Late Outcomes of Reintervention on the Descending Aorta After Repair of Aortic Coarctation

Morgan L. Brown, MD; Harold M. Burkhart, MD; Heidi M. Connolly, MD; Joseph A. Dearani, MD; Donald J. Hagler, MD; Hartzell V. Schaff, MD

Background—After repair of aortic coarctation, patients may develop restenosis, aneurysms, and pseudoaneurysms at the site of prior repair. We assessed the outcomes of late reintervention on the descending aorta after aortic coarctation repair.

Methods and Results—From March 1954 to July 2008, 130 patients had operations or endovascular procedures on the descending aorta after previous coarctation repair. We excluded patients who had complex left-sided cardiac lesions or interrupted aortic arch. Mean age at reintervention was 32±24 years and 28% were female. The interval between coarctation repair and reintervention was 17±13 years. Seventy-four percent of patients had hypertension. Reasons for reintervention were restenosis (n=122 [94%]), aneurysm (n=4 [3%]), and pseudoaneurysm (n=4 [3%]). Ninety-five patients (73%) underwent operative procedures including an extra-anatomic conduit (n=41), patch repair (n=32), interposition graft (n=14), end–end anastomosis (n=6), and subclavian flap (n=2). Thirty-five patients underwent endovascular treatment (balloon dilatation, n=22 or stenting, n=13). There was no early mortality. In the surgical group, 5 patients required early reoperation for bleeding and 5 patients had early vocal cord paralysis. One patient in the endovascular group had aortic rupture at the time of intervention requiring urgent operation. Survival was 97% at 10 years. At 5 years, freedom from a second repeat procedure on the descending aorta was 96% in the surgical group and 72% in the endovascular group (P<0.001). Five years after reintervention, fewer patients required treatment for hypertension (57% versus 74%, P<0.001) and a median of 1 antihypertensive medication was prescribed compared with a median of 2 medications preintervention.

Conclusions—Operative and endovascular management of recoarctation can be performed safely with good late outcomes. (Circulation. 2010;122[suppl 1]:S81–S84.)

Key Words: aorta ■ coarctation ■ hypertension ■ stents ■ surgery

After repair of aortic coarctation, patients may develop restenosis, aneurysms, and pseudoaneurysms at the site of repair. In a recent review from our institution, freedom from reintervention after operative repair of coarctation of the aorta was 89% at 30 years. Operation, balloon angioplasty, and stenting are possible options to treat these high-risk patients. However, although endovascular treatment for recoarctation or pseudoaneurysm has been reported frequently in the literature, there are fewer institutions reporting the outcomes of operative reinterventions after coarctation repair.

The American College of Cardiology and American Heart Association guidelines for adults with congenital heart disease recommend percutaneous catheter intervention for recurrent discrete coarctation of the aorta. Surgery is advised for long segments of recoarctation and concomitant hypoplasia of the aortic arch. Our objective was to examine the early and late outcomes of endovascular and operative reinterventions after primary coarctation repair at the Mayo Clinic.

Methods
Institutional Review Board approval was obtained, which waived the need for individual patient consent. From March 1954 to July 2008, 130 patients had operations or endovascular procedures on the descending aorta after previous coarctation repair. We excluded patients who had complex left-sided cardiac lesions, interrupted aortic arch, or Shone complex.

Perioperative data were collected using all available medical records. Follow-up data were collected using all medical records and a database that included late clinical outcomes obtained through prospective surveys. Survival was ascertained through Accurint (www.accurint.com).

Statistical analyses were performed using SAS (Version 9.1). Data are presented as means and SDs, medians and ranges, or numbers and percentages, as appropriate. Univariable and stepwise multivariable models were created using logistic regression for binary outcomes and Cox proportional hazards for time-related data. Kaplan–Meier curves were compared using a log-rank test. Paired data were compared using the McNemar test.

Results
One hundred thirty patients were identified with a mean age at reintervention of 32±24 years and 28% were female. The interval between coarctation repair and reintervention was 17±13 years. Twenty-nine patients (22.3%) had a mild or moderately hypoplastic arch noted on the operative report.
Seventy-four percent of patients had hypertension defined as a diagnosis of hypertension or the use of antihypertensives preoperatively. Patients taking antihypertensive medications were on a median of 2 medications (range, 1 to 5). Symptoms were present in 54 patients and are listed in Table 1. Symptoms were absent in 76 patients (58%), but 51 of these asymptomatic patients had preoperative hypertension. No patients had diabetes, stroke, or renal failure. One patient had preoperative hypertension. No patients had a prior myocardial infarction and 2 patients had chronic obstructive pulmonary disease. The mean ejection fraction was 61±8%. Details of the previous procedures performed are shown in Table 2.

