr. Risk-adjusted morbidity in teaching hospitals correlates with reported levels of communication and collaboration on surgical teams but not with scale measures of teamwork climate, safety climate, or working conditions. J Am Coll Surg. 2007;205:778–784. 10.1016/j.jamcollsurg.2007.07.039

**Cite this article as:** Soppa G, Abdulkareem N, Smelt J, Van Besouw J-P, Jahangiri M. High-Volume Practice by a Single Specialized Team Reduces Mortality and Morbidity of Elective and Urgent Aortic Root Replacement. Aorta 2013;1(1):40–44. DOI: http://dx.doi.org/10.12945/j.aorta.2013.13.001

## EDITOR'S COMMENTS

Jahangiri and colleagues show us how very safe aortic root replacement can be in a high-volume center. They have achieved a mortality for this extensive aortic surgery that would be very desirable for routine CABG or valve surgery. Once again, as in so many fields of cardiac surgery, we are shown the benefits of an experienced and active overall team in securing the best outcomes.