Fast-track article

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PulseCath, a new short-term ventricular assist device: our experience in off-pump coronary artery bypass graft surgery

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We utilized a new ventricular assist device, the PulseCath catheter, to perform an off-pump bypass procedure in a patient with low ejection fraction. The 21 Fr PulseCath catheter, driven by a standard intra-aortic balloon pump console, can generate a pulsatile flow of 2–3 l/min. The PulseCath coupled with an intra-aortic balloon pump device is an important tool for left ventricular assistance. *J Cardiovasc Med* 9:423–426 © 2008 Italian Federation of Cardiology.

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Introduction

Off-pump coronary artery bypass surgery is indicated in patients with poor left ventricular function. Nevertheless, beating heart surgery in patients with a dilated ventricle can be technically demanding. We report the case of off-pump coronary artery bypass grafting in a patient with a very low ejection fraction assisted by a new short-term ventricular assist device.

Methods and results

A 76-year-old man with progressive dyspnea (NYHA class III) was referred to our institution. His medical history was positive for type 2 diabetes mellitus, obesity, moderate renal failure, and chronic obstructive pulmonary disease. Transthoracic echocardiographic parameters were as follows: end-diastolic diameter 60 mm, mild aortic and mitral regurgitation, ejection fraction <20%. The electrocardiogram showed stable sinus tachycardia with paroxysmal atrial fibrillation; QRS duration 144 ms. The patient was receiving ramipril 2.5 mg/day, furosemide 25 mg twice daily, and amiodarone 200 mg/day.

Coronary angiography showed critical stenosis of the left anterior descending and circumflex coronary arteries; the right coronary artery was closed and the posterior descending artery was visualized retrogradely.

Owing to the complex coronary anatomy, coronary angioplasty could not be performed and surgical strategy was opted for; a beating heart procedure was chosen because of poor ejection fraction. In order to assist the heart during the maneuvers of luxation, we adopted the PulseCath LV21 catheter (Intra-Vasc NL, Groningen, The Netherlands).

The PulseCath consists of a disposable extracorporeal membrane pump (EMP), connected to a 21 or 17 Fr polyurethane catheter. This catheter has an integrated two-way valve system that sucks blood from the left ventricle and delivers it into the ascending aorta. The PulseCath is driven by an intra-aortic balloon pump (IABP) console to which it is connected by a standard catheter supplying helium. The IABP drives the EMP by helium insufflation and suction. The IABP console is triggered by a dedicated peripheral pressure line or electrocardiogram [1].

Anesthesia was performed using a total intravenous technique. Hemodynamic monitoring was obtained using a left radial artery catheter; the electrocardiogram and central venous pressure were continuously monitored. Target coronary arteries were stabilized using the Octopus II tissue stabilization system (Medtronic, Minneapolis, Minnesota, USA). Appropriate size intracoronary shunts (Clearview Shunt, Medtronic) were used to maintain distal perfusion and to achieve a bloodless operative field. Visualization was aided with a humidified oxygen blower. Hypothermia was prevented by application of an air warming blanket at the lower half of the body.

After standard sternotomy, the left internal mammary artery was harvested. At the same time a segment of the saphenous vein was drawn. Intravenous heparin was given at a dosage of 3 mg/kg of body weight. The activated clotting time was kept around 600 s. By Seldinger technique, a pigtail catheter coupled with a guide-wire was positioned into the ascending aorta, in the standard site of aortic cannulation, through two aortic purse-string

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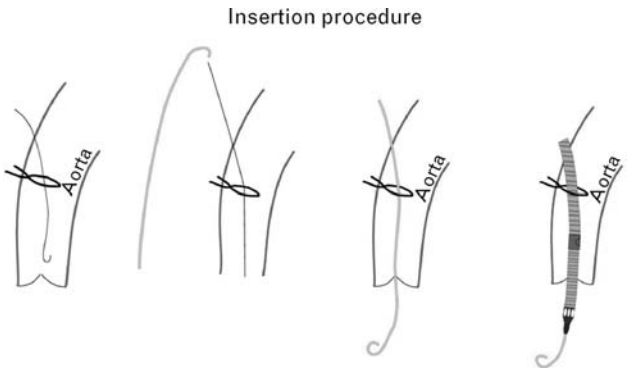
Fig. 1



A pigtail catheter coupled with a guide-wire is positioned into the ascending aorta through two aortic purse-string sutures of 2–0 Tycron. The pigtail is introduced through the aortic valve into the left ventricle. The PulseCath catheter is inserted into the left ventricle over the pigtail: the tip of the PulseCath is positioned in the left ventricular outflow tract and the two-way valve in the ascending aorta.

