

Apicoaortic Valve Conduit for a Patient with Aortic Valve Stenosis and Patent Coronary Bypass Grafts Using Cardiopulmonary Bypass

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Presented at Case Reports in the Sun VI, Tampa, Florida, September 9, 2010.

Abstract: In adults over 65 years of age, aortic valve stenosis has been found to be present in 2–9% within this group. Furthermore, aortic valve replacements in patients whom have had a previous coronary artery bypass grafting surgery have a mortality rate as high as 18%. A non-conventional effective surgical approach of bypassing the aortic valve by inserting an apicoaortic

valve conduit (AVC) connecting the left ventricular apex to the descending thoracic aorta has been previously documented. We describe the case of a successful implantation of an AVC in a 64-year-old Caucasian male using cardiopulmonary bypass. **Keywords:** aortic valve replacement, cardiopulmonary bypass, heart valve, bioprosthesis, surgery. *JECT. 2015;47:233–236*

Cardiovascular diseases have been the leading cause of death in the United States every year since 1900, except in 1918. Of these deaths, 52% are specifically from coronary artery disease (CAD) (1). Currently, coronary artery bypass grafting (CABG) remains the most common open-heart surgery procedure performed in the United States with 50% of all open-heart surgery procedures being performed on patients greater than 65 years of age (1). Concomitantly with CAD, the prevalence of cardiac heart valve disease increases with age (2). In adults over 65 years of age, aortic valve disease, defined as sclerosis, calcification, and thickening of the valve, has been found to affect 21–26% of this population (3,4). And of this subset of the population of adults, ages 65 years and older, aortic valve stenosis (AS) has a prevalence rate of 2–9% (3,4). In most cases, the treatment for outflow limiting AS is aortic valve replacement (AVR).

With the continual advancement of modern medicine and increased life expectancy, a subpopulation of this demographic, which has been ever present, is likely to increase substantially in numbers. First, consider that the older population demographic (>65 years of age) of the United States is projected to double in number by the year 2050 (5). Second, by projecting incidence and prevalence rates of the aforementioned diseases, unto the increased population projections, it is highly probable the arena of cardiovascular surgery will begin to encounter an increased number of patients whom present with aortic valve stenosis (AS) requiring an AVR and whom have had a previous CABG. Although bypass graft patency decreases with age, there exists a smaller population of patients who possess patent coronary artery bypass grafts and only need treatment of their AS. Performing reoperative open-heart surgery in this subgroup of patients has a mortality rate as high as 18% (6). Furthermore, for patients who have atherosclerotic aortic disease, commonly seen with AS, conventional replacement of the aortic valve in patients with severe atherosclerotic disease of the ascending aorta has been reported to have atheroembolic events in 37% of the patients compared to 2% in patients without atherosclerotic disease (6).

Given this high morbidity and mortality rate in these patients, an alternative, non-conventional, and effective

Received for publication April 23, 2014; accepted December 6, 2015.
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The senior author has stated that the authors have reported no material, financial, or other relationship with any healthcare-related business or other entity whose products or services are discussed in this paper.

surgical approach has been previously documented (7). In this procedure, the native diseased aortic valve is bypassed by inserting an apicoaortic valve conduit (AVC) between the left ventricular apex and the descending thoracic aorta (8). This procedure presents some advantages to the conventional approach such as 1) another sternotomy is avoided, thereby preventing injury or sacrifice to existing patent grafts (especially a left internal mammary graft) and 2) because no aortotomy and aortic cross-clamping is required, manipulation of the ascending is also avoided.

The purpose of this case report is to document a successful case of implantation of an AVC using cardiopulmonary bypass (CPB) in a patient with severe AS subsequent to coronary artery bypass surgery.

