Is there a role for beating heart valve surgery with continuous antegrade coronary perfusion?

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ABSTRACT

Keywords: beating heart valve surgery, myocardial protection, antegrade coronary perfusion.

Objective: the aim of this study was to describe a technique for beating heart valve surgery with continuous antegrade coronary perfusion, to assess its safety and feasibility and to report our initial clinical experience.

Methods: from July 2007 to December 2008, 19 patients underwent beating heart valve surgery. The indications were: coronary artery disease in patients with acute coronary syndrome (ACS) associated with valve disease in 10 cases; valve disease in patients with previous CABG and patent grafts in 9 cases. Aortic valve replacement, mitral valve replacement, mitral valve repair and double valve replacement were performed in 15, 1, 2 and 1 patients respectively. Associated CABG was performed in all patients with ACS. Coronary arteries were continuously perfused via patent LIMA graft and/or selective graft perfusion using a single roller pump separate from the systemic circulation and/or direct cannulation of the coronary ostia using a specific balloon cannula.

Results: aortic cross clamp time and cardiopulmonary bypass time were 63±17 and 96±20 minutes respectively. There was no hospital mortality. No major complications were observed during hospital stay. All patients were successfully discharged.

Conclusion: in our experience, this technique has shown to be safe and effective. In selective patient, it could be considered as an alternative to conventional techniques.

1. INTRODUCTION

Cardioplegic arrest during CPB is still a cornerstone for the majority of cardiac surgical procedures, but in some clinical conditions this technique could be potentially inadequate. In selected patients presenting with acute coronary syndromes and requiring urgent surgical revascularization associated with valve surgery, cardioplegia administration could exacerbate ischemic injury and result in myocardial damage [1]. Furthermore, in CABG patients undergoing reoperation for aortic valve disease, the need for LIMA to LAD graft isolation and clamping is mandatory for successful myocardial protection but this manoeuvre brings with it the risk of graft damage [2].

Based on these assumptions, on-pump normothermic beating heart valve surgery using continuous antegrade perfusion could have two main theoretical advantages:

1) there is no need for cardioplegic arrest which might results in myocardial ischemia and reperfusion injury in patients with recent or ongoing acute coronary syndromes;

2) in redo patients with previous CABG there is no need for total heart dissection and LIMA isolation, with less probability of graft injury.

The aim of this study is to describe a technique for beating heart valve surgery with continuous antegrade coronary perfusion, to assess its safety and feasibility and to report on our initial clinical experience.

2. MATERIALS AND METHODS

From July 2007 to December 2008, 19 patients (15 males, age: 67.9±10.1 years, range: 56-79) underwent normothermic beating heart valve surgery at our institution. The indications for surgery were:

1) coronary artery disease in patients with recent or ongoing acute coronary syndromes associated with aortic valve stenosis, mitral valve regurgitation and mitro-aortic disease in 7, 2 and 1 patient respectively;

2) aortic valve stenosis, mitral valve regurgitation and mitral valve stenosis in patients with previous CABG and patent LIMA to LAD graft in 7, 1 and 1 patient respectively.

Preoperative patients characteristics are shown in table 1. The operative variables are shown in table 2. All operations were performed by the same surgeon.

Surgical technique

All procedures were performed through a median sternotomy.

2.1. Patients with acute coronary syndromes

After complete heparinization, arterial and venous cannulations were performed uing standard techniques. Taking into consideration the body surface area of the patient (BSA, 2.4 L/min/m²), cardiopulmonary bypass (CPB) flow rate was maintained at the usual level, with a mean systemic pressure

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Table 1. Preoperative variables.

	N (%)	Mean	Range
Age		67.9±10.1	56 - 79
Sex (male)	15 (78.9)		
Valvular disease – Aortic valve stenosis – Aortic valve regurgitation – Mitral valve stenosis – Mitral valve regurgitation	 13 3 1 3		
Previous myocardial infarction	10 (52.6)		
Previous cardiac surgery (CABG)	9 (47.4)		
Non elective surgery	10 (52.6)		
Logistic Euro SCORE – Redo patients – ACS patients	 9 (47.4) 10 (52.6)	 10.9±7.4 24.8±12.7	 7.9 – 31.8 7.7 – 41.7
NYHA class – I-II – III-IV	 9 (47.4) 10 (52.6)		
Ejection fraction (%)		48.1±13.9	25 - 65
Left ventricular disfunction (FE<30%)	6 (31.5)		
Pre-operative IABP	2 (10.5)		

CABG = coronary artery bypass grafting; NYHA = New York Heart Association; IABP = Intra Aortic Balloon Pump.

