

## DOES BEATING HEART SURGERY TECHNIQUE REDUCE THE MORTALITY AND MORBIDITY AFTER REDO VALVE OPERATIONS?

Mungan Ufuk,<sup>1</sup> Demirdas Ertan,<sup>2</sup> Altinay Levent,<sup>3</sup> Cetin Erdem,<sup>4</sup> Atilgan Kivanc,<sup>2</sup> Katircioglu Fehmi,<sup>5</sup> Cicekcioglu Ferit<sup>2</sup>

<sup>1</sup> Lokman Hekim Akay Hospital Cardiovascular Surgery Department, Ankara, Turkey

<sup>2</sup> Bozok University Medicine Faculty Cardiovascular Surgery Department, Yozgat, Turkey

<sup>3</sup> Bulent Ecevit University Medicine Faculty Cardiovascular Surgery Department, Zonguldak, Turkey

<sup>4</sup> Karabük University Medicine Faculty Cardiovascular Surgery Department, Karabük, Turkey

<sup>5</sup> Ankara Education and Research Hospital Cardiovascular Surgery Department, Ankara, Turkey

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**Abstract: Aim:** The aim of this study was to determine the effect of beating heart technique on mortality and morbidity after redo valve operations.

**Material and Method:** Fifty-two patients who had redo open-heart surgery between May 2005 and November 2006 in a Hospital included in this prospective study. All patients had a history of open-heart surgery with median sternotomy. Thirty-two patients who had redo open-heart surgery with beating heart technique were included in Group 1 and 20 patients who had redo open-heart surgery with conventional cardioplegic myocardial arrest technique were included in Group 2. Patients who had any cardiac surgery without median sternotomy were excluded. **Results:** Functional capacity according to New York Heart Association classification was significantly lower and number of patients with chronic obstructive lung disease was significantly higher in Group 1 ( $p = 0.011$  and  $p = 0.003$  respectively). There was no significant difference in other preoperative variables. Operation, cardiopulmonary bypass and aortic cross-clamping times were significantly higher in Group 2 ( $p = 0.001$ ,  $p = 0.003$ ,  $p = 0.04$  respectively). Mechanical ventilation, inotropic agent support and hospitalization times were significantly higher in Group 2 ( $p < 0.05$ ). Intensive care unit time was significantly longer in Group 1 ( $p < 0.05$ ). Drainage volumes, blood product transfusion volumes, intra-aortic balloon pump support times were not significantly different between the groups.

**Conclusion:** Beating heart technique in redo heart valve operations has better outcomes than the conventional technique.

**Key words:** Redo operation; heart valve surgery; cardioplegia; beating heart technique.

### INTRODUCTION

The success of the open-heart surgery is dependent on not only the technical abilities of the surgeon and the operation technique but also on the preservation of the myocardium. Development of cardiopulmonary bypass (CPB) and progression of elective cardiac arrest techniques provided time long enough to do an open-heart surgery safely and comfortably. The effect of hypothermia for myocardium preservation was firstly introduced by Bigelow and it was used solitarily or concomitantly with intermittent aortic cross-clamping (XCL) until 1970.

Diastolic arrest of the heart with potassium was first introduced by Melrose et al in 1955 (1). Improvements of cardioplegia solutions provided better myocardial preservation of the heart through the surgery.

The negative effects of CPB and myocardial ischemia time (XCL time) are two important predictors of morbidity and mortality after open-heart surgery. The most deteriorative effect of CPB on the heart is the reperfusion injury. Besides that, another major cause of myocardial dysfunction after open-heart surgery is myocardial oedema caused by diastolic arrest of the heart (2, 3).

The incidence of redo open-heart surgeries increases nowadays. The beating heart operation technique could be an alternative for conventional surgery technique in this high-risk patient population to reduce the mortality and morbidity rates. The aim of this prospective study was to determine the effect of beating heart technique on mortality and morbidity after redo valve operations.

## MATERIAL AND METHODS

Fifty-two patients who had redo open-heart surgery between May 2005 and November 2006 in Türkiye Yüksek İhtisas Hospital were enrolled in this prospective study. All patients had a history of open-heart surgery with median sternotomy. Thirty-two patients who had redo open-heart surgery with beating heart technique were included in Group 1 and 20 patients who had redo open-heart surgery with conventional cardioplegic myocardial arrest technique were included in Group 2. Informed consent was taken from all of the patients and research approval was acquired from the local ethical committee.