DESCRIPTION

A 64-year-old Caucasian male presented to the hospital with dyspnea, angina, and a non-ST segment elevation myocardial infarction. His weight was 74 kg, a height of 157 cm with a resultant body surface area of 1.76 m². His medical history included a 14-year prior history of CABG × 5 surgery, hypertension, hyperlipidemia, coronary artery atherosclerosis, type II diabetes mellitus, and chronic renal insufficiency (creatinine 3.05 mg/dL). This patient was in diastolic congestive heart failure, and had encountered four separate episodes of percutaneous cardiac interventions resulting in a cumulative placement of five intracoronary stents. Cardiac catheterization found the patient to have a patent left internal mammary graft to the left anterior descending artery, patent saphenous vein graft to the posterior descending artery, AS with mild aortic regurgitation and mild mitral regurgitation, left atrial enlargement, and a 55% ejection fraction. The patient was referred to surgery for AVR. His preoperative lab values were: hemoglobin = 11.3 g/dL, hematocrit (Hct) = 33.8%, platelet count = 280,000/mm³, fibrinogen = 200 mg/dL, white blood cell count = 11,300/μL, prothrombin time = 13.2 seconds, partial thromboplastin time = 34.2 seconds, serum sodium concentration = 134 milliequivalents/L, serum potassium concentration = 4.9 milliequivalents/L, chlorine = 97 milliequivalents/L, glucose = 246 mg/dL, and creatinine = 3.05 mg/dL.

On entering the operating room, the patient received intravenous lines, and for hemodynamic monitoring received a pulmonary artery catheter, right radial artery catheter, and pulse oximetry on right index finger. A midazolam, fentanyl, and etomidate combination was used for induction and the trachea was intubated with a left-sided double-lumen endotracheal tube after adequate neuromuscular blockade was achieved. Transcutaneous pacing/defibrillator pads were applied. The patient was positioned for a left lateral thoracotomy and was prepared and draped in a stan-

dard sterile fashion. The extracorporeal circuit was composed of a Terumo Xcoating[®] (Terumo Cardiovascular Systems, Ann Arbor, MI) bypass circuit with 3/8" arterial and 1/2" venous lines that included a Capiiox[®] SX-25 oxygenator (Terumo Cardiovascular Systems, Ann Arbor, MI) with an open venous reservoir, and a Capiiox[®] arterial line filter and two pump suctions. No sump or vent was used. The circuit was primed with 1500 mL Plasmalyte-A (Baxter Healthcare Corp., Deerfield, IL) and 25 milliequivalents of sodium bicarbonate. The heart-lung machine used was a Terumo[®] Advanced Perfusion System 1 heart-lung machine with an arterial roller pump (Terumo Cardiovascular Systems) that included a CDI Blood Parameter Monitoring System 500[®] (Terumo Cardiovascular Systems). A left thoracotomy was performed to access left ventral and descending thoracic aorta. The patient was systemically heparinized with a loading dose of 30,000 international units (400 international units/kg). Post-heparin activated clotting time was 510 seconds. A 27 French Bio-Medicus Femoral Venous Cannula (Medtronic, Minneapolis, MN) was inserted into the femoral vein and subsequently connected to the venous line of the extracorporeal circuit. An 18 mm × 40 mm Gelweave[™] Graft (Vascutek; Terumo Cardiovascular Systems) with an 8-mm sidearm graft was sewn to the descending aorta using a partially occluding clamp. Blood flow as permitted to slowly flow through graft to expunge all air and subsequently clamped. A 7-mm Sarns[™] Soft-Flow[®] Aortic Cannulae (Terumo Cardiovascular Systems) was inserted into the side branch, the air was expunged, and the cannula was connected to the arterial line of the extracorporeal bypass circuit. CPB was initiated using vacuum-assisted venous drainage ranging between -25 and -40 mmHg. Full cardiopulmonary support was achieved with mean arterial pressure maintained between 60 and 70 mmHg, alpha-stat blood gas management, and the patient temperature kept at normothermia. No cardioplegia was administered and the heart remained beating, once on bypass mechanical ventilation was suspended.

The valve conduit was constructed by connecting a 19-mm Freestyle porcine valve (Medtronic) to a 16-mm Hancock Apical Left Ventricular Connector (Medtronic) and lastly sewn to the clamped end of graft. Using the trocar blade, a core of the left ventricular muscle was removed and the connector was inserted into the left ventricle and sutured into the place.

