Opening the Gates for Beating Aortic Surgery

Çalışan Kalpte Aort Cerrahisinin Kapılarını Açmak

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ABSTRACT Objective: This study assessed the advantages of on-pump beating aortic valve surgery in high-risk aortic regurgitation patients. The superiority of this operation was approved in comparison to traditional aortic valve replacement. **Material and Methods:** Sixteen high-risk aortic regurgitation patients were followed-up prospectively. Seven patients had undergone beating aortic surgery compared to nine patients with traditional aortic valve replacement. Blood samples for Troponin T and creatine kinase-mB (CKmB) were collected at 0, 1, 6, 12, 24 and 48 hours of surgery. Surgery was performed on beating heart and continous normothermic normokalemic coronary perfusion with aortic cross clamping while traditional surgery was done with hypothermic cardioplegic arrest. **Results:** For both groups there were no significant differences in preoperative echocardiography findings, cardiopulmonary pump time, cross clamp time, intensive care unit and hospital stay times. The mean cardiac troponin T and CKmB values showed significant differences with the protective effects of beating heart aortic valve surgery. Postoperative echocardiographic findings of the patients were encouraging, with preservation of ventricular functions and well-functioning mechanical aortic valve. **Conclusion:** On-pump beating aortic valve replacement has encouraging results especially in high-risk patients. At the same time, results revealed superiority of this approach in postoperative outcome in comparison to traditional aortic valve replacement.

Key Words: Aortic valve; troponin T; myocardial reperfusion injury

ÖZET Amaç: Bu çalışmanın amacı, yüksek riskli aort yetmezliği olan hastalarda pompada çalışan kalpte yapılan aort kapak cerrahisinin avantajlarını belirlemektir. Bu tür operasyonların geleneksel kapak cerrahisiyle kıyaslandığında üstünlüğü daha önceden kanıtlanmıştır. **Gereç ve Yöntemler:** Yüksek riskli 16 aort regürjitasyonlu hasta ileriye dönük olarak takip edilmiştir. 7 Adet çalışan kalpte aort cerrahisi yapılan hastayla, 9 geleneksel aort kapak replasmanı yapılan hasta karşılaştırılmıştır. TroponinT ve kreatin Kinaz-mB(CKmB) için kan örnekleri operasyonun 0, 1, 6, 12, 24 ve 48. saatlerinde toplanmıştır. Geleneksel cerrahi hipotermik kardiyoplejik arrest ile yapılırken, diğer cerrahide çalışan kalpte ve sürekli normotermik normokalemik koroner perfüzyonla aorta klemplenerek yapılmıştır. **Bulgular:** Cerrahi öncesi ekokardiyografi bulgularında, kardiyopulmoner pompa zamanında, kross klemp süresinde, yoğun bakım ve hastane yatış sürelerinde anlamlı farklılık gözlenmemiştir. Ortalama kardiyak Troponin T ve CKmB değerlerinde çalışan kalpte aort kapak cerrahisin koruyucu etkileriyle birlikte anlamlı farklılıklar görülmüştür. Cerrahi sonrasındaki ekokardiyografi bulguları, ventrikül fonksiyonlarının korunması ve iyi fonksiyone mekanik aort kapak hareketleri cesaret verici bulunmuştur. **Sonuç:** Yüksek riskli hastalarda pompada çalışan kalpte yapılan aort kapak replasmanının sonuçları umut vericidir. Aynı zamanda, geleneksel cerrahiyle kıyaslandığında cerrahi sonrası sonuçlarındaki üstünlüğü de ortaya çıkmıştır.

