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Original Article

Pump assisted beating heart coronary bypass in patients with renal dysfunction: Can we prevent acute renal damage development?

Böbrek fonksiyonu bozuk hastalarda pompa destekli atan kalpte koroner bypass: Akut renal hasar gelişimini önleyebilir miyiz?

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Abstract

Aim: Different coronary bypass surgery techniques can be used to protect the kidneys in patients with impaired renal function. In conventional coronary artery bypass grafting technique, cardiopulmonary bypass (CPB) is established, hypothermia is performed, cardiac arrest is achieved by clamping the aorta. In the pump-assisted beating heart coronary bypass grafting technique, CPB is maintained for keeping the mean arterial pressure between certain levels. Hypothermia is avoided, aortic clamp and cardioplegia are not used. In this study, patients with impaired renal function were compared weather they had coronary artery bypass grafting in conventional or pump-assisted beating heart technique, in terms of acute renal damage and dialysis requirements in patients.

Material and Methods: Forty-eight patients who had coronary artery bypass graft surgery and whose serum creatinine level was higher than 1,3 mg / dl were included in the study. Twenty-four patients who underwent pump-assisted method were classified as Group I and 24 patients who underwent conventional method as Group II.

Results: There was no difference between the two groups in terms of renal function tests on preoperative evaluation. There were significant differences in urinary outputs before and during CPB, intensive care stays, acute renal damage and dialysis requirements ($p < 0.05$). Four out of 24 patients in group I (16.66%) and 18 patients of 24 patients in group 2 (75%) had acute renal failure (ARD). In group I patient dialysis was not required and in group II eight patients required dialysis ($p < 0.05$).

Conclusion: Different techniques have been developed due to increased mortality, morbidity and health expenditures in coronary artery bypass grafting in the presence of accompanying diseases. In our study, ARD and dialysis requirements were found to be higher by the conventional method in cases with serum creatinine level above 1.3 mg / dL. Pump-assisted beating heart coronary bypass surgery can be a good option in patients with high creatinine levels which we may encounter kidney problems in the postoperative period.

Keywords: coronary bypass; renal function; acute kidney injury

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Öz

Amaç: Böbrek fonksiyonları bozuk olan olgularda böbrekleri korumak amacı ile farklı koroner bypass ameliyatı teknikleri kullanılabilir. Konvansiyonel koroner arter bypass greftleme tekniğinde kardiyopulmoner bypassa (KPB) girilerek, hipotermi uygulanmakta, aorta klemplenerek kardiyopleji ile kardiyak arrest sağlanmaktadir. Pompa destekli atan kalpte bypass greftleme tekniğinde ise ortalama arteriyel basıncı belli düzeyde tutmak amacıyla ihtiyaç duyulması halinde KPB'a girilmektedir. Hipotermiden kaçınılmakta, aorta klempi ve kardiyopleji kullanılmamaktadır. Bu çalışmamızda, böbrek fonksiyonları bozuk olan olgularda, konvansiyonel yöntem ile pompa destekli atan kalpte yapılan koroner bypass ameliyatı olan hastalarda gelişen akut renal hasarlanma ve diyaliz gereksinimi açısından karşılaştırdık.

Gereç ve Yöntemler: Klinigimizde 3 yıl içerisinde koroner arter hastalığı nedeniyle izole koroner arter bypass greft cerrahisi uygulanan ve serum kreatinin düzeyi 1,3 mg/dl'den yüksek olan 48 olgu çalışmaya dahil edildi. Atan kalpte pompa destekli yöntem uygulanan 24 olgu Grup I, konvansiyonel yöntem uygulanan 24 olgu Grup II olarak kabul edildi.

Bulgular: Preoperatif değerlendirmede böbrek fonksiyon testleri açısından her iki grup arasında farklılık yoktu. KPB öncesi ve KPB esnasında idrar outputları, yoğun bakım kalış süreleri, akut renal hasarlanma ve diyaliz gereksinimleri açısından anlamlı farklılık saptandı ($p<0.05$). Grup I'de 24 olgunun dördünde (%16,66); Grup 2'de ise 24 olgunun 18'inde (%75) akut böbrek hasarı saptandı. Grup I olgularında diyaliz ihtiyacı saptanmazken, Grup II'de sekiz hastada diyaliz ihtiyacı olduğu görüldü ($p<0.05$).