Patients who had any cardiac surgery without median sternotomy were excluded.

### *Statistical analysis*

All data were recorded as continuous and categorical variables. The SPSS 11.05 (Statistical Package for the Social Sciences SPSS Inc., Chicago, IL) for Windows programme was used for statistical analysis of the data. Student t-test was used to calculate the statistical significance of the variables such as age, ejection fraction, aortic cross-clamping time, postoperative drainage volume and chi-square test was used to evaluate the data of the variables gender, functional capacity, preoperative patient condition, cardiac rhythm, morbidity and mortality. P value lower than 0.05 was accepted as statistically significant.

### *Operative technique*

All operations were done under general anaesthesia. In Group 1, median sternotomy was done in all of the patients. CPB was initiated after systemic heparinization with proper dose heparin administration, standard aortic and unicaval cannulation. In five patients with ascending aortic aneurysm, arterial cannula was introduced through right femoral artery. A retrograde perfusion cannula was introduced through coronary sinus to perfuse the heart. The pressure on this retrograde cannula was monitored and it was used to supply oxygenated blood to the heart through a line from the CPB machine. Jostra HL 20 heart-lung machine was used for extracorporeal circulation and Dideco D 708 Simplex III oxygenator and systems was used in all of the cases. All operations were done with non-pulsatile flow. Patient body temperature was monitored with rectal heat probe and the body temperature of the patient maintained between 35–37 °C. Aortic, right pulmonary vein and apical venting was achieved. In 15 patients, aortic cross-clamp was applied and retrograde

coronary sinus perfusion was initiated. The flow pressure on the retrograde coronary sinus perfusion line was maintained between 60–90 mmHg and the flow rate was maintained between 300–500 ml/min. In 17 patients, aortic cross-clamp was not applied and antegrade blood supply was achieved by holding the patient in Trendelenburg's position so retrograde perfusion was not utilized in these patients. Intraoperative electrocardiography (ECG) monitoring was done to follow the ischemia of the myocardium. Arterial pressure, blood oxygen saturation, central venous pressure and urine output was also monitored. While perfusing the heart through retrograde cannula, partial oxygen pressure (pO<sub>2</sub>) was measured in blood samples taken from the aortic vent line and coronary sinus perfusion line in every 20 minutes. Presence of anaerobic metabolism was checked by measuring pH and lactate levels in blood samples taken from the aortic vent line in every 5 minutes. Transcranial Doppler ultrasonography (DUSG) imaging and electroencephalographic monitoring was done intraoperatively to follow any air embolism of intracranial vessels. Preoperative transoesophageal echocardiography (TEE) imaging was done in all of the cases to evaluate the heart valve functionality and check the residual air bubbles in heart chambers. In postoperative period, transthoracic echocardiography (TTE) imaging was done to evaluate the myocardial functions and heart valve functions in all of the cases.

In Group 2, median sternotomy was done in all of the patients. After standard aortic unicaval cannulation, retrograde coronary sinus cannulation and aortic vent implantation, CPB was initiated. In two patients, arterial cannula was introduced through right femoral artery. Cardiac arrest was achieved with antegrade and retrograde infusion of cold crystalloid and blood cardioplegia solutions following the aortic XCL. Patient body temperature was monitored with rectal heat probe and it was maintained between 28–32 °C. Warm blood cardioplegia solution was administered before de-clamping the aorta. Myocardial and valve function evaluation was done with TTE imaging in all of the patients in this group.

## RESULTS

Preoperative data is presented in Table 1. Functional capacity (New York Heart Association (NYHA) Functional Classification) was significantly lower and number of patients with chronic obstructive lung disease (COLD) was significantly higher in Group 1 when compared with Group 2 ( $p = 0.011$  and  $p = 0.003$  respectively). There was no significant difference in other preoperative variables. The initial operations that the patients had and redo operation types are presented

