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Minimally Invasive Valve Surgery and Single Vessel Coronary Artery Bypass via Limited Anterior Right Thoracotomy

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ABSTRACT

Background: Coronary artery bypass grafting with aortic valve replacement (AVR) or mitral valve replacement (MVR) is traditionally performed via sternotomy. Minimally invasive coronary surgery (MICS) and minimally invasive valve surgery have been successfully performed independently. Patients with critical right coronary artery (RCA) stenosis not amenable to percutaneous intervention are candidates for valve replacement and single vessel coronary artery bypass. We present our series of six patients who underwent a concomitant valve and single vessel intervention via right thoracotomy.

Methods: Between January 2011 and June 2013, six patients underwent right thoracotomy with valve replacement and single vessel bypass. Four aortic and two mitral valves were replaced and all received single vessel RCA bypass using reversed saphenous vein graft. Thoracotomy was via right anterior approach for AVR and right lateral for MVR. The patients were assessed postoperatively for overall outcomes.

Results: The average age was 74 years (range 69-81); two patients were elective (AVR-1; MVR-1) and four were urgent (AVR-3; MVR-1). For MICS AVR and MICS MVR, the average cardiopulmonary bypass time was 171 ± 30 and 169 ± 7 minutes and the average aortic cross-clamp time was 122 ± 36 and 112 ± 2 minutes, respectively. Three patients were discharged home, one patient to a nursing home, and two to rehab. No patients required conversion to sternotomy; one patient developed atrial fibrillation, and one sepsis.

Conclusion: Concomitant valve replacement and single bypass grafting via right anterior mini-thoracotomy is a viable option for select patients, particularly in non-stentable RCA stenosis. In the appropriate patient population, combined coronary artery bypass grafting and valve surgery can be safely performed via right thoracotomy.

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INTRODUCTION

Concomitant valve replacement and single vessel right coronary artery bypass grafting (CABG) has been performed through right thoracotomy in a selected group of patients. Minimally invasive valve surgery for aortic valve replacement (AVR) and mitral valve repair/replacement (MVR) is well established with reproducible results [Lamelas 2011; Santana 2012]. Concomitant procedures without median sternotomy have been reported for pulmonary intervention in patients with cardiac disease and reoperation for valve or CABG through a thoracotomy approach [Seeburger 2009; Onnasch 2002; Sharony 2006; Pineda 2013]. Bilateral thoracotomy has also been described for CABG and CABG-valve procedures [Smit 2013]. The thorocotomy approach avoids complications such as sternal dehiscence, mediastinitis, and limitations on activities that delay recovery and a return to normal lifestyle [Srivastava 2003]. Management of isolated significant right coronary artery (RCA) stenosis [Ilia 2013], and AVR and RCA bypass grafting has been described [Mihos 2014]. We report our series of combined single valve surgery (AVR or MVR) with isolated RCA stenosis via right thoracotomy, specifically surgical technique and outcomes.

MATERIALS AND METHODS

We retrospectively reviewed all patients who underwent concomitant valve and single vessel CABG to the RCA between 2011 and 2013. Sternotomy cases were excluded. Approval was obtained from Staten Island University Hospital's Institutional Review Board, which included waiver of patient consent. Four of the patients underwent AVR, and two MVR.

Patient demographics, risk factors, and postoperative outcomes were reviewed. All patients were followed for a minimum of 30 days following discharge from the hospital. Long-term mortality was defined as mortality occurring after postoperative day 30. The definitions and variables selected for outcome analysis were based on the STS database. Table 1 lists the preoperative characteristics of all patients consecutively with means, standard deviations, frequency and/or percentages.