greater than 60 mmHg, at a systemic temperature of 35°C-36°C. All patients received a LIMA to LAD graft, that was performed first in order to allow for rapid myocardial revascularization. The remaining distal anastomoses were performed using the radial artery or the saphenous vein before the proxymal anastomoses. Coronary artery immobilization was carried out with a suction stabilizer (Estech, San Ramon, CA, USA). The proxymal ends of the saphenous and radial grafts were connected to the antegrade coronary perfusion circuit that was formerly prepared with a ¼ inch tube and a single roller pump and maintened separate from the systemic circulation. Using a left ventricular venting with maximal draining, the aorta was cross-clamped and antegrade coronary perfusion was started. Whenever coronary perfusion was not completely achieved by LIMA to LAD and graft flow, the left main and/or the right coronary ostia were selectively cannulated using a specific polystan self-inflating balloon cannula (Maquet Cardiopulmonary AG, Hirrlingen, Germany) in order to completely protect the myocardium. To prevent dislodgment, the two catheters into the coronary ostia were secured to the aortic wall with a 4-0 polypropilene suture. Coronary perfusion was mantained at a rate of 220 to 250 ml/min and verified using a transit-time doppler flowmeter (Transonic Systems Inc., NY, USA). In isolated mitral surgery, when the ascending aorta was not opened, antegrade coronary perfusion was obtained with the needle commonly used for antegrade cardioplegia administration. Since the trans-septal approach sec Guiraudon [3] through the right atrium was used in all patients undergoing mitral valve procedures, we used an additional vent in the coronary sinus in order to avoid refluent blood filling the operating field.

The proximal vein graft anastomoses were performed when the aortic cross-clamp was removed.

2.2. Redo patients

In redo aortic valve surgery in patients with previous CABG and patent LIMA graft, limited dissection was performed in order to: 1) identify the position of the proximal vein graft anastomoses, 2) allow for cannulation of the aorta and the right atrium, 3) for venting of the left ventricle through the right superior pulmonary vein and 4) for application of the aortic cross clamp. No attempt was made to dissect the left side of the heart, thus reducing the risk of potential damage to the LIMA. Whenever possible, the aortic cross clamp was positioned proximal the proximal anastomoses, in order to leave patent grafts perfused; if not possible, selective antegrade graft perfusion was performed as previously described, in order to avoid intra-operative myocardial ischemia.

Transesophageal echo (TEE) and 12-lead EKG were continuously monitored so that any potential sign of myocardial ischemia during the procedure could be identified in a timely manner. Besides, removal of air after aortic declamping is very important in this procedure. The air evacuation, performer using the venting tube continuosly until the end of CPB, was confirmed by monitoring with TEE. No episode of air embolism was experienced in our study.

Table 2. Operative variables.

	N (%)	Mean	Range
Aortic crossclamp time (minutes)		63.7±17.4	40 - 89
Cardiopulmonary bypass time (minutes)		96.2±20.4	65 - 132
Valve procedures			
– AVR	15 (78.9)		
– MVR	1 (5.2)		
– Mitral repair	2 (10.5)		
– DVR	1 (5.2)		
CABG	9 (47.4)		
Troponin I (µmol/L)		23.1±11.2	7 - 41
Ventilation time (hours)		11.1±5.6	6 - 30
Mean total dopamine use (µg/kg/min)		3.1±1.7	0 - 6
ICU stay (hours)		48.8±17.6	24 - 96
Hospital stay (days)		7.6 ±1.3	6 - 12

AVR = aortic valve replacement, MVR = mitral valve repair, DVR = double valve replacement (aortic and mitral valve), CABG = coronary artery bypass grafting.

Aortic valve replacement was performed in 16 patients using single interrupted pledgeteds sutures and stented pericardial bioprostheses (Perimount Magna, Edwards Lifesciences, Irvine, CA, USA); of these, one patient underwent concomitant mitral valve replacement with a porcine stented bioprosthesis (Mosaic, Medtronic Inc., Minneapolis, USA) using single interrupted pledgeteds sutures. Two patients underwent mitral valve repair with quadrangular resection of the posterior leaflet associated with restrictive annuloplasty with a semi-rigid complete ring (Memo 3D, Sorin Group, Saluggia, Italy). Echocardiographic examination was performed on all patients before the discharge.