<table>
<thead>
<tr>
<th>Table 1. Patient Presentation</th>
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<tr>
<td>Symptoms</td>
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<tr>
<td>Shortness of breath</td>
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<td>Arm or leg pain</td>
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<tr>
<td>Chest pain</td>
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<td>Headaches</td>
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<td>Hypertensive crisis</td>
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<td>Dysphagia</td>
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<td>Failure to thrive</td>
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<td>Palpitations</td>
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<tr>
<td>Hypoxia/cyanosis</td>
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<tr>
<td>Low cardiac output</td>
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<tr>
<td>Repeated infections</td>
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<td>Asymptomatic</td>
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</table>

Pathology at reintervention was restenosis (n=119 [92%]), aneurysm (n=4 [3%]), pseudoaneurysm (n=4 [3%]), and a combination of restenosis and aneurysm or pseudoaneurysm (n=3 [3%]).

Ninety-five patients (73%) underwent operative procedures, including an extra-anatomic conduit (n=41), patch repair (n=32), interposition graft (n=14), end–end anastomosis (n=6), and subclavian flap (n=2). Extra-anatomic conduits consisted of 35 ascending to descending aortic conduits and 5 left subclavian to descending aorta conduits. Over half of patients (54%) had reoperations through a thoracotomy and most repairs used cardiopulmonary bypass (Table 3). In the surgical group, 5 patients (5.3%) required early reoperation for bleeding and 5 patients (5.3%) had temporary vocal cord paresis. One patient (1.1%) developed renal failure requiring dialysis and 1 patient had diaphragmatic paralysis, which resulted in prolonged ventilation. Another patient had low cardiac output postoperatively requiring intra-aortic balloon pump insertion. Subsequently, this patient developed compartment syndrome and required a below-knee amputation. One additional patient had transient right leg weakness, but after rehabilitation had complete recovery of function. There was no early mortality and no cases of permanent paraplegia.

Thirty-five patients underwent endovascular treatment (balloon dilatation, n=22 or stenting, n=13). The first balloon angioplasty was performed in 1989 and the first stent was inserted in 1997. Thirty-four (97%) procedures were performed for relief of a gradient secondary to recoarctation and 1 patient had a covered stent for a pseudoaneurysm. One patient in the endovascular group had aortic rupture requiring urgent operation. The operation was uncomplicated and the patient survived. Another patient had a small tear in the aortic lumen, which caused a localized dissection, but there was no progression of the dissection and this child was followed without surgical intervention. This case also had a balloon rupture related to the intervention, but there were no complications from this. There was no early mortality in the endovascular group.

Follow-up was available at a mean of 8.8±8.1 years. Survival was 97% at 5 and 10 years, respectively (Figure 1). There was no difference in survival between operative and endovascular patients at 10 years (99% versus 91%, respectively, P=0.178). Age, gender, reason for reintervention, and any degree of arch hypoplasia were not associated with survival in a univariate analysis.
At 5 years, freedom from a repeat procedure on the descending aorta was 96% in the surgical group and 72% in the endovascular group \( (P<0.001) \). A total of 15 patients needed \( \geq 1 \) repeat procedures, including 3 patients who received a stent, 5 patients who had balloon angioplasty, and 7 patients who had surgical repair. One patient in the endovascular group required multiple endovascular interventions due to an inability to successfully dilate the recoarctation. Three patients had planned dilation of coarctation segments in a staged manner. After removal of these planned reinterventions, the freedom from a repeat procedure on the descending aorta was 80% in the endovascular group at 5 years, which was also significantly different than the surgical group \( (P=0.02) \). Age, gender, arch hypoplasia, and reason for reintervention were not associated with repeat procedures on the descending aorta. Due to the small number of cases, we were unable to perform a multivariable analysis to determine the predictors of repeat procedures on the descending aorta.

Late information \( (>30 \text{ days after dismissal}) \) about hypertension and medication use was available in 104 patients \( (80\%) \) at a median of 5.4 years \( \text{(range, 30 days to 29.9 years; mean, } 7.9 \pm 7.7 \text{ years}) \). After reintervention, fewer patients had hypertension \( (57\%, P=0.002) \) and a median of 1 antihypertensive medication was prescribed compared with 2 medications before reintervention.

**Discussion**

Our study demonstrates good early and late results in 130 patients after reintervention on the descending aorta after original repair of coarctation. Survival was excellent at 97% at both 5 and 10 years. Due to the nature of this study, we are unable to provide an incidence rate for reintervention on the descending aorta because these patients had initial coarctation repair at various institutions over a very long period of time \( (1956 \text{ to } 2005) \). In this cohort of reinterventions, 62 \( (48\%) \) had undergone initial coarctation repair elsewhere. However, in our larger cohort of patients undergoing initial surgical coarctation repair, the freedom from reintervention on the descending aorta was 97%, 92%, and 89% at 10, 20, and 30 years, respectively.\(^1\)

Our patients required reintervention at a mean of 18 years after the primary repair of coarctation. The longest period between coarctation repair and reintervention was 52.6 years. This re-emphasizes the fact that the need for lifelong follow-up in all patients with coarctation repair is important. It also was interesting to note that there was a significant group of patients \( (n=20 \ [15\%]) \) who had \( >1 \) previous intervention on the descending aorta before their procedure at the Mayo Clinic, underlining the difficulty in treating these patients.