Surgical Technique

Cardiopulmonary bypass (CPB) was initiated via axillary or femoral artery, and femoral vein cannulation. Patients were

Table 1. Patient Demographics

Patient	1	2	3	4	5	6
Age	81	69	80	70	78	69
Sex	F	M	M	M	F	F
EF	45	20	45	50	55	66
HTN	Yes	Yes	No	Yes	Yes	Yes
COPD	No	Yes	No	No	No	No
CHF	No	Yes; NYHA Class III	No	No	No	No
Previous myocardial infarction	No	No	No	No	No	No
Previous stroke	No	No	No	Yes	No	Yes
Peripheral vascular disease	No	No	No	Yes	No	No
Prior coronary artery bypass graft surgery	No	No	No	No	No	No
Preoperative hematocrit	36	48	30	41	31	35
Preoperative creatinine, mg/dL	0.7	1.2	0.75	1.49	1	0.72
Number of vessels diseased	One	Two	One	One	One	One
Previous PCI-location			Ostial RCA	First obtuse marginal		
Valve disease	Aortic stenosis	Aortic stenosis	Aortic stenosis	Aortic stenosis	Mitral stenosis	Mitral incompetence/stenosis
STS-risk of mortality, %	4.25%	2.96%	2.06%	3.92%	12.256%*	5.791%*
STS-risk of morbidity and mortality, %	22.42%	22.90%	13.77%	23.37%	47.18%	31.01%
Cardiac presentation on admission	Symptoms unlikely to be ischemia	No symptoms, No angina	Stable angina	Stable angina	Symptoms unlikely to be ischemia	Stable angina
CCS Class	2		3	2	1	3

*STS calculation was done with other procedures. CCS Class indicates Canadian Cardiovascular Society Class; NYHA, New York Heart Association; RCA, right coronary artery.

cooled to 28 degrees centigrade and a cross-clamp was placed. Cold blood cardioplegia was infused into the coronary sinus and reinfused every 15 minutes until declamping (Table 2).

AVR-CABG

The second intercostal space was entered following disarticulation of the third rib from the sternum. Distal anastomosis was performed followed by aortic valve replacement, and lastly proximal anastomosis of the saphenous vein graft to the ascending aorta after closure of aortotomy and removal of cross clamp. Non-clamp technique utilizing Heartstring (MAQUET Cardiovascular, Wayne, NJ, USA) was used in one patient with severe atherosclerosis of the aorta for proximal anastomosis (Table 3).

MVR-CABG

The right fourth intercostal space was entered, followed by distal anastomosis of the RCA. A MAZE III procedure [Schaff 2000] and oversewing of the right atrial appendage was performed on two patients followed by mitral valve replacement and proximal anastomosis on the aorta (Table 3).

Anesthesia Consideration

A bronchial blocker was used on the first two patients for single lung ventilation. Later it became evident that the blocker was not necessary because the approach is fairly medial and the lung does not hinder access or visualization. A few brief periods of apnea were required during preparation for cardiopulmonary bypass. Transesophageal echocardiogram was utilized to confirm venous cannula in the superior vena cava. The heart cannot be easily agitated during de-airing, as with a sternotomy, because of the limited access, therefore it takes longer to adequately eliminate the air. Vasopressor and inotropic support is patient-specific and not different from procedures with a sternotomy approach. Patients were followed for 30-days and long-term follow-up was achieved via medical record and Social Security Death Index utilization.

RESULTS

The mean age was 74 years (range 69-81), with 3 men and 3 women. The preoperative morbidities included previous stroke, congestive heart failure (2 patients), hypertension