3. RESULTS

All patients underwent surgery successfully. Conversion to conventional technique was not required. Mean aortic cross clamp time was 63.7±17.4 minutes (Range: 40-89). Cardiopulmonary bypass time was 96.2±20.4 minutes (Range: 65-132). Patients neither developed ST-segment elevation in the electrocardiogram nor major ventricular arrhythmias during the procedure; intra-operative TEE did not show abnormalities in left ventricular segmental wall motion. We did not encounter any LIMA injury in redo operations. All patients were weaned from CPB smoothly. Two patients required pre-operative IABP support. In both cases it was removed 24 hours after surgery. No major adverse events, such as myocardial infarction, low cardiac output syndrome, acute kidney injury or neurologic events were observed during the hospital stay. No patient required ventilation > 24 hours. Mean postoperative peak troponin I value was 23.1±11.2 µmol/L (range 7-41 µmol/L). Mean dose of dopamine required in these patients was 3.1±1.7 µg/kg/min (range 0-6 µg/kg/min). Echocardiographic examination showed good prosthetic valve function. Peak and mean transaortic gradients were 15.0±5.7 and 7.8±3.1 mmHg respectively. Trans-thoracic echo (TTE) did not show any paravalvular leak. No mitral valve regurgitation was found in patients who underwent mitral valve repair. Left ventricular function was comparable to the preoperative data (post-operative ejection fraction: 49.3±14.2%). There was no hospital mortality and all patients were successfully discharged. Mean ICU stay and hospital stay were 48.8±17.6 hours and 7.6 ±1.3 days respectively.

4. DISCUSSION

The idea of continuous normothermic blood perfusion of the heart is not new. In 1956 Lillehei et al. first reported a clinical case of aortic valve surgery using a retrograde continuous coronary sinus perfusion [4]. In 1957 Gott et al. described the use of continuous coronary perfusion with chemical asystole [5]. This technique was then abandoned due to the advances in cardioplegic arrest techniques. Recently, Matsumoto et al. described on-pump beating heart valvular operations using retrograde coronary sinus perfusion. Principal advantages of this technique include the avoidance of potential damage to the coronary arteries while assuring an oxygenated blood distribution in the presence of coronary artery disease [6]. In our experience, with direct coronary cannulation we did not observe any injury of the coronary arteries and we did not have to interrupt the surgical procedure due to selective antegrade coronary ostial perfusion. Additionally, in case of coronary artery disease, CABG was always performed before the valve procedure in order to obtain a complete coronary revascularization and therefore complete coronary perfusion. Salerno et al. reported their beating heart experience with simultaneous antegrade and retrograde warm blood perfusion as a way of protecting hypertrophied hearts in cardiac valve

and aortic root operations [7]. In our experience, we obtained good results as well only with the antegrade approach. All patients underwent intraoperative TEE without evidence of any ischemic regional wall motion abnormality.

The possibility to evaluate the mitral valve under more physiologic conditions than those encountered with cardioplegic arreste, before, during and after completion of the repair, gives to this technique a further potential field of application, In fact, the three-dimensional architecture of the beating heart provides a good opportunity for examining leaflet and annulus motion as well as the condition of the subvalvular apparatus.

We used our technique also for aortic valve replacement in patients with previous CABG and patent LIMA grafts. In this case, the purpose of the beating heart valve replacement technique was to avoid the risk of a potential injury to the internal thoracic artery graft during mediastinal reentry and during the dissection of the left side of the heart. Thus, direct cannulation of the coronary ostia, associated with selective graft perfusion should provide complete myocardial protection. Savitt and coworkers used direct cannulation of the coronary ostia and continuous perfusion of the heart with oxygenated blood at 200-300 ml/min during aortic valve replacement [8]. Sunderland et al. described two cases of aortic valve replacement with a continuously perfused beating heart in patients with patent bypass conduits [9]. They recommend this technique for patients with a specific disposition of previous vein graft proximal anastomoses in order to place the aortic cross clamp proximal to the vein grafts. In our experience, whenever this was not possible, we directly cannulated the proximal vein graft anastomoses above the cross clamp in order to supply the myocardium with a complete antegrade blood coronary perfusion.

Major limitation of the present study is its retrospective nature and the low numbers of cases. A randomized study or a retrospective analysis with matched-controlled patient cohorts would be useful. Therefore at this time we can only demonstrate the feasibility of this approach.

5. CONCLUSION

In conclusion, selecting the most suitable candidate for this technique is not an easy task, but we believe that in selective cases, on-pump beating heart valve surgery might represent a valid alternative option. However this method might be associated with some problems and site effects. The operative conditions are not as optimal as the usual technique, because the operating field may be not so clear, so this approach results technically more difficult. Besides, there is a potential risk of air embolism. Moreover performing the coronary perfusion through the direct cannulation of the coronary ostia may be associated with complications, such as coronary ostial stenosis, catheter dislodgement, and risk of inadequate myocardial perfusion.

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