Current recommendations from the American College of Cardiology and American Heart Association suggest that reintervention is required in patients who have a peak-to-peak recoarctation gradient of \( \geq 20 \text{ mm Hg} \) or patients who have a gradient \(<20 \text{ mm Hg} \) in the presence of imaging evidence of significant coarctation with significant collateral flow.\(^12\) These were the indications used for reintervention in all of our patients. However, it should be noted that these guidelines are based on expert opinion only, because there is little evidence to guide the timing of reintervention for patients with recoarctation.

Hypertension also remains a serious concern in patients with coarctation. The potential long-term sequelae from significant hypertension includes increased risk of diastolic dysfunction, atrial fibrillation, stroke, and death.\(^13\) Although we only had late information in 80% of patients, it was reassuring to see that fewer patients had hypertension \( (74\% \text{ versus } 57\%) \) postintervention. Recoarctation in hypertensive patients should be aggressively sought; if found, reintervention appears to be an effective strategy to decrease the incidence and severity of hypertension.

A study from Riley Children’s Hospital looked at 56 children who underwent surgical repair for recurrent aortic coarctation. The majority of rerepairs were performed with a patch and there were no deaths or major complications noted.\(^7\) Our study differs in that our population was older \( \text{(mean age, } 32 \text{ years)} \) at the time of reintervention, our most common procedure was an extra-anatomic conduit \( (32\%) \), and we included endovascular procedures.

We, and others, have published results of extra-anatomic grafts to repair primary or recurrent coarctation in adults.\(^8–11,14\) There was no perioperative mortality reported in these series and few perioperative complications. Specifically, posterior pericardial ascending–descending aortic bypass conduits may be useful in patients who require concomitant repair of intracardiac defects through a midline sternotomy, in patients who have associated arch hypoplasia, or in patients in whom extra-anatomic repair was safer than a repeat thoracotomy.\(^8,9,14\) Grafts in an extra-anatomic position have also been reported\(^11\) from either the arch or subclavian artery to the descending aorta parallel to the aorta through a left thoracotomy. This was done in 6 of our patients who underwent an extra-anatomic graft. Although results are good, extra-anatomic grafts should generally not be used in patients who are still growing; they may limit options in future operations specifically on the mitral or aortic valves due to the placement of the graft.\(^8\)

Outcomes of endovascular treatment on recurrent coarctation have recently been published from the Congenital Cardiovascular Interventional Study Consortium.\(^2\) In this study, 565 patients who had stenting of a coarctation were reviewed; 248 \( (44\%) \) had previous coarctation repair. Data were not...
provided to distinguish between native and recoarctation patients, but successful procedures (poststenotic systolic gradient <10 mm Hg) were possible in 92% of patients. However, 81 of 565 patients (14.3%) had acute complications, including aortic intimal tear, aortic dissection, stroke, stent migration, and balloon rupture.

Data on the rates of reintervention after balloon angioplasty for plastic recoarctation were published from The Hospital for Sick Children in Toronto. In 74 patients who received an early optimal result from balloon angioplasty, 28% of patients required reintervention at a follow-up of 12 years. In another report from the Czech Republic of their experience with balloon angioplasty of recoarctation, infants (<1 year) had freedom from reintervention of 75%, whereas older children and adults had freedom from reintervention of 40%. A multi-institutional report of intravascular stenting for coarctation of the aorta reported numerous complications in late follow-up, including aneurysm formation, in-stent restenosis, and stent fracture. There are little data on what impact stent placement will have on reintervention rates in patients with previous coarctation repair.

Marcheix and colleagues reported the results of stenting in pseudoaneurysm after previous surgical coarctation repair. There was no mortality in 5 patients, but 1 patient had a Type II endoleak and 1 patient required carotid–subclavian bypass due to left arm claudication after the left subclavian artery was covered. We had only 8 patients with isolated aneurysm or pseudoaneurysm and 3 patients who had combined stenosis and aneurysm formation. Seven of these patients underwent successful operative repair, and 1 patient received a stent. As experience with stenting grows, it is likely that endovascular procedures for pseudoaneurysms will become more common.

The small number of percutaneous interventions performed in our series and the change in technology (use of covered stents) limits our ability to compare open reoperation versus percutaneous intervention for patients requiring reintervention after coarctation repair.

Conclusion
Operative and endovascular management of recoarctation can be performed safely with good late outcomes.

Disclosures
None.

References
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