Anahtar Kelimeler: Aort kapak; troponin T; miyokard reperfüzyon hasarı

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Aortic regurgitation (AR) is characterized by malcoaptation of the aortic cusps. This is may be due to abnormalities of the aortic valve leaflets or aortic root dilation that prevent leaflet coaptation. Presentations are variable and depend on many factors including age, hemodynamic condition, severity at presentation and underlying pathological conditions. The overall prevalence of AR in men was 13% and in women 8.5%.[1]

The diagnosis of aortic regurgitation is mainly based on clinical examination but its severity is assessed with peripheral findings and echocardiography. In cases of chronic AR, echocardiographic findings have an essential role in determining the surgical indications of patients. Deterioration of left ventricular functions (ejection fraction <30%, end-diastolic diameter 55-70 mm and/or end-systolic diameter 40-50 mm) may change the decision about surgical intervention. In addition, the left ventricular functions are considered predictive of operative morbidity and mortality. Moreover, perioperative risks and postoperative outcomes are affected by factors that increase myocardial ischemia such as reperfusion injury including effectiveness of myocardial protection, durations of cardiopulmonary bypass and aortic clamp.

In this study, we assessed the superiority of on-pump beating aortic valve replacement (AVR) with continuous normothermic normokalemic perfusion of coronary arteries in selected patients with high operative risk.

MATERIAL AND METHODS

Between January 2002 and September 2006, 7 patients with on-pump beating AVR (group A) were followed-up and compared to 9 patients with the same high risk criteria who underwent traditional aortic valve surgery (group B). High-risk criteria included chronic symptomatic AR with preoperative NYHA class III-IV, ejection fraction <30%, end-diastolic diameter 55-70 mm and/or end-systolic diameter 40-50 mm.

The mean values for group A/B wereas follows: age 55/ 52 years, ejection fraction (EF) 26.57/27.22, left ventricular end systolic diameter (LVESD) 45.14/ 44.44 mm and left ventricular end diastolic diameter (LVEDD) 59.43/ 60.56 mm. Blood samples for cardiac troponin T (cTnT) and creatine Kinase-mB (CKmB) were collected at 0, 1, 6, 12, 24 and 48 hours of surgery (cross clamp placement time considered 0 hours). The blood cTnT was evaluated using Cobalt analyzer troponin kit. CKmB was measured with immunoassay test kit.

For both groups, we reported cardiac performance evaluated with transthoracic echocardiography in the early postoperative period, and intensive care unit and hospital stay.

SURGICAL TECHNIQUE

All surgical interventions were done by the same surgeon. Surgical approach was with standard median sternotomy, cardiopulmonary bypass was established using aorto-atrial cannulation. The catheter for venting was administered through the right superior pulmonary vein to the left atrium. After the establishment of extracorporeal circulation and placement of aortic cross clamp, a transverse aortotomy was performed 2 cm above the sinotubular junction. Intraoperative evaluation presented another criteria for convertion to traditional method, that was the presence of heavy calcification.

In group A patients, coronary perfusion was established via a soft ostial cannulae with continuous infusion of warm noncardioplegic oxygen enriched blood concomitant with venting through right superior pulmonary vein. This way ensured myocardial protection and suitable view for aortic valve as good as traditional method. In group B patients, hyperkalemic cold blood cardioplegia was administered directly into the coronary ostia.

After resection of native valve leaflets and decalcification; on demand; we utilized mechanical valves (19-23 No./St Jude Medical Inc, Minnesota, USA) for valve replacement. After weaning from cardiopulmonary bypass machine, we evaluted cardiac functions clinically(depending on the stability of hemodynamic state of the patients) and with transesophageal echocardiography which give us detailed information about the valve morphological and functional status.

STATISTICS

Statistical evaluation was made using the tests mentioned below and p< 0.05 was considered statistically significant. Data were compared using the Mann-Whitney-U test. Comparison between control values within the group and cTnT and CKmB data; in which time factor is found to be important; we applied Repeated Measures analysis of variance with Bonferroni correction for P-values. Gender comparison between groups was performed using the Fisher's exact, chi-square test.