**Table 1.** Preoperative data

	Group I (n = 32)	Group II (n = 20)	P
Age (Mean ± sd)	50 ± 15	47 ± 9	> 0.05
Male	16	12	> 0.05
BMI (Kg/m <sup>2</sup> ) (Mean ± sd)	25 ± 5	27 ± 4	> 0.05
BSA (m <sup>2</sup> ) (Mean ± sd)	1,7 ± 0,1	1,8 ± 0,1	> 0.05
LVEF (%) (Mean ± sd)	53 ± 10	52 ± 7	> 0.05
SPAP (mmHg) (Mean ± sd)	57 ± 20	51 ± 15	> 0.05
NYHA Class II/III/IV	9/14/9	13/6/1	<b>0.011</b>
Diabetes mellitus(n)	6	3	> 0.05
Hypertension(n)	5	3	> 0.05
COLD(n)	8	1	<b>0.003</b>
CVI(n)	2	1	> 0.05
Active Endocarditis(n)	7	4	> 0.05

COLD: Chronic obstructive lung disease, BMI: Body mass index, BSA: Body surface area, SPAB: Systolic pulmonary arterial pressure, NYHA: New York Heart Association Classification, SVI: Cerebrovascular incident, LVEF: Left ventricle ejection fraction, sd: Standard deviation

**Table 2.** Distribution of the initial operations of the patients undergoing redo operations

Initial operations	Group I (n = 32)	Group II (n = 20)
MVR(n)	11	6
AVR(n)	3	4
AVR + MVR(n)	4	–
CABG + MVR(n)	1	–
CABG + AVR(n)	1	–
Open mitral valvulotomy(n)	8	6
Atrial septal defect(n)	1	1
Ventricular septal defect(n)	1	–
CABG(n)	2	3

MVR: Mitral valve replacement, CABG: Coronary artery bypass graft, AVR: Aortic valve replacement

in Table 2 and 3. Operative data of the groups are shown in Table 4. Operation, CPB and aortic XCL times were significantly higher in Group 2 when compared with Group 1 ( $p = 0.001$ ,  $p = 0.003$ ,  $p = 0.04$  respectively). Postoperative data of the patients is presented in Table 5. Mechanical ventilation, inotropic agent support and hospitalization times were significantly higher in Group 2 when compared with Group 1 ( $p < 0.05$ ). Intensive care unit time was significantly longer in Group 1 when compared to Group 2 ( $p < 0.05$ ) Drainage volumes, blood product transfusion volumes, in-

**Table 3.** Distribution of the redo operations

Reoperation	Group I (n = 32)	Group II (n = 20)
MVR(n)	22	10
AVR(n)	4	4
AVR & MVR	2	–
Thrombectomy of Mechanical Heart Valve(n)	2	–
AVR + Aortic Supracoronary Graft Implantation	2	3
Benthall procedure	–	2
Paravalvular leak repair	–	1

MVR: Mitral valve replacement; AVR: Aortic valve replacement

**Table 4.** Comparison of the operative data

	Group I (n = 32)	Group II (n = 20)	P value
Operation time	146 ± 52	346 ± 87	0.001
CPB time	83 ± 34	123 ± 56	0.003
XCL time	54 ± 39	84 ± 41	0.04

CPB: Cardiopulmonary bypass; XCL: Aortic cross-klemp

**Table 5.** Comparison of the postoperative data

	Group I	Group II	P
Mechanical ventilation (hr) (Mean ± sd)	12 ± 9	33 ± 11	< 0.05
Drainage volume (ml) (Mean ± sd)	824 ± 478	725 ± 437	> 0.05
Blood product transfusion volume (ml) (Mean ± sd)	1680 ± 870	1600 ± 820	> 0.05
Inotropic agent administration time (hr) (Mean ± sd)	22 ± 18	47 ± 32	< 0.05
IABP support(n)	1	1	> 0.05
ICU time (days) (Mean ± sd)	3.5 ± 2.9	2.7 ± 2.2	< 0.05
In-hospital mortality (n)	2	1	> 0.05
Hospitalization time (days)	7.7 ± 5.6	13 ± 12	< 0.05

IABP: Intra-aortic balloon pump; ICU: Intensive care unit; sd: Standard deviation

traoortic balloon pump (IABP) support times were not significantly different between the groups.

## DISCUSSION

The incidence of redo operations in heart valve diseases was increased in the last decades. As it was presented in the literature, the need for redo operations after heart valve reconstructive interventions –speci-

ally after mitral and tricuspid valve surgeries- increased in different rates. This increase might be caused by the increased mean age of general population, prosthetic heart valve disadvantages as well as the heart valve repair techniques or surgeon related factors (4).