Sonuç: Eşlik eden hastalıkların varlığında koroner arter bypass greftleme de mortalite, morbidite ve sağlık harcamalarının artması sebebi ile farklı teknikler geliştirilmektedir. Çalışmamızda serum kreatinin düzeyi 1,3 mg/dl'nin üzerinde olan olgularda ABH ve diyaliz ihtiyaçları konvansiyonel yöntem ile daha fazla olduğu tespit edilmiştir. Kreatinin seviyeleri yüksek olan ve ameliyat sonrası dönemde böbrek problemleri ile karşılaşabileceğimizi düşündüğümüz olgularda pompa destekli atan kalpte bypass ameliyatı iyi bir seçenek olabilir.

Anahtar kelimeler: koroner bypass; renal fonksiyon; akut böbrek yetmezliği

Introduction

Coronary artery bypass grafting (CABG) is a common method used in the treatment of coronary artery disease. CABG surgeries are usually performed in two ways. The first is the conventional method that is using cardiopulmonary bypass (CPB) (on-pump CABG) and the second is of-pump CABG without CPB.[1] Although it is not used frequently, there is also a pump assisted beating heart bypass (PABHB) method in which both methods are used together if needed.

Acute renal damage (ARD) develops 10 to 60% after CABG surgery.[2,3] ARD, which developed in the postoperative period, prolongs hospital stay and intensive care stay. Renal replacement therapy is required in 1 to 5% of patients with ARD, and mortality is increased in these patients. In patients undergoing CABG surgery, the risk of developing ARD is higher in patients with impaired renal function before surgery.[4,5] Several consensus bodies have been set up to provide uniform criteria for the detection of ARD, to assist the comparisons during studies, and to facilitate the development of quantitative surveys. The Kidney Disease / Improving Global Outcomes criteria (KDIGO) is also one of the renal damage consensus.[6] KDIGO criteria are an evaluation method based on changes in serum creatinine levels and urine output.

In this study, we aimed to compare acute renal damage and the need for dialysis due to this caused by on-pump CABG and PABHB, in cases with preoperative impaired renal function tests.

Material and Methods

The studies were conducted between January 2012 and January 2015. Forty-eight patients who underwent isolated CABG for coronary artery disease within three years were implicated in the study. Twenty-four patients undergoing PABHB surgery were treated as Group I, and 24 patients undergoing conventional CABG were treated as Group II.

All operations were performed by the same surgeon. All cases underwent median sternotomy. The surgical method to be applied is planned randomly.

Patients were cooled to 30°C with CPB by aortocaval cannulation with conventional CABG technique. After clamping of the aorta, cardiac arrest was performed with cardioplegia. Following the completion of the distal

anastomoses, patients were heated and discharged from CPB. Aorta-valvular cannulation was performed in PABHB surgery to keep the mean arterial pressure at a certain level. When the mean arterial pressure dropped below 50 mmHg and / or during distal anastomosis on the posterior aspect of the heart, CPB was established. In all cases of PABHB operation, left ventricular sump was placed via right upper pulmonary vein. Sump was used to reduce left ventricular wall tension during distal anastomoses on the lateral and posterior sides of the heart during CPB. In PABHB surgery, all anastomoses were performed using an intracoronary shunt. Hypothermia was not performed and therefore rewarming was not needed.

Comorbid factors; hypertension (HT), diabetes mellitus (DM), hyperlipidemia (HL), chronic obstructive pulmonary disease (COPD), compensated renal disease (CKD) and peripheral arterial disease (PAH) were recorded as demographic data. The European System for Cardiac Operative Risk Evaluation (Euroscore) scores were calculated.[6]

Ejection fractions (EF) were evaluated pre- and postoperatively. Urine outputs before and after CPB were recorded intraoperatively. Postoperative daily renal function tests (BFT) and hourly urine output were recorded.

For follow-up of renal function, serum creatinine levels and hourly urinary output were assessed according to the criteria of KDIGO (table 1). In our cases, we used KDIGO criteria only for the purpose of establishing the diagnosis of ARD and did not do any staging.