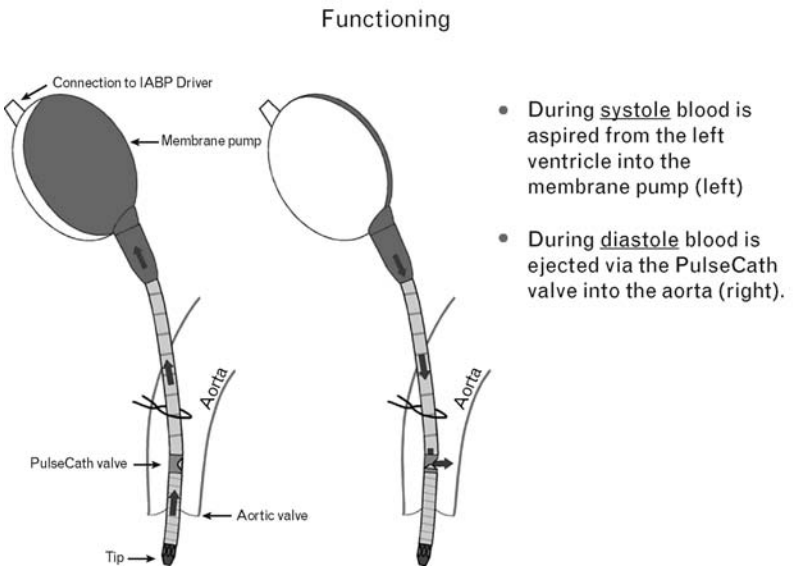
sutures of 2–0 Tycron. Under transesophageal guidance, the pigtail was introduced through the aortic valve into the left ventricle. The PulseCath catheter was inserted into the left ventricle over the pigtail: the tip of the PulseCath was positioned in the left ventricular outflow tract and the two-way valve in the ascending aorta. The purse-string sutures were secured by two tourniquets and the PulseCath catheter was strongly tied to them (Fig. 1). Finally, the PulseCath catheter was connected to the EMP (Fig. 2). This pump was connected to a Datascope System 98 IABP console, triggered by the right radial artery line; 1 : 1 counterpulsation started (Fig. 3). Before heart manipulation, dobutamine at 6 μg/kg/min was infused.

The left internal mammary artery was anastomosed to the left anterior descending artery. Owing to severe left ventricular dilatation, we utilized an apical suction device (Starfish II, Medtronic) to expose the posterior descending artery and one marginal branch of the circumflex artery. A sequential coronary artery grafting was performed between the posterior descending artery and the obtuse marginal branch by the saphenous vein segment. Heart luxation was perfectly tolerated without contractile dysfunction or atrial fibrillation episodes. During PulseCath utilization (about 60 min), we observed an increase in systolic blood pressure and mean arterial pressure; diastolic blood pressure was unchanged. The heart rate slowly increased (Fig. 4).

A definitive steroid eluting, bipolar, epicardial lead (Capsur Epi 4968–60 cm, Medtronic) was implanted in the lateral wall of the heart. The wire was tunneled under the sternum towards the left infraclavicular region where a small pocket was created.

The IABP driver was positioned in stand-by and the PulseCath catheter was removed from the ascending aorta as a standard aortic cannula; the purse-string sutures were tied as normal. The proximal aortic anastomosis of the saphenous vein graft was finally performed. The standard heparin dosage was totally neutralized.

Fig. 2



The PulseCath catheter is connected to the extracorporeal membrane pump. IABP, intra-aortic balloon pump.

Fig. 3

The PulseCath catheter is connected to an intra-aortic balloon pump (IABP) console through a standard catheter for helium.

The immediate postoperative period was uneventful. We changed dobutamine infusion to dopamine at 10 μg/kg/min because of sinus tachycardia. On postoperative day 1, serum levels of troponin I and creatine kinase-MB were 0.208 ng/ml and 13.4 ng/dl, respectively. A week later, a device for cardiac resynchronization therapy plus defibrillation (CRT-D, Medtronic InSync Maximo 7304, Medtronic) was implanted, utilizing the infraclavicular definitive epicardial lead. After slow titration, dopamine infusion was stopped on postoperative day 15. The patient was discharged with the following therapy: enalapril 2.5 mg/day, amiodarone 200 mg/day, and furosemide 50 mg twice daily. Transthoracic echocardiography showed an ejection fraction of 25%. After a follow-up of 12 months, the patient is alive and in NYHA class II.