The patient was placed in a Trendelenburg position and all air from the ventricle and conduit was removed and permitted to function. Mechanical ventilation was restored. Venous drainage was reduced, allowing the full restoration of the central blood volume. Normalization of pulmonary artery and central venous and systemic pressures and visual confirmation of adequate emptying of the left ventricle, and peripheral perfusion, confirmed by pulse oximeter, were observed. The patient's Hct on CPB was 21%, which

we transfused with two units of homologous blood prior to terminating CPB per surgeon's order. Weaning from CPB was uneventful and total bypass time was 52 minutes.

COMMENT

Aortic sclerosis, even in the absence of AS, produces a significant health risk and increases the risk of death from cardiovascular cause and myocardial infarction by approximately 50% (4,9). The AVC origins trace back to 1910 where Carrel, using animal models, developed an alternative method to divert blood to the brain while being able to clamp the ascending aorta (in the event of a needed repair). He reported being able to successfully graft either a paraffin tube or a large harvested jugular vein from the left ventricle to the descending aorta (7). In 1955, a non-conventional effective surgical approach of bypassing the aortic valve by inserting a valve conduit (Hufnagel valve in a Lucite tube) between the left ventricular apex and the descending thoracic aorta was successfully achieved in animal models (10) and was clinically achieved in 1963 (8).

We describe a case of a successful implantation of an AVC with the use of CPB. Implanting the AVC comes with advantages for this population. First, a sternotomy is avoided thereby avoiding injury to existing patent grafts and right ventricle. Secondly, aortic cross-clamping or any manipulation of the ascending aorta is avoided as well. This is important because under the conventional approach, injury to the grafts can happen at any time during the operation and if this occurs mortality has been found to be as high as 50% (11). It is important to note that this procedure would not be an acceptable treatment for patients with aortic insufficiency as an incompetent aortic valve will not afford isovolumetric contraction or adequate ventricular emptying thus not correcting the congestion and low cardiac output.

In this case, our standard CPB adult circuit was used. At the time of the procedure, a smaller venous line (3/8") was not part of the institution's standard protocol. This since has changed. This procedure has been reported to have been performed without the use of CPB, or in the case of needing CPB, a modified miniaturized extracorporeal circuit is deployed (12). It is beyond the scope of this report to address the inclusion criteria for the use of CPB for this procedure. However, based on our experience, we readily concur with the aforementioned authors that a reduced prime mini-circuit, perhaps reservoir-less or reservoir-ready system is feasible to use in this procedure for the following reasons: first, the procedure does not mandate for all of the central blood volume to be emptied from the patient thereby negating the primary need for a reservoir. Secondly, previous authors have documented the benefits of a miniaturized and more physiologically invisible extracorporeal circuit mini-circuit (13–16). Thirdly, in this particular case, the patient did have a marked reduction in the Hct as

a result of the asanguineous prime of the extracorporeal circuit and undoubtedly the patient would have benefitted from either having a circuit with a lower priming volume and/or employing retrograde autologous priming of the circuit. Retrograde autologous priming is part of our practice, however, given the patient's severity of AS, we chose not to use the technique. The concern was that if during the retrograde priming of the extracorporeal circuit myocardial ischemia, occurred in the presence of severe AS could produce an accelerated downward spiral of poorer and poorer myocardial performance leading to intraoperative myocardial infarction or even death. Lastly, this subset of patients usually present with multiple and/or severe comorbidities (hence, why they were excluded from conventional treatment) and it is likely these patients would benefit the most from a reduction in the systemic inflammatory response that has been seen with lower surface area extracorporeal circuits (17). Further research is needed with respect to outcomes with the use of smaller, reservoir-less circuits with this surgical approach compared to procedures without the use of CPB.

We report a successful case of an AVC using CPB as a surgical alternative to the standard AVR for patients with AS and previous CABG using the heart–lung machine. It is recommended that the perfusionist become familiar with this surgical alternative and make adjustments for the nuances this technique requires with respect to the conduct of CPB.

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