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Mitral Valve Replacements Under On-Pump Beating Heart and Lung Perfusion/Ventilation Using a Minithoracotomy: An Experience with 11 Cases

Ansheng Mo, MD,[1,2] Zhaoke Wen, MM,[2] Hui Lin, MD,[2] Changchao Lu, MM,[2] Shengjin Liang, MM[2]

[1]Department of Cardiothoracic Surgery, The First Affiliated Hospital of Guangxi Traditional Chinese Medical University, Nanning; [2]Department of Cardiothoracic Surgery, The People's Hospital of Guangxi Zhuang Autonomous Region, Nanning, People's Republic of China

ABSTRACT

Background: The primary aims of minimally-invasive cardiac valve surgery are to lessen the impact of the incision, extracorporeal circulation, myocardial ischemia, and pulmonary ischemia, to obtain satisfactory therapeutic results, and to allow a quicker rehabilitation. In this study, the feasibility of minimally-invasive mitral valve replacements without ascending aorta and vena cava cross-clamping under beating heart was evaluated by surveying 11 patients.

Methods: Preoperative risk factors, intraoperative techniques, and postoperative complications were surveyed and evaluated for one year (April 1, 2009 to March 30, 2010) in 11 patients who had undergone beating-heart mitral valve replacement surgery at The People's Hospital of Guangxi Zhuang Autonomous Region. Minithoracotomy and femoral arterial cannulation procedures were used in the surgeries for cardiopulmonary bypass (CPB) without ascending aorta and vena cava cross-clamping.

Results: The operations were performed successfully in all 11 patients. The CPB time was 52.80 ± 11.36 minutes; the mean postoperative mechanical ventilation assistance time was 8.20 ± 2.84 hours; and the mean transfusion volume of red cells was 2.20 ± 1.04 units. There were no cerebral complications, no periprosthetic leakage, no occurrence of permanent high-degree atrioventricular blockage, and no mortality.

Conclusion: Mitral valve replacement on the beating heart using a minithoracotomy and femoral arterial cannulation for CPB without ascending aorta and vena cava cross-clamping under pulmonary ventilation is feasible. A larger number of patients are required to further characterize the efficacy and safety of this procedure.

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A. Mo and Z. Wen contributed equally to this work.

Correspondence: Ansheng Mo, MD, No. 89-9 Dongge Rd, Nanning City, Guangxi Zhuang Autonomous Region, P. R. China 530021; +86-771-5862294; fax: +86-771-5862294 (e-mail:moansheng@163.com).

INTRODUCTION

The injurious impact of cardiac valve surgery results from the incision, extracorporeal circulation, and myocardial and pulmonary ischemia. The primary aims of minimally-invasive cardiac valve surgery are to lessen this impact, to obtain a satisfactory result, and to allow for a quicker rehabilitation. Herein, we report minimally-invasive cardiac valve replacements in 11 patients that were performed using a small incision, on-pump beating heart, pulmonary perfusion, and pulmonary ventilation.

METHODS

For one year (April 1, 2009 to March 30, 2010), we surveyed 11 patients who had undergone beating-heart cardiac valve replacement surgery at The People's Hospital of Guangxi Zhuang Autonomous Region. The patients' preoperative variables are summarized and listed in the table. All of the procedures were carried out with the legal consent of the individual patients and with the approval of the Ethics Committee.

Cardiopulmonary Bypass and Heart Perfusion

After making a 6–10 cm right anterolateral minithoracotomy in the fourth intercostal space and heparinization, femoral arterial and vena cava cannulation were performed for cardiopulmonary bypass (CPB). The CPB technique and heart perfusion procedure for air embolism prevention is reported in our previous study [Mo 2008].

Mitral Valve Surgery

The aorta was not cross-clamped and both vena cava were not snared. Continuous pulmonary artery perfusion and alveolar ventilation were performed during the CPB. Mitral valve replacement was performed via a transatrial approach; the incision parallel to the interatrial septum was made in the left atrium.

Lung Perfusion and Ventilation

During the mitral valve surgery, blood from the right atrium flowed through the tricuspid valve and was pumped to the pulmonary artery by the beating heart. At the same time,

mechanical ventilation was maintained at 5 cycles per minute with a tidal volume of 5mL per kg bodyweight, a positive end-expiratory pressure of 5 cmH_2O, and an inspired oxygen concentration of 100%. The mechanical ventilation method was synchronized intermittent mandatory ventilation.

Preoperative Variables of the 11 Patients with Rheumatic Heart Disease Who Underwent Beating-Heart Cardiac Valve Replacement Surgery*

Variable	
Male, n	5
Female, n	6
Age, y	39.60 ± 8.88
NYHA functional class II, n	4
NYHA functional class III, n	7
Pulmonary hypertension, n	3
Echocardiography	
Left atrial anteroposterior diameter (mm)	55.60 ± 7.09
Left ventricular end-diastolic diameter (mm)	61.82 ± 5.62

*NYHA indicates New York Heart Association. NYHA functional class II classifies symptoms as mild (shortness of breath and/or angina) and slight limitation during ordinary activity. NYHA functional class III classifies symptoms as causing marked limitations in activity and comfortable only at rest.