Table 1. The Kidney Disease / Improving Global Outcomes criteria

Stage	Serum creatinine level	Urine volume
1	1.5-2 times the baseline value within 7 days or ≥0.3 mg / dl increase within 48 hours	8 hours <0.5 ml / kg / hour
2	2.0-3 fold increase from baseline	16 hours <0.5 ml / kg / hour
3	Increase ≥ 3 times the baseline value Serum creatinine ≥4.0 mg / dL or Dialysis or <35 ml / min / 1.73 m2 reduction in eGFR in <18 years of age	≥ 24 hours <0.5 ml / kg / hour or 12 hour anuria

Patients requiring additional procedures, such as heart valve surgery, early mortality, patients with chronic renal failure, and patients with normal renal function (SCR <1.3 mg / dl) were considered exclusion criteria.

The obtained data was evaluated by SPSS (Statistical Package for the Social Sciences for Windows, version 20,0). We gave parametric values with mean and ± 2 standard deviations. We used Kolmogorov-Smirnov test for the normal distribution of data, Mann-Whitney U for parametric values and Chi-square tests for categorical values. The differences between the groups were compared with the One-Way ANOVA test. We considered p <0.05 as statistically significant.

This study was approved by the Baskent University Clinical Research Ethics Committee(94603339/18-050.01.08.01-779) and procedures were carried out in accordance with the 2013 Helsinki Declaration. Informed consents were obtained from all participants.

Results

The demographic characteristics of the patients are given in Table 2 and no statistical difference was found between the two groups.

Table 2. Demographic data

	Grup I	Grup II	p value
Average Age (years)	64.75 ± 11.76	68.00 ± 9.56	0.466
Weight (kg)	75.23 ± 9.45	77.49 ± 11.68	0.476
Length (cm)	168 ± 6.87	167.67 ± 9.59	0.255
Body Surface Area (m^2)	1.79 ± 0.154	1.78 ± 0.143	0.578
Male (n)	20	24	
Woman (n)	4	0	
Hypertension (n)	16	14	0.383
Diabetes mellitus (n)	6	10	0.249
Hyperlipidemia (n)	16	16	0.423
COPD (n)	6	4	0.381
Peripheric Arterial Disease (n)	4	6	0.451
Euroscore	5.27 ± 2.79	5.27±2.44	1.00
Preoperative EF (%)	47.25 ± 7.87	51.08 ± 10.41	0.32

*Abbreviations:COPD: Chronic obstructive pulmonary disease

The intraoperative and postoperative data of the patients are given in Table 3. There was no difference in terms of CPB durations, number of bypasses, patient temperature values, and duration of mechanical ventilation, while intensive care unit stay was found to be higher in patients treated with conventional methods (p = 0.011).

Compared with both groups before and after CPB, urine output was significantly lower in group II. According to the criteria of KDIGO ARD is developed in four (16.66%) of PABHB cases and 18 (75%) of conventional CABG cases (p <0.05). In the postoperative period, the PABHB group patients did not require dialysis whereas eight patients in the on-pump CABG group required dialysis (p <0.05).(Table 4)

Table 3. Postoperative characteristics of PABHB and CABG groups

	Grup I	Grup II	P value
Postoperative EF (%)	50.83± 7.18	49.66± 10.18	0.749
CPB Time (min)	79.83± 29.06	94.58± 23.59	0.186
Aortic clamp time (min)	0	50.41	
Temperature (° C)	33.84± 1.54	28.98± 1.89	0.488
Bypass Count (n)	4.08± 0.66	3.83± 0.83	0.427
Mechanical Ventilation Time (hour)	11.51±8.55	13.87±7.64	0.635
Intensive Care Time (days)	2.15±1.6	3.45±2.86	0.025
Time at the hospital (days)	9.77±4.45	10.15±3.47	0.412

*Abbreviations: PAHBB: Pump assisted beating heart bypass, EF: Ejection fraction, CPB: Cardiopulmonary bypass, min: minutes, °C: degree centigrade

Table 4. Intraoperative urine output, rate of ARD occurence and dialysis needs of patients

	Grup I	Grup II	p value
The volume of urine before CPB (ml)	658.33± 408.34	289.58± 188.73	0,01
Volume of urine during CPB (ml)	700.00± 380.19	239.58± 2210.93	0,002
Number of patients with ARD	4	18	0,003
Number of patients requiring dialysis	0	8	0,028

*Abbreviations: CPB: Cardiopulmonary bypass, ARD: Acute renal damage.