RESULTS

In the statistical comparison between groups in terms of age, gender, EF, LVEDD, and LVESD, no statistically significant differences were found (p> 0.05) (Table 1). Postoperative troponin T mean values for 0, 1, 6, 12, 24 and 48 hours of the surgery (cross clamp placement) were 0.016, 0.209, 0.432, 0.356, 0.233 and 0.191 ng/mL for group A and 0.014, 0.274, 0.532, 0.477, 0.263 and 0.206 ng/mL for group B. Statistically significant elevation was detected in the values of 1, 6 and 12 hours of surgery in group B (p< 0.05) compared to group A (Table 2). CKmB mean values were 13.95, 61.72, 47.73, 31.92, 26.93 and 21.99 U/L for group A and 15.73, 71.46, 60.30, 38.30, 32.21 and 26.57 U/L for group B. These results revealed statistically significant elevation in peri-and postoperative values in group B (p< 0.05) in comparison to group A (Table 3).

For groups A/B, mean cardiopulmonary bypass times were 76.29/69.44 minutes and mean cross-clamp times were 38.29/31.67 minutes. There was no intraoperative or early postoperative mortality. Major complications included 2 cases of atrial fibrillation (one case in every group), one case of multiple extrasystoles in group B patients and one case of acute renal failure in group B patients, which was treated conservatively. Mean intensive care unit (ICU) stay times for group A/B were 1.91/2.19 days and mean hospital stay times for group A/B were 9.14/10.33 days. No significant differences were found between groups in terms of cardiopulmonary bypass time, cross-clamp time, intensive care unit stay time, and hospital stay time (Table 4). Postoperative early follow-up with transthoracic echocardiography revealed preservation of myocardial functions with better contractility and correction in wall motility. All patients were discharged from the hospital in good health.

TABLE 1: Demographics variables, EF, EDD and ESD [(mean ± SD), n].

Characteristics	Group A (n= 7)	Group B (n= 9)	p
Age (year)	55.00 ± 8.94	52.00 ± 9.58	0.536
Gender (female:male)	4:3	5:4	0.949
EF (%)	26.57 ± 2.23	27.22 ± 1.86	0.681
EDD (mm)	59.43 ± 4.96	60.56 ± 3.57	0.606
ESD (mm)	45.14 ± 2.41	44.44 ± 2.51	0.681

EF: Ejection fraction, LVEDD: Left ventricular end diastolic dimension, LVESD: Left ventricular end systolic dimension.

TABLE 2: The mean serum levels of cTnT (ng/mL) for Group A and B.

Time of sample taking	Group A (n= 7)	Group B (n= 9)	p
0	0.016 ± 0.008	0.014 ± 0.007	0.758
1	0.209 ± 0.036^{+}	0.274 ± 0.050$^{*,+}$	0.016
6	0.432 ± 0.077^{+}	0.532 ± 0.064$^{*,+}$	0.023
12	0.356 ± 0.047^{+}	0.477 ± 0.076$^{*,+}$	0.005
24	0.233 ± 0.039^{+}	0.263 ± 0.042^{+}	0.114
48	0.191 ± 0.030^{+}	0.206 ± 0.028^{+}	0.299

All data presented as mean ± SD, cTnT: Cardiac troponin T.
*p< 0.05: Between groups,
+p< 0.05: 0 with comparative.

TABLE 3: The mean serum levels of CKmB (ng/mL) for group A and B.

Time of sample taking	Group A (n= 7)	Group B (n= 9)	p
0	13.95 ± 3.13	15.73 ± 2.39	0.091
1	61.72 ± 5.02^{+}	71.46 ± 4.30$^{*,+}$	0.002
6	47.73 ± 5.31^{+}	60.30 ± 2.95$^{*,+}$	< 0.001
12	31.92 ± 4.95^{+}	38.30 ± 2.42$^{*,+}$	0.023
24	26.93 ± 2.63^{+}	32.21 ± 2.17$^{*,+}$	0.004
48	21.99 ± 1.52^{+}	26.57 ± 2.73$^{*,+}$	0.003

All data presented as mean ± SD, CKmB: Creatine Kinase-mB.
*p< 0.05: Between groups,
+p< 0.05: 0 with comparative.
Note: Blood samples for cardiac troponin T(cTnT) and Creatine Kinase–mB(CKmB) were collected at 0, 1, 6, 12, 24 and 48 hours of surgery (cross clamp placement time considered 0 hour). Comparing to basal values of cTnT and CKmB, there is significant elevation in the follow up of both groups (Tables 2 and 3).

