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Beating heart technique in tricuspid valve replacement among patients which have a TAPSE index lower than 15 mm

TAPSE değeri 15 mm altında olan hastalarda atan kalpte triküspit kapak replasmanı

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Abstract

Aim: Tricuspid valve replacement (TVR) has always been a compelling issue for cardiovascular surgeons due to the poor postoperative outcomes. Besides myocardial ischemia caused by aortic cross clamp, cardioplegia resulting in reperfusion injury is still one of the major problems in open heart surgery. In this study, we aimed to evaluate the benefits of TVR with beating heart (BH) in terms of decreasing mortality and morbidity rates among the patients with TAPSE indexes lower than 15 mm.

Methods: This research was designed as a retrospective cohort study. Twenty-nine patients with isolated tricuspid valve diseases with a TAPSE index lower than 15 mm and who underwent TVR consecutively between 2006 and 2012 were enrolled in this study. Among 29 patients, 13 underwent TVR with cardioplegic arrest (AH group) and 16 underwent TVR with a beating heart (BH group).

Results: There were 5 males in the AH group and 6 males in the BH group. The mean ages of the patients in AH and BH groups were 55.42 (11.6) years and 57.92 (8.43) years, respectively. Sixty-two percent of the AH group was in New York Heart Association (NYHA) Class III or IV heart failure in comparison to 56% of the BH group. Atrial fibrillation was present in 9 patients (69%) in the AH group and 11 patients (69%) in the BH group. Left ventricular functions were calculated as 57.23% (7.62) and 58.65% (8.02) in the AH and BH groups, respectively. Mean systolic pulmonary artery pressure was 38.45 (11.42) mmHg in AH group and 42.68 (13.01) mmHg in BH group. TAPSE score was 14.12 (1.78) in AH group and 13.67 (1.13) in BH group. Cardiopulmonary bypass times were 78.3 (19.8) minutes and 54 (14.6) minutes in the AH and BH groups, respectively, with respective total operation times of 167.4 (67.6) minutes and 132.2 (39.7) minutes (P=0.023). Positive inotropic drug use was observed in 9 patients (69%) in the AH group and in 7 patients (44%) in the BH group (P=0.029). The independent effect of BH in decreasing the mortality rates was calculated by logistic regression analysis (Odds ratio (OR) 0.43, 95% confidence interval (CI) 0.22–0.76, P=0.001).

Conclusion: Operative and postoperative outcomes of the BH technique in TVR encourage us to recommend using the BH technique in TVR among patients with a TAPSE score lower than 15 mm.

Keywords: TAPSE, Tricuspid valve replacement, Beating heart, Mortality

Öz

Amaç: Triküspit kapak replasmanı (TKR) her zaman için kalp damar cerrahları için zorlayıcı bir durum olmuştur. Bunun yanında, aortik kros klemp neticesinde oluşan miyokardiyal iskemi, reperfüzyon hasarı ile sonuçlanan kardiyopleji halen kalp cerrahisindeki major problemlerin başında gelmektedir. Bu çalışmada, TAPSE değeri 15 mm altında olan hastalardaki mortalite ve morbiditeyi azaltmak açısından atan kalpte (AK) TKR ameliyatının yararlarını değerlendirmeyi amaçladık.

Yöntemler: Bu çalışma retrospektif kohort çalışma olarak tasarlanmıştır. İzole triküspid kapak hastalığı olan ve TAPSE değeri 15 mm altındaki 2006 ve 2012 yılları arasında TVR yapılan 29 hasta çalışmaya dahil edildi. Bu hastalardan 13'üne TVR kardiyoplejik arrest (KA grubu) ve 16'sına atan kalpte (AK grubu) uygulandı.