Discussion

When we compared PABHB and conventional CABG, we found that in the conventional method patients needed longer ICU care. Although there was no difference between the serum creatinine levels in both groups, postoperative ARD developed in 9% of the PABHB group and 75% of the conventional CABG group according to the KDIGO criteria. Again, the need for dialysis in these patient groups was 0 and 33.3%, respectively.

ARD is a complication frequently encountered after cardiac surgery, extending intensive care and hospital stay periods and increasing mortality seriously.[2,3,7] ARD and the need for postoperative renal replacement therapy increases the mortality rates from 25% to 50% .[8,9]

The development of ARD in CABG surgeries is multifactorial. Some of these risk factors are advanced age, female gender, DM, preoperative steroid use, past cardiac surgery, pre- and / or intraoperative mechanical support device use, and preoperative renal dysfunction.[10,11] Several studies have shown that a small change in preoperative renal function in patients undergoing cardiac surgery is an important effect on long- and mid-term outcomes.[12,13,14]

Another risk factor for ARD development is method of CABG surgery. While conventional CABG is still considered the gold standard method for coronary artery revascularization, this technique presents with a number of side effects including systemic inflammation, neurological and renal dysfunction. [15] The causes of ARD after cardiac surgery include ischemia - reperfusion, cytokine release, hemolysis and exposure to nephrotoxicity. CPB stimulates the systemic inflammatory response (SIRS) and SIRS has an adverse effect on renal blood flow.[16,17] Therefore, the duration of CPB is an important predictor of postoperative renal dysfunction.[18]

Conflicting results of renal dysfunction and mortality have been reported between the two groups in studies, while expecting the ARD is lower in the beating heart than conventional CABG, because of the absence of CPB.[19,20]

There is a very limited number of papers on the effect of PABHB technique on renal function. In a study conducted in patients with serum creatinine levels within the normal range (<1,3 mg / dl) in our clinic, there was no statistically significant difference between the two groups in terms of ARD development between the PABHB group and the conventional CABG groups.[21] In a study conducted by Chen et al., they found that the PABHB technique was superior to the conventional method.[22]

Prolonged CPB time is shown as a risk factor for ARD. In our study, there was no statistically significant difference between the two groups when the PAPHB and conventional CABG cases were compared in terms of CPB durations, but it was explicitly shorter in PABHB group (79.83 ± 29.06 minutes' vs 94.58 ± 23.59 minutes). The absence of difference in CPB duration between the two groups is due to multi-vessel bypass and complete revascularization desideration. We think that it is possible to explain ARD and dialysis requirements are less in the PABHB than the conventional method, the mean arterial pressure is not allowed to drop during the PABHB procedure, hypothermia is not applied, cardioplegia is not given.

Another effect on ARD is rewarming which is needed because of the hypothermia and CPB applied with organ protection purpose during CPB. Low CPB perfusion heat is associated with postoperative ARD.[23] In a study conducted by Boodhwani and colleagues, they found that the development

of postoperative renal dysfunction was higher in patients who underwent rewarming from 32°C to 37°C than those who rewarmed from 34°C during 10-15 minutes of rewarming.[24] We did not use hypothermia in the cases of PABHB and we did not need rewarming for this reason.

As a result; the PABHB technique is a good method to be applied in cases of impaired renal function. The advantage of the PABHB method over the conventional method is that the duration of CPB is short, it does not require hypothermia, and the aortic clamping is not used. At the same time, according to the on-pump CABG method, it provides advantages such as providing technical convenience and allowing complete revascularization because the hemodynamic stabilization can be kept for a long time.

Conclusion

The PABHB method is an important alternative to conventional CABG and on-pump CABG procedures in patients with impaired renal function tests. Hypothermia is not required, coronary perfusion is continued during bypass with the help of intracoronary shunt, hemodynamic problems are edged out by establishing CPB for keeping the mean arterial pressure above a certain level, the left ventricle can be decompressed during bypass procedure on the lateral and posterior surfaces of the heart and because of that possibility of total revascularization is increased. For these reasons we believe that the PABHB method is advantageous especially in patients with impaired renal function.

Declaration of conflict of interest

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