The mortality and morbidity rates are higher in redo open-heart surgeries and they are technically more challenging according to primary operations. Multiple factors such as myocardial injuries due to adhesion of scar tissue on the heart during exploration, pulmonary hypertension accompanying heart valve dysfunction, excessive bleeding and blood product transfusions, inappropriate myocardial protection increase the morbidity and mortality rates after redo open heart surgeries (5). Due to improvements in myocardial preservation techniques, operative mortality risk and postoperative morbidity rates were decreased (6). Retrograde perfusion of the heart through coronary sinus cannula and achievement of myocardial preservation was already presented in the literature (7, 8, 9).

The number of valve operations done with beating heart technique increased in the last few years. The blood itself is the most effective myocardial protective agent despite the improved myocardial preservation techniques. Cardioplegia techniques inevitably cause myocardial reperfusion injury. Besides that, myocardial dysfunction after open-heart surgery is a result of myocardial oedema accumulated in the heart during diastolic arrest period. Thus, keeping the heart beating during the surgery will lessen the myocardial oedema and improve the postoperative cardiac functions (10).

Due to recent improvements in beating heart coronary bypass and heart valve surgeries, we decided to

utilize these techniques and use them in our operations with some improvements. Continuous blood perfusion throughout the surgery reduces the uncontrolled myocardial perfusion risk. In recent studies, the beating heart valve surgery was proved a practicable and logical technique with reasonably positive results (11).

In this study we found that, the morbidity and mortality rates were lower in the patient group undergoing redo heart valve surgery operated with beating heart on-pump technique when compared with the patient group who were operated with conventional technique in which the heart was arrested with cardioplegic solutions. In addition, we found that our technique provided better myocardial preservation and resulted with better postoperative outcomes especially in the patients who had impaired myocardial functions.

**In conclusion**, lower mortality and morbidity rates, practicability, lower hospitalisation times, lower costs and improved quality of life after the operations are the positive results of beating heart valve surgery technique. Although these encouraging outcomes, we think that more studies should be conducted including larger patient series and more centres.

## DECLARATION OF INTEREST

The authors declare that there are no conflicts of interests.

## Licensing

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## Sažetak

# DA LI OPERACIJE NA KUCAJUĆEM SRCU REDUKUJU MORTALITET I MORBIDITET NAKON OPERACIJE ZAMENE SRČANIH ZALISTAKA

Mungan Ufuk,<sup>1</sup> Demirdas Ertan,<sup>2</sup> Altinay Levent,<sup>3</sup> Cetin Erdem,<sup>4</sup>  
Atilgan Kivanc,<sup>2</sup> Katircioglu Fehmi,<sup>5</sup> Cicekcioglu Ferit<sup>2</sup>

<sup>1</sup> Lokman Hekim Akay Hospital Cardiovascular Surgery Department, Ankara, Turkey

<sup>2</sup> Bozok University Medicine Faculty Cardiovascular Surgery Department, Yozgat, Turkey

<sup>3</sup> Bulent Ecevit University Medicine Faculty Cardiovascular Surgery Department, Zonguldak, Turkey

<sup>4</sup> Karabük University Medicine Faculty Cardiovascular Surgery Department, Karabük, Turkey

<sup>5</sup> Ankara Education and Research Hospital Cardiovascular Surgery Department, Ankara, Turkey

**Cilj:** Cilj ove studije bio je da se utvrde efekti operativnih tehnika na kucajućem srcu na mortalitet i morbiditet nakon operacije zamene valvula.

**Materijal i metode:** U ovoj prospektivnoj studiji učestvovalo je 52 pacijenta koji su bili podvrgnuti operacijama na otvorenom srcu između maja 2005. i novembra 2006. godine u Türkiye Yüksek İhtisas bolnici. Svi pacijenti su imali operaciju na otvorenom sr-

cu sa medijalnom sternotomijom. 32 pacijenta, koja su imala operaciju tehnikom na kucajućem srcu svrstani su u grupu 1, dok je 20 pacijenata bilo podvrgnuto operaciji sa konvencionalnom kardioplegijskom metodom zaustavljanja rada srca i svrstani su u grupu 2. Pacijenti koji su imali bilo koju kardiohirursku operaciju bez medijalne sternotomije su bili isključeni iz studije.