Bulgular: KA grubunda 13 kişiden 5'i erkek ve ortalama yaş 55,42 (11,6) idi. AK grubunda 16 kişiden 6'sı erkek ve ortalama yaş 57,92 (8,43) idi. KA grubunun %62'sinde New York Kalp Vakfı (NYHA) sınıf III veya IV iken AK grubunda bu oran %56 idi. Atriyal fibrilasyon KA grubunda 9 (%69) hastada görülürken AK grubunda 11 (%69) hastada gözlendi. Sol ventrikül fonksiyonu AK grubunda %57,23 (7,62) ve KA grubunda %58,65 (8.02) idi. Sistolik pulmoner arterial basınç KA grubunda 38,45 (11,42) mmHg iken AK grubunda 42,68 (13,01) mmHg idi. TAPSE skoru KA grubunda 14,12 (1,78) mm iken AK grubunda 13,67 (1,13) mm idi. Kardiyo pulmoner baypas zamanı KA grubunda 78,3 (19,8) dakika iken AK grubunda 54 (14,6) dakika idi (P=0,015), ve toplam ameliyat süresi KA grubunda 167,4 (67,6) dakika iken AK grubunda 132,2 (39,7) dakika olarak ölçüldü (P=0,023). Pozitif inotropik destek kullanımı KA grubunda 9 (%69) hastada görülürken AK grubunda 7 (%44) hastada mevcut idi (P=0,029). AK tekniğinin mortalite oranını düşürmedeki bağımsız etkisi lojistik regresyon analizi ile değerlendirildi (Odds ratio (OR) 0,43, 95% confidence interval (CI) 0,22–0,76, P=0,001).

Sonuç: AK ile TVR uygulamasına ait operasyonel ve postoperatif veriler bizleri TAPSE skoru 15 mm altında olan hastalarda AK tekniğinin kullanılmasını önermekte cesaretlendiriyor.

Anahtar kelimeler: TAPSE, Triküspit kapak replasmanı, Atan kalp, Mortalite

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Introduction

Despite the valuable impairments in surgical techniques, tricuspid valve replacement (TVR) has always been a compelling issue for the cardiovascular surgeons due to the poor postoperative outcomes. However, under certain circumstances TVR may be the first option in consideration of the elevated risks of mortality and morbidity.

Right ventricle dysfunction (RVD) is one of the major risk factors increasing the operative and postoperative mortality rates in tricuspid valvuloplasty operations [1]. Fractional area change (RVFAC) and ejection fraction (RVEF) are two main parameters of trans-thoracic echocardiography (TTE) in defining right ventricle function. However, they have a limited value in clinical practice due to the lack of inadequate right ventricle endocardial examination [2,3]. Tricuspid annular plane systolic excursion (TAPSE) shows apex to base shortening diameter of right ventricle and is used to define right ventricle function [4-6]. Patients which have a TAPSE index lower than 15 mm are considered to have a high risk of peroperative mortality and morbidity due to remarkable RVD [7].

Due to the negative systemic effects of cardiopulmonary bypass (CPB) and myocardial ischemic duration (cross clamp time), in recent years, performing TVR operations with beating heart technique (BH) has become popular to avoid additional elevated morbidity and mortality rates [8].

This study was designed to evaluate the benefits of TVR with BH in terms of decreasing mortality and morbidity rates among the patients with TAPSE indexes <15 mm.

Materials and methods

This retrospective cohort study, which complies with the standards defined by the Declaration of Helsinki, was conducted in the Cardiovascular Surgery Department of Akay Hospital. Twenty-nine consecutive patients with isolated tricuspid valve diseases who underwent TVR between 2006 and 2012 were enrolled. Patients who have a TAPSE index>15 mm, a history of coronary artery bypass operation and those who were reoperated were not included. Among 29 patients, 13 underwent TVR with cardioplegic arrest (AH group) and 16 underwent TVR with BH (BH group).

The computerized institutional database was used to obtain demographic data and record co-morbidities. Age, gender, history of coexisting diseases, and intra-postoperative parameters of the patients were noted.

A preoperative TEE exam was performed using multiplane TEE probes (Acuson, Mountain View, CA) by an experienced cardiologist certified in perioperative TEE. TAPSE was measured in a mid-esophageal four chamber view. 2D cursor was placed at the tricuspid lateral annulus and the distance of systolic annular RV excursion along a longitudinal line was measured defining the end of systole as the end of the T wave in the electrocardiogram [9].