RESULTS

The operations were successful in all patients. The CPB time was 52.80 ± 11.36 minutes, the mean transfusion volume of red cells was 2.20 ± 1.04 units, and the postoperative mean mechanical ventilation assistance time was 8.20 ± 2.84 hours. There were no cerebral complications, no periprosthetic leakage, no permanent high-degree atrioventricular blockage, and no mortality.

DISCUSSION

Myocardial and pulmonary ischemia during CPB has been associated with postoperative cardiac and pulmonary dysfunction, as well as other poor outcomes. The primary aims of minimally-invasive cardiac valve surgery are to lessen the impact of the incision, to reduce extracorporeal circulation, myocardial ischemia, and pulmonary ischemia, and to obtain satisfactory therapeutic results with a faster rehabilitation time.

From April 1, 2009 to March 30, 2010, on-pump beating-heart minimally-invasive cardiac valve replacement surgery was performed on 11 patients in The People's Hospital of Guangxi Zhuang Autonomous Region. Our survey indicates that the outcomes were satisfactory. Based on our experience, femoral arterial cannulation for CPB can provide an optimal operative view and reduced operative time when using a right anterolateral minithoracotomy for valve surgery. These strategies have the potential advantages of myocardial protection, the need for only a small incision, and pulmonary protection. Improved myocardial protection has been demonstrated by a number of studies [Hui 2001; Mo 2008; Wang 2006; Wang 2009] and the benefits of the small incision are well proven. However, the following mechanisms for lung protection have been conjectural: (1) no reperfusion injury; (2) limited sequestration of neutrophils with pulmonary artery continuous perfusion [Liu 2000; Sievers 2002; Suzuki 1997; Suzuki 2000; Suzuki 2001; Zheng 2004]; (3) adequately maintained aerobic glycolysis [Hewson 1983], lung collapse prevention, and a reduced shunt with continuous ventilation; (4) reduced systemic inflammatory response with continuous heart perfusion [Liebold 1999; Tütün<<u (x2) with umlaut>> 2011; Wan 1996]; and (5) reduced inflammatory response and reduced apoptosis during CPB with pulsatile pulmonary perfusion [Siepe 2008].

In our study, mitral valve replacements were performed under on-pump beating heart, lung perfusion, and pulmonary ventilation using a minithoracotomy. A similar technique, through a midline sternotomy, is reported by Tütün and colleagues [Tütün 2011]. In their study, both vena cava were snared and mitral valve replacement was performed through a transseptal incision. This method is the same method that we reported in 2005 [Mo 2005]. We have made some improvements in the old strategies: the aorta is not cross-clamped, both vena cava are not snared, and a transatrial approach is used during CPB. In this approach, the incision parallel to the interatrial septum is made in the left atrium, which lets more blood perfuse in the pulmonary artery and provides better pulmonary results. Another similar technique, performing a midline sternotomy, is reported by Gologorsky and colleagues [Gologorsky 2011; Macedo 2011]. In their study, the pulmonary artery was perfused via two catheters, one catheter derived from the ascending aortic cannula and the other catheter perfused with venous blood via a separate line and pump (a different method than that used in our study). Gologorsky et al performed operations on 21 high-risk patients, all with left ventricular ejection fractions less than 25% and poor exercise tolerance. Their results, however, are encouraging. Seven patients were extubated immediately in the operating room, 13 patients were extubated within 2 hours of arrival to the intensive care unit, and only one patient required mechanical ventilation longer than 24 hours after the operation. Increased pulmonary protection is presented in their study. Another technique for lung protection under arrested heart is the Drew-Anderson technique [Friedman 1994; Massoudy 2003; Richter 2000]. The studies by Friedman, Massoudy, and Richter demonstrated that pulmonary injury was ameliorated by pulmonary perfusion together with ventilation. Compared with these studies, there are four favorable features in our study that stand out: (1) the pulmonary artery is only perfused with venous blood; (2) the flow rate of perfusion may be reduced; (3) the incision is smaller; and (4) the procedure is simpler.

There are several limitations in our study. First, the flow rate of the pulmonary artery is unknown; second, the data is inadequate to prove better pulmonary protection; and lastly, there are no control groups in our study.

Our results show that mitral valve replacements performed under on-pump beating heart, lung perfusion, and pulmonary ventilation via a minithoracotomy are feasible. It is important

that further basic science research and clinical trials confirm the benefits of lung perfusion/ventilation during beating-heart cardiac-valve surgery.

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