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Surgical Strategy for Biventricular Assist Device Implantation after Previous Coronary Artery Bypass Grafting

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ABSTRACT

In an aging population, numerous patients who underwent previous coronary artery bypass grafting (CABG) are presenting with end-stage ischemic cardiomyopathy. Although redo CABG and cardiological interventions are possible treatment options, orthotopic heart transplantation remains an ultimate option for these patients. However, there is high morbidity and mortality on the waiting list, and mechanical circulatory support is a life-saving concept [Hetzer 2006; Taylor 2009].

We developed a simplified and safe technique for implantation of a biventricular assist device as a redo in complex patients after previous CABG and end-stage heart failure.

INTRODUCTION

The last therapeutic option for patients with end-stage coronary heart disease is orthotopic heart transplantation. Unfortunately, due to the shortage of organ donors, mechanical circulatory support becomes necessary from time to time as a bridge-to-transplantation.

We report on 2 patients suffering from end-stage ischemic cardiomyopathy after coronary artery bypass grafting (CABG) who finally needed mechanical circulatory support.

CASE REPORTS

Patient 1 was a 65-year-old man with a history of smoking (40 pack years). At the age of 36 years, CABG was performed to the left anterior descending artery (LAD), a diagonal, and a marginal branch with saphenous vein grafts. Coronary revascularization was repeated at the age of 46 years with 3 saphenous vein grafts to the posterior descending artery (PDA), the marginal and the diagonal branch. In 1990, he had his third CABG with the left internal thoracic artery to the LAD and a radial artery to the diagonal branch. Only these 2 grafts remained patent. He was listed for heart transplantation without any further options for surgical or interventional revascularization. An implantable cardioverter defibrillator (ICD) was implanted in 2005 and upgraded to a cardiac resynchronization therapy (CRT)-ICD in 2009. Nevertheless, the patient deteriorated continually with signs of multiorgan failure and became dependent on inotropic support. In this situation, we decided to implant a biventricular assist device (BVAD) (Berlin Heart EXCOR®, Berlin Heart GmbH, Berlin, Germany) as a re-re-redo procedure.

Patient 2 was a 63-year-old man who had CABG in 1996 with right internal thoracic artery (RITA) to the LAD and 2 saphenous vein grafts to the circumflex and right coronary arteries. A CRT-ICD was implanted in 2006. He became septic with staphylococcus on a central venous catheter and decompensated acutely. Even with the intraaortic balloon pump and the calcium-sensitizer levosimendan (Simdax®, Abbott Laboratories, Chicago, Illinois, USA) he remained dependent on high-dose inotropic support and developed multiorgan failure, and a BVAD had to be implanted as a redo procedure.

The patients were taken to the operating room, and cardiopulmonary bypass (CPB) was installed over the femoral artery and vein in order to minimize the risk of repeated sternotomy. The chest was opened most carefully, and the heart was gradually dissected. After minimal dissection of the left atrium, a 40 French Medos cannula (Medos Medizintechnik AG, Stolberg, Germany) was inserted and fixed with 2 purse-string sutures (4-0 Prolene). The right atrium was cannulated with a Berlin Heart atrial cannula (12 mm).

Surgical Concept for Implantation of a Biventricular Assist Device after Previous Coronary Artery Bypass Graft

1. Femoral cannulation and starting cardiopulmonary bypass
2. (Re-)Sternotomy
3. Dissection of the right and left atria, aorta, and small parts of the right ventricle
4. Implantation of the left (Medos Medizintechnik AG, Stolberg, Germany) and right (Berlin Heart GmbH, Berlin, Germany) atrial cannulae
5. Anastomosis of the arterial cannula (Medos) to the aorta
6. Purse-string suture (pledget-enforced) on the right ventricular outflow tract and insertion of the arterial cannula
7. Start of the assist device and weaning from cardiopulmonary bypass
8. Hemostasis and (eventually) chest closure

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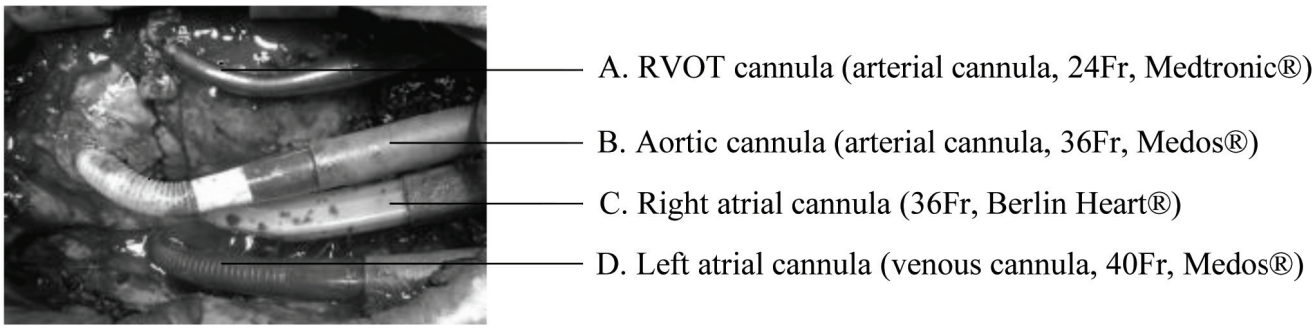

Figure 1. Intraoperative view of the connection sites of a biventricular assist device (BVAD) (Berlin Heart EXCOR®, Berlin Heart GmbH, Berlin, Germany) in a patient after multiple coronary artery bypass graft (CABG) procedures. A, Right ventricular outflow tract (RVOT) cannula (24 French Medtronic DLP Elongated One-Piece Arterial Cannula [EOPA®]; Medtronic Inc., Minneapolis, MN, USA). B, Aortic cannula (36 French, Medos Medizintechnik AG, Stolberg, Germany). C, Right atrial cannula (36 French, Berlin Heart GmbH, Berlin, Germany). D, left atrial cannula (40 French, Medos Medizintechnik AG, Stolberg, Germany).