The indications of TVR were as follows: One patient due to tricuspid valve endocarditis, one patient due to tricuspid valve stenosis and 27 patients due to severe tricuspid valve insufficiency. Mortality occurring in the first postoperative 30 days were considered hospital mortality.

Operational technique

A midline sternotomy was performed on 8 patients in the AH group and 7 patients in the BH group. Arterial cannulation of ascending aorta and bicaval venous cannulation of right atrium were done. Right anterolateral thoracotomy was performed to the remaining patients of both groups following arterial cannulation of femoral artery and bicaval venous cannulation from femoral vein by means of transesophageal echocardiography (TEE). CPB was initiated. Tape strips were placed to Vena Cava Inferior and Superior. In the AH group, following mild systemic hypothermia (30°C) and application of topical ice slush, heart was arrested by means of cold cardioplegia solution. BH group patients had systemic normothermia (36.5 °C). In both groups, a right atriotomy was performed after tightening the snares of caval tape strips. Tricuspid valve was replaced with a mechanical prosthetic valve in 7 patients of the AH group and 11 of the BH group, and with a bioprosthetic valve in 6 patients in the AH group and 5 in BH group by preserving tricuspid valve tissue and sub-valvular apparatus in order to decrease the risk of damaging signal transduction pathways and support right ventricle function. Antegrade hot cardioplegia was applied before declamping the aorta in the AH group. Blood samples were obtained in the postoperative 1^{st}, 4^{th}, 12^{th} and 24^{th} hours to monitor serum lactate, troponin-T and CK-MB levels.

Postoperative follow-up

Peroperative and follow-up data were recorded in a computerized database. Death within postoperative 30 days was defined as mortality. All patients were followed up via transthoracic echocardiographic evaluation, which was performed at discharge, at the end of first and sixth months, and annually thereafter.

Statistical analysis

Statistical analysis was conducted using the SPSS for Windows software package (ver. 17; SPSS Inc., Chicago, IL, USA). All variables were evaluated using visual (histograms, probability plots) and analytical (Kolmogorov Smirnov test) methods to determine whether they were normally distributed. Continuous variables are reported as means (SDs) for normally distributed variables, and as medians with interquartile ranges for non-normally distributed variables. Categorical variables are presented as numbers and percentages.

Group comparisons were performed using chi-squared or Fisher's exact tests for qualitative variables, independent t-tests for normally distributed continuous variables, and the Mann-Whitney U test for non-normally distributed continuous variables.

Logistic regression analysis was used to evaluate the effect of BH and cardioplegic arrested heart techniques on the mortality rates of the patients undergoing TVR. Potential risk factors and predictor variables with a *P*-value lower than 0.25 in the univariate analysis were included as covariates in the multivariate model. The multivariate model was regulated for age, sex, operational and CPB time, intensive care unit stay duration. *P*-values <0.05 were considered to indicate statistical significance.

Results

The demographic data of AH group (n=13, 5 males, mean age: 55.42 (11.6) years) and BH group (n=16, 6males, mean age: 57.92 (8.43) years) are presented in Table 1. Sixty-two percent of the AH group was in New York Heart Association (NYHA) Class III or IV heart failure in comparison to 56% of the BH group. Atrial fibrillation was present in 9 patients (69%) in the AH group and 11 patients (69%) in the BH group. Left ventricular functions were calculated as 57.23% (7.62) and 58.65% (8.02) in the AH and BH groups, respectively. Mean systolic pulmonary artery pressure was 38.45 (11.42) mmHg in AH group and 42.68 (13.01) mmHg in BH group. TAPSE score was 14.12 (1.78) in AH group and 13.67 (1.13) in BH group. There was no statistically significant difference between the two groups in terms of age, gender, preoperative atrial fibrillation, left ventricular function, NYHA functional class, and preoperative cardiac surgery history. However, EuroSCORE II risk scoring system of BH group had a significantly higher predicted mortality rate than AH group (P=0.03) (Table 1).