TABLE 4: Cardiopulmonary bypass time, cross-clamp time, intensive care unit time, intensive care unit time for group A and B.

Paramaters	Group A (n= 7)	Group B (n= 9)	p
Cardiopulmonary bypass time (minute)	76.29 ± 21.20	69.44 ± 15.33	0.536
Cross-clamp time (minute)	38.29 ± 10.87	31.67 ± 5.22	0.210
Intensive care unit time (day)	1.91 ± 0.34	2.19 ± 0.37	0.201
Hospital stay time (day)	9.14 ± 1.77	10.33 ± 1.58	0.174

All data presented as mean ± SD, CKmB: Creatine kinase-mB.

DISCUSSION

The majority of aortic insufficiency patients are able to compensate chronic regurgitation.[2,3] Current researches support medical follow-up of asymptomatic patients with preserved left ventricular function. Aortic valve surgery is indicated once follow-up reveals functional deterioration.[4,5] The prognosis of symptomatic patients is poor with death occurring within 4 years after development of angina and within 2 years after the onset of congestive heart failure.[2] Thus, when ejection fraction fall below 55% with left ventricular end diastolic diameter >75 mm and/or end systolic diameter >55 mm, surgery is indicated.[6,7]

Typically, irreversible myocardial fibrosis and hypertrophy should be prevented and surgery should be performed before the point of ventricular function deterioration. Although there was high perioperative risk in patients with deteriorated ventricular functions, this did not circumvent the fact that survival in this group was better than in those on follow-up with medical treatment. One year mortality in medically (nonoperative) managed severe aortic regurgitation patients with left ventricular dysfunction is up to 50%.[8] Correct timing of surgery leads to recovery of ejection fraction to normal levels postoperatively.[9] Following aortic valve surgery, the reduction in the left ventricular dimensions may take up to three years. Preoperative end diastolic enlargement is considered one of the predictors for postoperative left ventricular dimension but not for the outcomes. In addition, preoperative duration of symptoms may predict poor postoperative outcome.[10]

Despite all the developments in cardiac surgery techniques, myocardial protection remains a one of the challenging issue. Still there is no ideal method for myocardial protection; this may be due to increasing researches about ischemic-reperfusion injury and variable methods of myocardial protection during surgery. Here, we tried to confirm the advantages of on-pump beating AVR and present it as an alternative method to the traditional aortic valve replacement in selected high-risk AR patients.

This technique was first described by Savitt in redo cases with patent coronary bypass conduit.[11] This was followed by other studies that confirmed the effectiveness of on-pump beating in preservation of hypertrophic myocardium, especially in redo coronary bypass and in pregnant patients.[12-14] The beating heart technique allows the physiological condition of the cardiac tissues to be maintained throughout the procedure.[15] Thus, attenuation of the damaging effects of ischemic-reperfusion injury is possible. It is considered one of the simple and effective methods in myocardial injury and it may give sufficient protection for hypertrophic myocardium.[14]

Also we depend on the knowledge from the literature on the close correlation that was described between cTnT and CK-mB levels and pathological infarct size after experimental induction of acute myocardial ischemia.[16,17] On the other hand, there is no significant impact of aortic cross-clamping time on the postoperative values of cTnT and CK-mB.[18] Thus, we relied on cTnT as a marker of ischemic myocardial damage and utilized it as a mirror in studying myocardium injury.

The cTnT and CKmb values of patients with on-pump beating aortic surgery revealed better

myocardial protection. Although there was no significant difference in the ICU and hospital stay times, the biochemical results were encouraging and are in favor of on-pump surgery especially in high-risk patients.

CONCLUSION

Beating aortic valve surgery is preferable particularly in patients with deteriorated ventricular function. Every effort should be spent for better protection of the myocardium. This will give a chance for better recovery in the postoperative period.

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