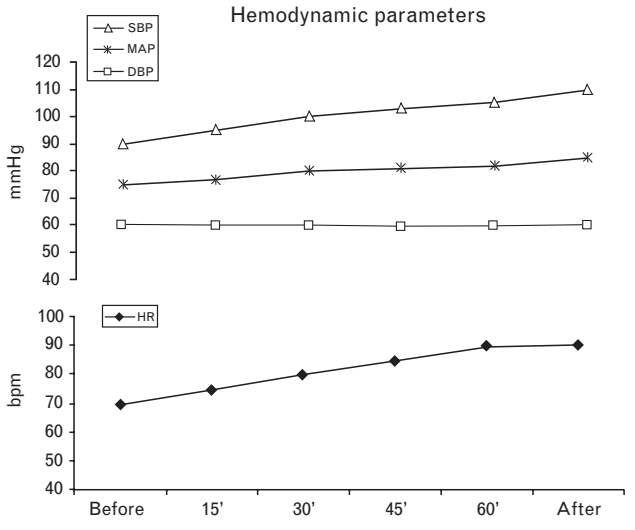
Discussion

The good long-term results of beating heart coronary surgery in patients with poor left ventricular function have been established, as long as a complete revascularization is achieved. The main problem of a widespread application of off-pump bypass surgery in patients with left ventricular dysfunction appears to be the exposition of the vessel lying on the rear wall of the heart.

In our brief experience, the PulseCath catheter has proved to be a useful device for left ventricular assistance during off-pump bypass surgery in a patient with low ejection fraction. We completed all distal coronary anastomoses without conversion to heart–lung machine due to hemodynamic instability. No atrial fibrillation was observed.

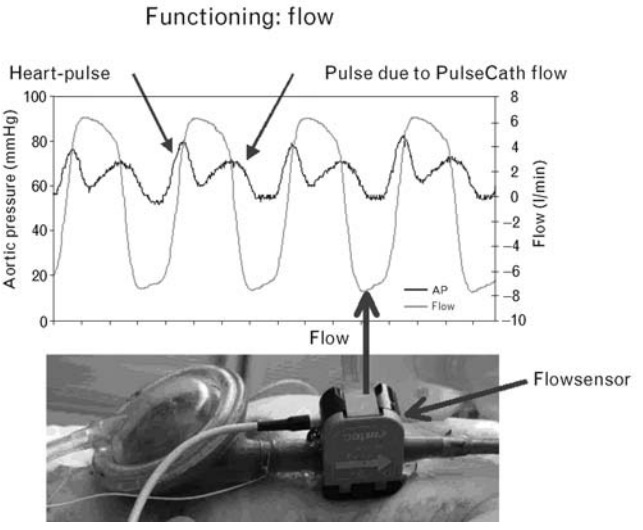
The PulseCath catheter, unlike the IABP catheter that exerts its effect only by volume displacement, has a double action: in addition to venting the left ventricle, with a left ventricular unloading effect, it is able to create a real pulsatile flow in the ascending aorta (Fig. 5). The 21 Fr catheter with a heart rate of 60–120 bpm can generate a flow of 2–3 l/min. In consideration of the patient's body surface area (2.19 m^2, theoretical total flow

Fig. 4



PulseCath utilization time: 60 min. We observed an increase in systolic blood pressure (SBP) and mean arterial pressure (MAP); diastolic blood pressure (DBP) was unchanged. The heart rate (HR) slowly increased.

Fig. 5



The PulseCath catheter is able to create a real pulsatile flow in the ascending aorta. The 21 Fr catheter with a heart rate of 60–120 bpm can generate a flow of 2–3 l/min. AP, aortic pressure.

5.25 l/min) the 21 Fr PulseCath catheter could ensure half the total flow of this patient.

Regarding cost-effectiveness, the PulseCath device costs more than the standard IABP catheter but less than a short-term assist device. Moreover, the PulseCath has an enormous advantage: it does not need dedicated hardware to be driven, but it is simply connected to a standard IABP console. During PulseCath utilization, our perfusionist has easily made the set up of our Datascope System 98 IABP, without the need for a dedicated specialist. For the above reasons, the PulseCath catheter can always and immediately be available and usable in every cardiothoracic ward.

We utilized the PulseCath for a brief period during surgical maneuvers in the operating room. More clinical studies and observations are warranted in order to evaluate preservation of aortic valve leaflets, especially in patients with aortic valve disease, and hemolysis after longer utilization of the PulseCath.

Reference

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