According to intraoperative data given in Table 2, cardiopulmonary bypass times were 78.3 (19.8) minutes and 54 (14.6) minutes in the AH and BH groups, respectively, with respective total operation times of 167.4 (67.6) minutes and 132.2 (39.7) minutes (P=0.023). In AH group, X-clamp time was 48.27 (17.2) minutes and total amount of cardioplegia was 1057 (467) ml.

Positive inotropic drug use was observed in 9 patients (69%) in the AH group and in 7 patients (44%) in the BH group (P=0.029). The AH group required significantly prolonged inotropic support (Table 3).

Mechanic ventilator support time was 33 (17) hours in AH group and 13 (4) hours in BH group (P=0.047). Intensive care unit stay time was 6.1 (2.7) days in AH group and 3.4 (1.7) in BH group (P=0.035). The total hospital stay times were similar in both groups (P=0.089).

Although the postoperative tube drainage amounts were similar in both groups (575.6 (263.1) mL in AH group vs. 512.3 (178.5) mL in BH group, P=0.398), RBC transfusion amount was 6.31 (6.83) Units in AH group and 5.27 (5.1) Units in BH group (P=0.003). The amount of plasma transfusion was 725.54 (632.76) mL in AH group and 570.12 (532.12) in BH group (P=0.008). Only one patient was re-explored in AH group and none were re-operated in the BH group (P=0.854). The causes of death were heart failure in three, ventricular arrhythmias in one, and multi-organ dysfunction in two patients. In-hospital mortality was 30.7% with four patients of the AH group and 12.5% with two patients of the BH group (P=0.011) (Table 3).

Postoperative CK-MB and Troponin-T levels are given in Table 4. CK-MB levels within the first postoperative four hours were 26.2 (2.8) IU/L and 18.4 (3.4) IU/L in the AH and BH groups, respectively (P=0.041). However, CK-MB levels at the end of the 12^{th} and 24^{th} hours were similar in both groups (P=0.723 and P=0.265, respectively). Peak CK-MB levels were 31.7 (10.1) IU/L and 21.4 (6.7) IU/L in the AH and BH groups, respectively (P=0.015). Troponin-T levels at the 4^{th}, 12^{th} and 24^{th} postoperative hours were all significantly lower in the BH group (Table 4).

Peak Troponin-T levels were 0.23 (0.08) ng/mL in AH group and 0.11 (0.05) ng/mL in BH group (P=0.001). Peak Lactate levels were 4.7 (2.2) mmol/L x and 3.3 (1.6) mmol/L in the AH and BH groups, respectively (P=0.023). The independent effect of BH in decreasing the mortality rates was calculated by logistic regression analysis (Odds ratio (OR) 0.43, 95% confidence interval (CI) 0.22–0.76, P=0.001) (Table 5).

Table 1: Preoperative data

	AH Group (13)	BH Group (16)	*P*-value
Age	55.42 (11.6)	57.92 (8.43)	0.403
Gender (Male/Female)	5/8	6/10	0.361
SPAP	38.45 (11.42)	42.68 (13.01)	0.792
TAPSE	14.12 (1.78)	13.67 (1.13)	0.915
LVEF	57.23 (7.62)	58.65 (8.02)	0.877
Atrial fibrillation	9	11	0.743
NYHA class 3-4	8 (%62)	9 (%56)	0.885
Euro SCORE II (%)	12.4 (9.1)	18.3 (12.4)	0.03
AST (IU/L)	53 (47)	59 (51)	0.501
ALT (IU/L)	57 (68)	62 (71)	0.622
Albumin (g/dl)	3.6 (0.9)	3.7 (1.1)	0.718
Total bilirubin (mg/dl)	3.3 (2.4)	3.5 (3.2)	0.641
Hb (g/dl)	12.1 (1.7)	12.5 (1.8)	0.867
Creatinine (mg/dl)	1.07 (0.2)	1.08 (0.2)	0.906
Preoperative cardiac surgery history			
AVR	0	2	0.552
MVR	3	4	0.855
AVR+MVR	2	2	0.916
MVR+TV Repair	3	4	0.855
No history of prior cardiac surgery	5	4	0.922