Table 2. Operative Characteristics

Patient	1	2	3	4	5	6
Surgical priority	Urgent	Urgent	Urgent	Elective	Urgent	Urgent
Cannulation site						
Arterial	Femoral	Femoral	Femoral	Axillary	Femoral	Axillary
Venous	Femoral	Femoral	Femoral	Femoral	Femoral	Femoral
Procedure	AVR	AVR	AVR	AVR	MVR/Radiofrequency or operative ablation	MVR/Radiofrequency or operative ablation
Surgical steps						
1	Aorta incision	Distal anastomosis	Distal anastomosis	Distal anastomosis	Distal anastomosis	Distal anastomosis
2	Valve replacement	Aorta incision	Aorta incision	Aorta incision	Left atrial incision	Left atrial incision
3	Aorta closure	Valve replacement	Valve replacement	Valve replacement	MAZE III procedure/ Oversewing of right atrial appendage	MAZE III procedure/ Oversewing of right atrial appendage
4	Distal anastomosis	Aorta closure	Aorta closure	Aorta closure	Valve replacement	Valve replacement
5	Proximal anastomosis (proximal anastomotic device used)	Proximal anastomosis	Proximal anastomosis	Proximal anastomosis	Left atrial closure	Left atrial closure
6					Proximal anastomosis	Proximal anastomosis

AVR indicates aortic valve replacement; MVR, mitral valve replacement.

(5 patients), smoker (4 patients), chronic obstructive pulmonary disease (1 patient), congestive heart failure, peripheral artery disease, renal disease (2 patients), and previous percutaneous coronary intervention (PCI) (2 patients) (Table 1). No patients had a history of previous myocardial infarction, diabetes, or previous CABG. Mean ejection fraction was 46% (range 20-66); STS risk of mortality was 5.2% (range 2-12%); and risk of morbidity and mortality was 26.8% (range 14-47%).

All patients received a Mosaic Porcine Heart Valve (Medtronic, Minneapolis, MN, USA), 4 aortic and 2 mitral. The prosthesis sizes for the aortic valve cases were 21 mm (2 cases), 23 mm, and 25 mm. The mitral valve prosthesis sizes were 25 mm and 27 mm. The mean aortic cross-clamp time was 118 minutes (range 79-153 min). The mean total bypass time was 170 minutes (range 142-201 mins). The mean operation time was 331 minutes (range 269-416). No patients required conversion to sternotomy.

Postoperative Course

The mean intraoperative estimated blood loss was 332 mL (range 200-573) and perioperative packed red blood cells given 3.5 units (range 1-9). The mechanical ventilation time was 1.0 days (median; range 0.5-58 days) with a hospital length of stay of 8.5 days (median; range 5-109 days). Postoperative complications included new onset atrial fibrillation, stroke, pleural effusion, renal failure, pneumonia, sepsis, and gastrointestinal complications in. None of the patients died in the perioperative phase. Two patients required readmission to the hospital for lower extremity cellulitis and chronic obstructive pulmonary disease exacerbation. Table 3 lists all 6 patients.

Patient 3 received transfusion and developed atrial fibrillation requiring cardioversion. This patient also underwent pericardial window via left thoracotomy for pericardial effusion and was discharged to a nursing home. Patient 4 developed respiratory failure requiring tracheostomy. Vasopressor and inotropic support was continued for postoperative cardiogenic shock and anti-arrhythmic for rapid atrial fibrillation. This patient was found to have ischemic bowel on postoperative day 22, which was managed by performing a left hemicolectomy with a Wittmann patch. The patient tolerated continuous positive airway pressure and was weaned off the ventilator 38 days after the colectomy and discharged to an assisted care facility. Patient 5 was noted to have seizure activity on postoperative day 1, requiring reintubation. The patient was diagnosed with metabolic encephalopathy and critical illness neuromyopathy. She developed renal failure and required continuous venovenous hemofiltration. The patient was made do-not-resuscitate, as per family, and 4 months later expired. The other patients' hospital courses were unremarkable.