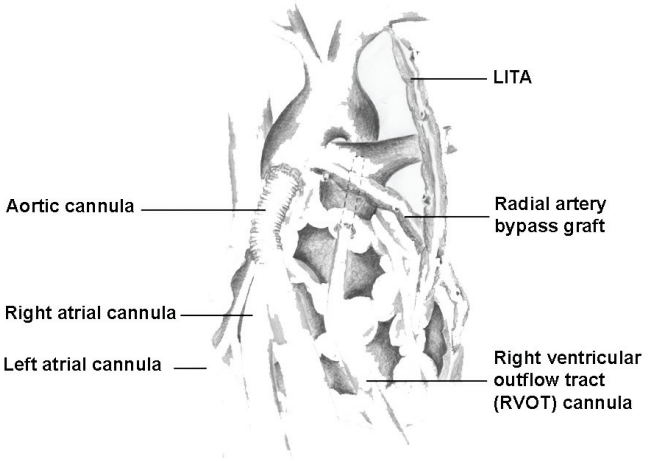

Figure 2. Intraoperative view of the connection sites of a Berlin Heart Excor® (Berlin Heart GmbH, Berlin, Germany) biventricular assist device (BVAD) in a patient with 2 patent arterial bypass grafts (left internal thoracic artery [LITA] to left anterior descending artery [LAD] and radial artery to a diagonal branch).

Because of severe adhesions and crossing of the patent bypass grafts, we decided not to dissect the extremely fragile pulmonary artery but to cannulate the already exposed right ventricular outflow tract (RVOT). Therefore, we inserted a 24 French Medtronic DLP Elongated One-Piece Arterial Cannula (EOPA®; Medtronic Inc., Minneapolis, MN, USA) over the pulmonary valve into the main pulmonary artery and fixed it with 2 purse-string sutures (4-0 Prolene). Afterward, the ascending aorta was partially clamped, and a Medos arterial cannula (12 mm; Medos Medizintechnik AG) was anastomosed end-to-side to the aorta (Figures 1 and 2). All cannulae (left and right atrium, aorta, and RVOT) were connected extracorporally to the Berlin Heart Excor pumps (right ventricular pump volume, 60 mL; left ventricular pump volume, 80 mL). The assist device was started, and the patient was gradually weaned from CPB (see Table for surgical concept).

After the procedure, both patients recovered slowly from multiorgan failure and are now awaiting heart transplantation.

DISCUSSION

Multiple previous surgical procedures are a crucial problem before BVAD implantation associated with a high morbidity and mortality [Odell 1996]. As a first step in our surgical concept, we describe the installation of CPB via the femoral vessels to minimize the risk of injury and to have better control of potential complications during re-sternotomy. Odell and colleagues studied 145 patients who underwent aortic valve replacement as a redo procedure after CABG [Odell 1996; Sodian 2008]. Of these, reentry problems occurred in 23 patients (16%): injury of grafts in 13 patients (9%), the innominate vein in 3 patients (2%), the right atrium in 2 patients (1%), and the pulmonary artery, aorta, and right ventricle in 1 patient each. Therefore, we think that a primarily safe opening of the chest is essential for a finally successful implantation of a BVAD.

In a following step, we intend to dissect only the surgical targets for implantation of the cannulae in order to minimize the risk of excessive bleeding from adhesions. In any redo procedure the risk of bleeding is increased, especially in patients who need BVADs because they almost always suffer from an impaired liver function [Loebe 2000], with reduced synthesis of coagulation factors.

With our concept (Table), BVAD implantation as a redo procedure is simplified compared to classical implantation techniques and their variants [Pasic 1999]. The re-sternotomy was performed under stable conditions using CPB via the femoral vessels without stressing or even damaging the thoracic organs. Moreover, with this technique, it was possible not to dissect the pulmonary artery, the patent bypass grafts, and the left ventricle, but only the right side of the mediastinum. Hereby, we were able to minimize the risk of damaging important anatomic structures and potential sources of bleeding complications. In patient 1, we additionally left the chest open for 48 hours until he was completely stable to prevent life-threatening tamponade. This was not necessary in

patient 2, in whose case the chest could be closed primarily. Moreover, we only used the conventional Berlin Heart cannula for the right atrium, but more flexible cannulae for the aortic, pulmonary, and left atrial cannulation. With these cannulae, it is possible to perform the above described cannulation technique.

Using our concept, in close cooperation with anesthesiologists and intensive care specialists, the implantation of a BVAD as a redo procedure is possible and effective, especially in such a group of complex and high-risk patients.

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