AH: Arrested heart, BH: Beating heart, SPAP: Systolic pulmonary artery pressure, TAPSE: Tricuspid annular plane systolic excursion, LVEF: Left ventricle ejection fraction, NYHA: New York Heart Association. AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, Hb: Hemoglobin, AVR: Aortic valve replacement, MVR: Mitral valve replacement, TV: Tricuspid valve

Table 2: Operative data

	AH Group (13)	BH Group (16)	*P*-value
Midline sternotomy	8	7	0.667
Right anterolateral thoracotomy	5	9	0.241
Mechanical valve	7	11	0,188
Bioprosthetic valve	6	5	0,442
CPB duration (min)	78.3 (19.8)	54 (14.6)	0.015
Cross-cl amp duration (min)	48.27 (17.2)	NA	
Total operation duration (min)	167.4 (67.6)	132.2 (39.7)	0.023
Amount of cardioplegia (ml)	1057 (467)	NA	

AH: Arrested heart, BH: Beating heart, CPB: Cardiopulmonary bypass, NA: not applicable

Table 3: Postoperative data

	AH Group (13)	BH Group (16)	*P*-value
Positive İnotropic drug use (dopamine, dobutamine, adrenaline)	9 (69%)	7 (44%)	0.029
Intubation duration (hr)	33 (17)	13 (4)	0.047
Intensive care unit stay duration (day)	2.7 (6.1)	1.7 (3.4)	0.035
Total hospitalization duration (day)	14 (13)	8.7 (6.7)	0.089
Chest tube drainage amount (ml)	575.6 (263.1)	512.3 (178.5)	0.398
Total Transfusion			
RBC (U)	6.31 (6.83)	5.27 (5.1)	0.003
Plasma (mL)	725.54 (632.76)	570.12 (532.12)	0.008
Re-exploration	1	0	0.854
Tracheostomy	2	1	0.116
Mortality	4 (%30.7)	2 (%12.5)	0.011

AH: Arrested heart, BH: Beating heart, RBC: Red blood cell

Table 4: Postoperative CK-MB and Troponin-T levels

	AH Group (13)	BH Group (16)	*P*-value
CK-MB(IU/L) (normal reference 0–25 IU/L) 4.h	26.2 (2.8)	18.4 (3.4)	0.041
CK-MB(IU/L) (normal reference 0–25 IU/L) 12.h	18.8 (3.2)	17.6 (3.9)	0.723
CK-MB(IU/L) (normal reference 0–25 IU/L) 24.h	17.4 (2.6)	15.4 (2.7)	0.265
Troponin-T(ng/mL) (upper reference limit=0.1 ng/mL) 4.h	0.72 (0.38)	0.17 (0.14)	0.023
Troponin-T(ng/mL) (upper reference limit=0.1 ng/mL) 12.h	0.55 (0.22)	0.18 (0.15)	0.012
Troponin-T(ng/mL) (upper reference limit=0.1 ng/mL) 24.h	0.47 (0.22)	0.14 (0.11)	0.028
Peak CK-MB (IU/L) (normal reference 0–25 IU/L)	31.7 (10.1)	21.4 (6.7)	0.015
Peak Troponin-T (ng/mL) (normal reference <0.1 ng/mL)	0.23 (0.08)	0.11 (0.05)	0.001
Peak Lactate (mmol/L)	4.7 (2.2)	3.3 (1.6)	0.023

AH: Arrested heart, BH: Beating heart, CK-MB: Creatine kinase myocardial band

Table 5: Results of the logistic regression analysis

	OR	95% CI	*P*-value
Age	0.86	0.83–0.94	0.178
Female sex	1.01	0.69–2.29	0.242
CPB time	0.93	0.9–1.01	0.752
Beating heart technique with CPB	0.43	0.22–0.76	0.001