DISCUSSION

In high-risk patients with an isolated coronary lesion, PCI serves as a less invasive alternative to surgery to treat patients with coronary artery disease [Santana 2012; Serruys 2010]. Although isolated RCA lesions are rarely seen, survival prognosis for patients with these lesions is

Table 3. Postoperative Outcomes

Patient	1	2	3	4	5	6	Average	Standard deviation
Estimated blood loss, mL	295	573	306	200	371	252	332.8	130.7
Cross clamp time, minutes	79	153	105	150	110	113	118.3	28.40
Cardiopulmonary bypass time, minutes	147	192	142	201	164	174	170.0	23.7
Operation time, minutes	291	416	291	371	269	349	331.2	56.9
Time to extubation, days	0.6	1.2	0.9	58.1	4.0	0.5	10.9	23.2
Perioperative blood products	2	0	9	0	4	6	3.5	3.6
Hospital, day	5	5	12	96	109	5	38.7	49.7
30-day mortality	No	No	No	No	No	No		
Discharge location	Home	Home	Skilled nursing home	Inpatient physical medicine & rehab	Acute/Longterm care facility	Home		

excellent even with non-surgical management [Kumpuris 1980]. Complications, however, can be severe and cases of papillary muscle rupture, posterior infarction, myocardial rupture and arrhythmias have been reported [van der Bolt 1996; Stefanovski 2012]. In our case series, the indicated RCA lesions presented with stable angina in 3 patients, and failed PCI in 2 patients. Two other patients had unstable angina (CCS Class 3) and with severe isolated RCA lesions not amenable to PCI. One patient (patient 2) presented with shortness of breath and decreased left ventricular function.

Ischemic mitral regurgitation demonstrates decreased long-term survival and case reports of infarcted papillary muscle have been reported [Kay 1985; Bouma 2013]. Thourani et al [Thourani 2000] compared elective versus urgent MVR patients with and without need for CABG, showing that age, concomitant CABG, and urgent surgical status were predictors of in-hospital mortality with an increased incidence of strokes and myocardial infarctions postoperatively. They did not report patients by number of bypasses, location of bypass, or type of graft utilized. The two mitral valves presented in our series were unique in that one had no ischemic symptoms but had a high STS mortality score (12.3%; patient 5) and another presented with CCS class of 3 and a lower STS score (5.8%; patient 6).

Aortic valve surgery via a minimally invasive approach confers advantage in decreased rates of infection, shorter length of hospital stay, and reduced morbidity [Grossi 1999; Tabata 2008]. Feasibility of the minimally invasive approach via right thoracotomy with concomitant procedures has been reported [Lamelas 2011]. The aortic valve patient group had an average STS risk of mortality of 3.29% and two of the four patients had previous PCI interventions. Patient 3 had a persistent ostial RCA lesion that was stented previously and had developed a discrete 90% in stent restenosis at presentation. PCI followed by minimally invasive valve surgery (hybrid approach) has been documented as well [George 2015]. In these studies, the isolated RCA lesion was seen 16-40% of the time and intervention via stent followed by valve surgery had good outcomes [Santana 2014; Brinster 2006]. One patient excluded from this study underwent a RCA stent followed by MVR during the same hospital admission. PCI has not shown survival benefit in high burden atherosclerotic coronary artery disease patients in which CABG is the preferred choice. Isolated RCA with diffuse disease and difficult-to-graft lateral wall targets during off-pump CABG have been omitted by surgeons [Kieser 2014]. George and colleagues [George 2015] performed a review of valve-PCI assessing the feasibility of success in high-risk patients. Their study had a cohort of 3 isolated RCA/right posterior descending artery (25%) and 4 secondary RCA/right posterior descending artery (33%) lesions that were intervened via PCI. This hybrid option demonstrates the need to address these lesions on a case by case basis.

The limitations of this study include non-random prospectively recruited patients and small sample size of both mitral and aortic valves. Our department is well versed in minimally invasive procedures, thus the learning curve has been passed for the thoracotomy approach. Patients were selected based on a multidisciplinary team decision, comprised of cardiologists and cardiothoracic surgeons. The patient's presentation, location of the lesion, and surgical approach were discussed prior to surgery.

Our report supports concomitant valve replacement and single bypass grafting via right anterior mini-thoracotomy as a viable option for select patients, particularly in non-stentable RCA stenosis. Patient selection, including lesion characteristics and patient risk, results in an appropriate treatment strategy with optimal outcomes.

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