**Rezultati:** Kod pacijenata u grupi 1, funkcionalni kapacitet srca prema NYHA klasifikaciji je bio značajno niži, a komplikacije hronične opstruktivne bolesti pluća su bile značajno više u ( $p = 0,011$  i  $p = 0,003$  respektivno). Nije bilo statistički značajne razlike između drugih preoperativnih varijabli. Operacija, kardiopulmonalni bypass kao i vreme klemovanja aorte su bili statistički značajno viši u grupi 2 ( $p = 0,001$ ,  $p = 0,003$ ,  $p = 0,04$  respektivno). Mehanička ventilacija, inotropni agensi kao i vreme hospitalizacije je bilo značajno više u grupi 2. ( $p < 0,05$ ). Vreme

provedeno u jedinici intenzivne nege je bilo statistički značajno duže u grupi 1. Kada je u pitanju zapremina drenaže, zapremine elemenata za transfuziju krvi, vreme provedeno u korišćenju intra-aortne balon pumpe nije bilo statistički značajne razlike među grupama.

**Zaključak:** Operativna tehnika srčanih zalistaka kod kucajućeg srca, ima bolji ishod u poređenju sa konvencionalnim tehikama.

**Ključne reči:** operacije, hirurgija srčanih zalistaka, kardioplegija, tehnika kucajućeg srca.

## REFERENCES

1. Melrose DG, Dreyer B, Benthall HH, Baker JB. Elective cardiac arrest. *Lancet*. 1955; 269(6879): 21-2.

2. Allen BS, Okamoto F, Buckberg GD, Bugyi H, Leaf J. Reperfusion conditions: critical importance of total ventricular decompression during regional reperfusion. *J Thorac Cardiovasc Surg*. 1986; 92(3 Pt 2): 605-12.

3. Weman SM, Karhunen PJ, Penttila A, Jarvinen AA, Salminen US. Reperfusion injury associated with one-fourth of deaths after coronary artery bypass grafting. *Ann Thorac Surg*. 2000; 70(3): 807-12.

4. Femes SE, Goldman BS, Ivanov J, Weisel RD, David TE, Salerno T. Valvular surgery in the elderly. *Circulation*. 1989; 80(3 Pt 1): 177-90.

5. Weerasinghe A, Edwards MB, Taylor KM. First redo heart valve replacement: a 10-year analysis. *Circulation*. 1999; 99(5): 655-8.

6. Cohn LH, Peigh PS, Sell J, DiSesa VJ. Right thoracotomy, femorofemoral bypass, and deep hypothermia for re-

placement of the mitral valve. *Ann Thorac Surg*. 1989; 48(1): 69-71.

7. Katircioglu SF, Gokce P, Ulus AT, Tutun U, Apaydin N, Koc B. Reduction of the infarcted area with the use of simplified coronary sinus retroperfusion during experimental coronary artery occlusion. *Int J Cardiol*. 2000; 73(2): 115-21.

8. Katircioglu SF, Iscan HZ, Ulus T, Santas Z. Myocardial preservation in acute coronary artery occlusion with coronary sinus retroperfusion and carnitine. *J Cardiovasc Surg* 2000; 41(1): 45-50.

9. Lazar HL. Coronary sinus retroperfusion: can forward progress still be achieved by using a backward technique *J Thorac Cardiovasc Surg*. 2004; 127(6): 1549-52.

10. Mehlhorn U, Allen SJ, Adams DL, Davis KL, Gogola GR, Warters RD. Cardiac surgical conditions induced by beta-blockade: effect on myocardial fluid balance. *Ann Thorac Surg*. 1996; 62(1): 143-50.

11. Gersak B, Sutlic Z. Aortic and mitral valve surgery on the beating heart is lowering cardiopulmonary bypass and aortic cross clamp time. *Heart Surg Forum*. 2002; 5(2): 182-6.

## Correspondence to / Autor za korespondenciju

Dr. Kivanç Atilgan

Bozok University Medicine Faculty Cardiovascular Surgery Department, Yozgat

Phone number: +905056579890

E-mail: kivanatilgan@gmail.com