OR: Odds ratio, CPB: Cardiopulmonary bypass, CI: Confidence interval

Discussion

Among the literature, this study is first to compare the early postoperative results of BH and cardioplegic arrested heart techniques (CAH) of TVR among the patients having a TAPSE score under 15 mm. Enrolling these patients only helped us obtain a more homogenized patient group in comparison to similar studies. Forfia et al. [10], evaluated 63 consecutive patients with pulmonary hypertension by a right heart catheterization and TAPSE measurement. They demonstrated that patients with a TAPSE score lower than 18 mm had an increased risk of mortality compared to those with a TAPSE score higher than 18 mm. ROC analysis showed that the TAPSE cut-off of 18 mm was highly sensitive of impending death and useful in ruling out the risk of perioperative death (Negative predictive value: 31/31=100%).

Although many improvements have been made in myocardial protection, myocardial ischemia caused by aortic cross clamp and cardioplegia resulting with reperfusion injury are still some of the major problems in open heart surgery. BH cardiac surgery without the use of cross-clamp results in shortened cross-clamp and CPB times, helping the patient avoid systemic inflammatory response caused by extracorporeal circulation and associated negative effects such as myocardial hypoxemia, malnutrition, and electronic imbalance, which may strongly increase morbidity and mortality [1,11-14]. Patients with a poor right ventricle dysfunction such as a TAPSE score lower than 15 mm would benefit from BH the most [7,10,15].

Matsumoto et al. [15] evaluated the catecholamine, CK-MB and Troponin levels released postoperatively in their randomized study involving 50 patients who underwent left cardiac valve surgery. According to their study, shorter CPB times accompanied decreased catecholamine release and resulted in lower CK-MB and troponin release during the postoperative period. In our study, CK-MB levels within the first postoperative four hours and Troponin-T levels at the end of 4^{th}, 12^{th} and 24^{th} hours were lower in the BH group compared to the AH group.

Performing TVR with the arrested heart technique results in CPB with a hemodiluted blood and an increased number of blood transfusions, which bring about transfusion-related complications like plasma and erythrocyte hemolysis, acute pulmonary injury, allergic reactions, metabolic and coagulative abnormalities, volume overload, alloimmunization, immunosuppression, ferrum overload, graft versus host reaction and a remarkable increase in hospitalization costs [16]. In our study, the need of blood transfusion was significantly less in the BH group despite the similar amounts of chest tube drainage. Intensive care unit stay, and intubation times were also lower in the BH group.

Performing TVR with CAH provides an easier surgical exposure and bloodless operative field due to less amount of blood flow of coronary sinus and the lack of leaflet movement (especially in case of thrombus, vegetation or tumoral tissue). However, TVR with BH is a more complicated process for the patient due to limited surgical vision resulting in a more difficult surgical manipulation [1,6,8,15]. There are also some advantages of BH. For example, an atrioventricular block caused by the sutures placed on the septal side would easily be observed by the surgeon and early manipulation would prevent the patient from needing a permanent pacemaker.

In a beating heart, tricuspid valve environment decreases by 19% and tricuspid valve area decreases by 30% during systole, which may cause a reasonable shearing force improvement on posterior annulus resulting with the dehiscence of prosthetic valve [17-19]. On the follow-up, we did not observe any case with dehiscence of the prosthetic valve. However, for more reliable results a longer follow-up duration would be beneficial.

Limitations

The main limitation of our study is the small number of the cases. Further, multi-center studies involving larger number of cases would provide more realistic and meaningful statistical results.

Conclusion

Tricuspid valve insufficiency in patients having a TAPSE index lower than 15 mm is a strongly challenging process to operate and manage peroperative times both for the patients and clinicians. Therefore, as clinicians, it is our duty to use recent operational technique improvements. In our study, CPB and total operational time, the need of positive inotropic drug, intubation and intensive care unit stay duration, and mortality rate were significantly lower in the BH group. Operative and postoperative outcomes of BH technique in TVR process encourages us to recommend using the BH technique in TVR among the patients with a TAPSE score lower than 15 mm.

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